DECARBONIZATION OF THE MINING SECTOR

MODULE 2

Material for group work

GOALS OF SECTORAL GROUP WORK

- Identify the main sources of greenhouse gas emissions in your sector.
- Familiarize yourself with the target indicators and quantitative measures of decarbonization in the industry.
- Learn which climate risks companies in this sector consider most significant.
- Assess the activities and technological solutions that are most common and acceptable in the short and long term for sector decarbonization.

MAIN SOURCES OF GREENHOUSE GAS EMISSIONS IN METALLURGY

Iron and Steel Production:

- Blast Furnaces: The traditional method of iron and steel production in blast furnaces involves the reduction of iron ore using coke (derived from coal) as a reducing agent, leading to CO2 emissions (Scope 1 emissions).
- Electric Arc Furnaces: In electric arc furnaces, scrap metal is melted using electricity, which also contributes to greenhouse gas emissions depending on the electricity generation mix (Scope 2 emissions).

Aluminium Production:

- Bayer Process: During aluminium production from bauxite ore, the Bayer process results in CO2 emissions due to the thermal decomposition of aluminium hydroxide (Scope 1 emissions).
- Hall-Héroult Process: The Hall-Héroult process, used to extract aluminium from alumina, consumes significant amounts of electricity, leading to indirect emissions depending on the energy source (Scope 2 emissions).

MAIN SOURCES OF GREENHOUSE GAS EMISSIONS IN METALLURGY

Copper Production:

- Smelting and Refining: Extracting copper from copper ore involves smelting and refining processes, which emit greenhouse gases primarily through fuel combustion for heat generation (Scope 1 emissions).

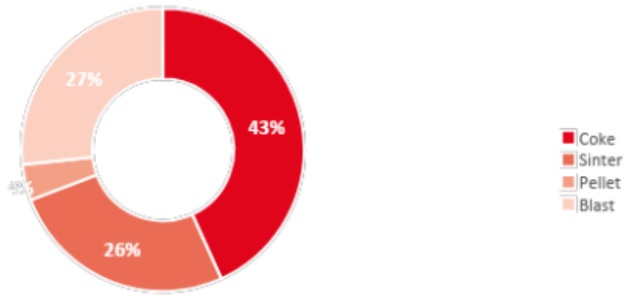
Other Metallurgical Products:

- Various other metals such as zinc, lead, nickel, and titanium are also produced using energy-intensive processes involving heat treatment and chemical reactions, resulting in greenhouse gas emissions (Scope 2 emissions).

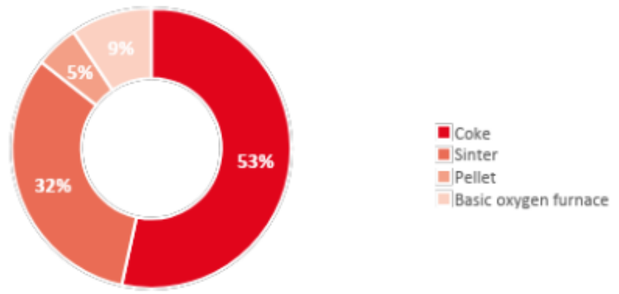
In general, greenhouse gas emissions in the metallurgical industry are primarily associated with the combustion of fossil fuels in high-temperature processes, thermal decomposition of materials, and electricity consumption.

GREENHOUSE GAS EMISSIONS INTENSITY IN STEELMAKING PROCESSES

Greenhouse gas emissions intensity (in CO2eq. per ton of steel) from blast furnace



Greenhouse gas emissions intensity (in CO2eq. per ton of steel) with main oxygen

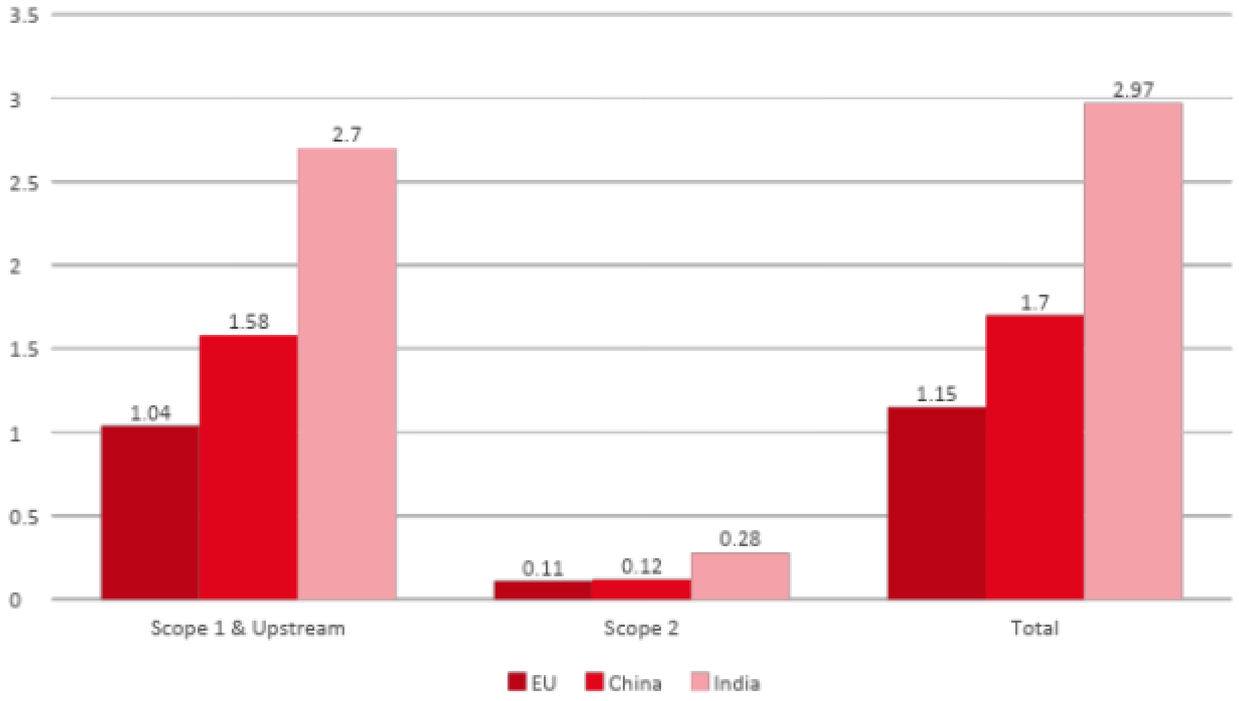


The intensity varies depending on the technology: the oxygen converter process is less carbon-intensive (0.19 tCO2/ton of steel compared to 0.67 for the blast furnace technology).

INTENSITY OF GREENHOUSE GAS EMISSIONS: EU VS CHINA VS INDIA

- Available technologies and the use of coal for electricity production impact the carbon intensity of steel production in different countries..
- China has developed more efficient technologies, although it still makes a significant contribution to total greenhouse gas emissions due to high levels of production.
- Steel production in India still primarily relies on coal, which explains its higher intensity.

CO2 in whole black metallurgy in EU, China and India (TCO2e/t of steel)



WHAT PROCESSES LEAD TO SCOPE 1 AND SCOPE 2 GHG EMISSIONS AT YOUR COMPANY?

Usage of electricity:_____

Usage of coal: _____

Steel-making processes : _____

Other sources:_____

CORPORATE GOALS FOR REDUCING EMISSIONS

Company	Target year: 2030	
	Scope 1 and 2	Scope 3
Vale S.A. (Brazil)	33% (vs 2017) or 2.54%	15% by 2035 (vs 2018) or annually 1.25
BHP Group (Australia)	30% (vs 2020) or annually 3.0%	30-40% (vs 2020) or annually 3-4%
Polymetal (Russia)	35% (vs 2019) or annually 3.2%	No
KazMinerals (Kazakhstan)	5% by 2024 (vs 2018) or annually 1%	No

ARE THERE DECARBONIZATION GOALS SET AT YOUR COMPANY?

Scope 1 and 2:_____

Scope 3 : _____

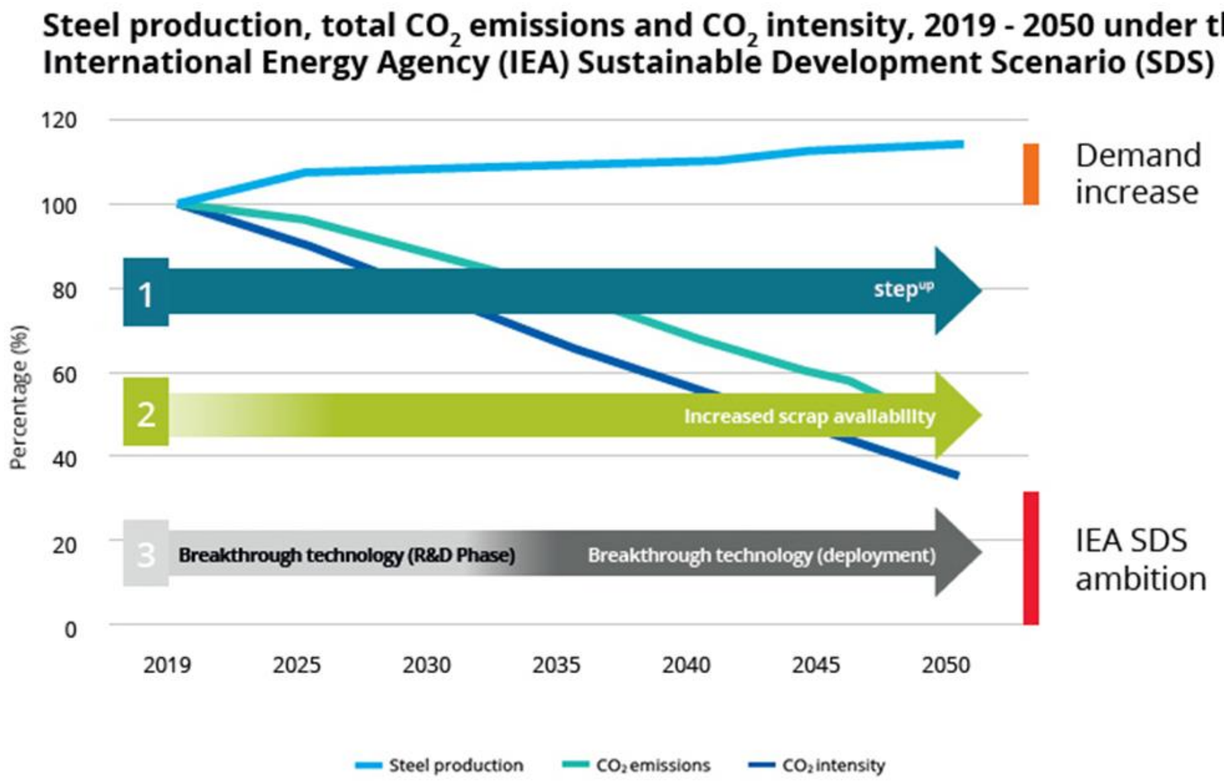
Other goals:

•Energy efficiency improvement_____

•Usage of RES_____

•Other goals:_____

WORLDSTEEL : DECARBONIZATION ROADMAP FOR THE INDUSTRY



1) Forward Step: An industry-wide efficiency analysis process based on best practices to improve raw material quality and energy efficiency. Successful implementation by companies potentially could reduce emissions in steel production by 20%.

WORLDSTEEL : DECARBONIZATION ROADMAP FOR THE INDUSTRY

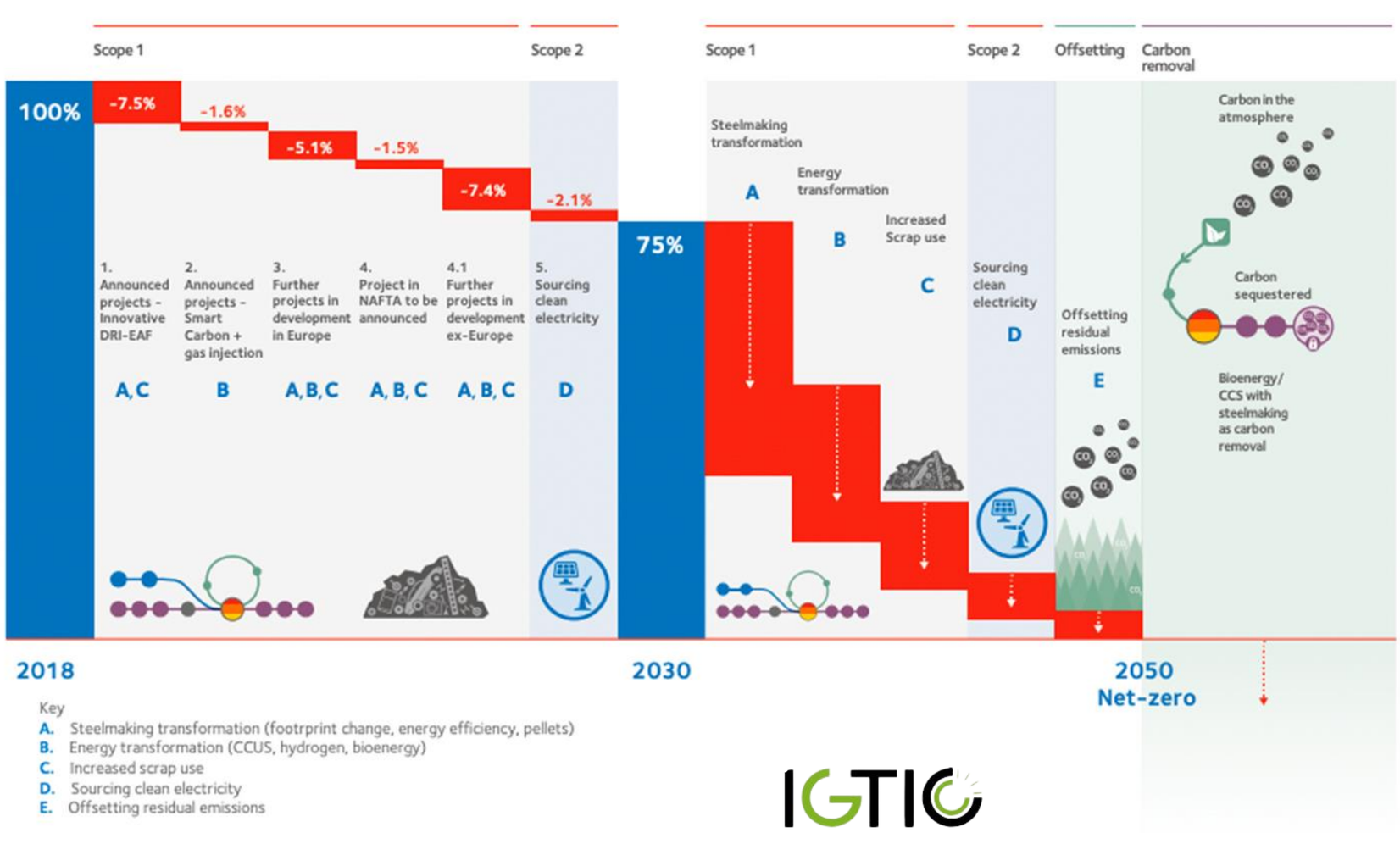
2.Maximum Scrap Utilization: Each ton of scrap used in steel production avoids the emission of 1.5 tons of carbon dioxide. Future expansion is necessary to reduce the impact of the steel industry.

3.Breakthrough Technologies: A transformative approach to iron production is needed to reduce dependence on coal. There are three categories of promising technologies.

Utilization and storage of carbon (CCUS) and/or sustainable biomass for offsetting emissions.

- Green hydrogen as a restorative.
- Use of clean/renewable electricity through an electrolysis-based process.

ARCELORMITTAL: DECARBONIZATION STRATEGY



ARCELORMITTAL:

A - Transformation of Steel Production	Over the coming decades, the steel industry will undergo a technological transformation in steel production on a scale not seen in over 100 years. This includes • the transition of iron **production to the direct reduced iron (DRI) process**. Essentially, the direct reduced iron process involves reducing iron ore without using the blast furnace process, meaning coke is not involved. • Transition to electricity: the use of **electric arc furnaces** • Changing the **processes of iron ore preparation** from sintering plants (using heat or pressure to compact the material) to pelletizing plants (which compress or shape the iron material into pellet form).

ARCELORMITTAL: DECARBONIZATION STRATEGY

B - Energy transformation	Transition to lower-carbon fuels: - Natural gas (in the short term) - Biomass or synthetic biomass - Green hydrogen - Coal only in combination with carbon capture and storage (CCS) installations The world's first large-scale zero-carbon steel factory in Sestao, Spain, with the construction of a hydrogen-powered DRI plant, will be completed in 2025.
C - Circular economy	Increasing the use of scrap metal
D – Pure energy	Acquisition of renewable energy certificates or entering into direct power purchase agreements with renewable energy suppliers.

COMPARISON OF ACTIONS

Summary of the action	Energy efficiency and modernisation	Transformation of steel production	Transition to low-carbon fuels	Maximum utilisation of scrap	Clean power purchase
Emission reduction potential in %	-25%	-50-60%	-100%	1 t of scrap reduces emissions by 1.5 tones of CO2	-100% with full realization
Technological readiness (from 1 to 3)	3	2	1	3	1
Investments	Low	High	high	Low	Average

EVALUATE THE TECHNICAL AND ECONOMIC FEASIBILITY OF IMPLEMENTING DECARBONIZATION ACTIONS AT YOUR ORGANIZATION

RATE FROM 1 (LOW) TO 5 (HIGH(

Actions	Technologically possible	Economically justified
Energy efficiency and modernization		
Transformation of steel production		
Transition to low-carbon fuels		
Maximum utilisation of scrap		
Clean power purchase		

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WHAT ACTIONS HAVE ALREADY BEEN IMPLEMENTED AT YOUR COMPANY?

Utilization of renewable energy sources:_____

Energy efficiency improvement:_____

Transformation of industrial processes:_____

Other actions:_____

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CLIMATE RISK ASSESSMENT

Risks associated with the global transition to low-carbon development

Credit Risk Associated with ESG (Environmental, Social, and Governance): Risk of facing higher interest rates and difficulties in accessing financing due to strict ESG compliance requirements.

Regulatory Risk: Risk of potential changes in national climate-related legislation, including greenhouse gas taxation, carbon footprint reduction targets, and potential litigation for non-compliance with regulatory requirements.

Market risk: Risk exposure to carbon taxation in importing countries of production.

Customer Risk: Risk of losing customers due to failure to meet their decarbonization targets as a supplier.

"CLIMATE RISK ASSESSMENT

RISKS RELATED TO THE NEGATIVE IMPACT OF CLIMATE CHANGE ON OPERATIONS

- Operational risk due to changes in the amount of precipitation
- Operational risk due to extreme temperatures
- Operational risk due to extreme weather conditions
- Operational risk due to water scarcity

ASSESS THE IMPACT THAT THE RISK MAY HAVE ON YOUR ENTERPRISE AND THE PROBABILITY THAT THE RISK WILL MATERIALISE

Risk	Impact	Probability
Credit risk: Access to capital		
Regulatory risk: Stricter legislation		
Market risk: Taxation of imports		
Customer risk: Loss of markets		
Operational Risk: Changes in precipitation levels		
Operational Risk: Extreme temperatures		
Operational Risk: Extreme weather conditions		
Operational risk: Water scarcity		

Rate from 1(low) to 5 (high)

RESULTS OF GROUP WORK

- What are the main sources of GHG emissions in your industry?
- What goals do your companies set for themselves?
- Which decarbonization measures do you consider most realistic?
- Which measures have already been implemented?
- What are the main climate risks for your company?

DECARBONIZATION OF METALLURGY

Module 2 – Additional information

CURRENT ACTIONS OF METALLURGICAL COMPANIES

ARCELORMITTAL: SUSTAINABLE DEVELOPMENT STRATEGY

OBJECTIVES	Goals for emissions reduction	Commitment to reduce emissions intensity by 25% by 2030, based on the 2007 baseline (35% in Europe, scales 1 and 2). Operations span India, USA, Europe, and Kazakhstan.
	Clean electricity	Transition to scrap and DRI-EAF technology to increase the share of electricity + acquisition of renewable energy certificates and direct power purchase agreements (PPAs) from renewable energy suppliers.
SOLUTIONS	Steel production and energy transformation	Transition to natural gas + future use of 'green' hydrogen + fossil carbon in combination with CCS.
	Other	Increasing the use of scrap metal. The XCarb™ Accelerator program, designed to support the development of low-carbon steel production technologies.

JSW STEEL: SUSTAINABLE DEVELOPMENT STRATEGY

OBJECTIVES

SOLUTIONS

Goals for emissions reduction	2030 Goal: Commitment to reduce CO2 emissions intensity to 1.95 tCO2-eq per ton of steel. Emissions intensity in the 2022-23 fiscal year is expected to be 2.36 tCO2-eq per ton of steel. Main operations are primarily in India.
Net zero target	2050 y.
Clean electricity	2030 Goal: Installation of 10 GW of renewable energy sources for full utilization in steel production.
Steel production and energy transformation	Interventions at factories in Vijayanagar, Dolvi, and Salem aimed at increasing efficiency and implementing advanced technologies.
Other	Sustainable Energy and Decarbonization (SEED): a large-scale decarbonization program in Vijayanagar with a total annual potential to reduce CO2 emissions by 9+ million tonnes by 2030.

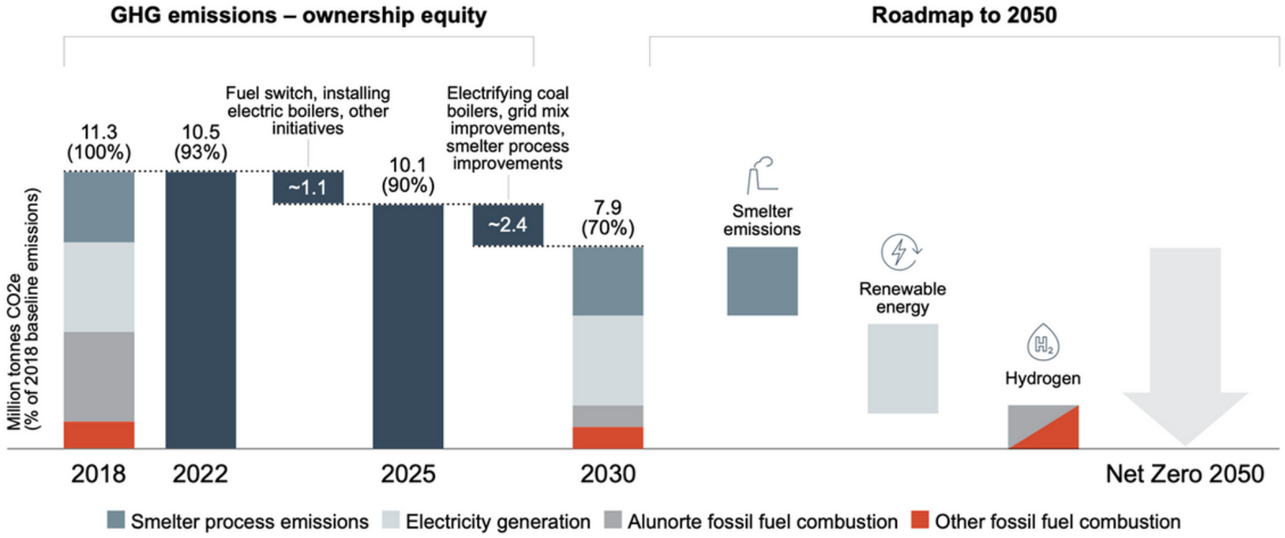
HYDRO: STRATEGY FOR SUSTAINABLE DEVELOPMENT

Clean electricity	Hydropower as a primary source of electricity production, making aluminium produced by hydroelectric stations one of the least carbon-intensive
Smelting/refining and energy transformation	HalZero enables the production of the world's most environmentally friendly and energy-efficient primary aluminium.
Expenditure	63.5 million USD for research and development aimed at advancing technologies in recycling, digitization, and competency enhancement in the battery and hydrogen sectors. CCS for decarbonizing existing smelting plants, the HalZero chloride process for decarbonizing new smelting capacities, and utilization of consumption waste.

HYDRO'S DECARBONIZATION ROADMAP

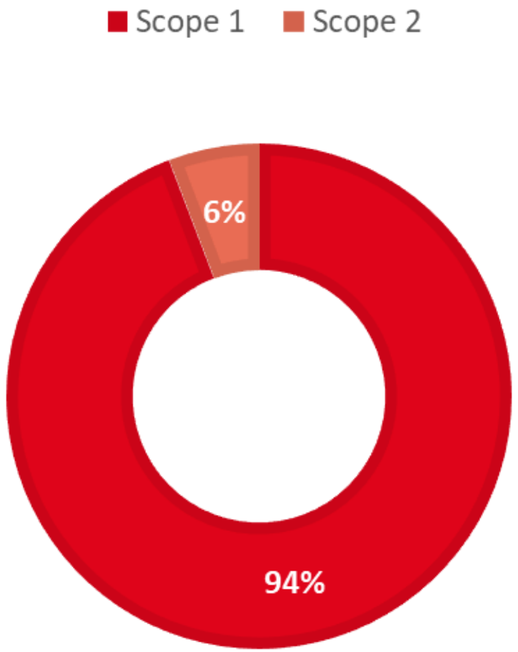
•By 2030: focus on improving fuel/energy/electricity efficiency, electrification of lightly utilised technologies, improvement of smelting processes.

•-2030-2050: CCS/carbon-free smelting; renewable energy deployment;
Hydrogen for complete fossil fuel divestment.

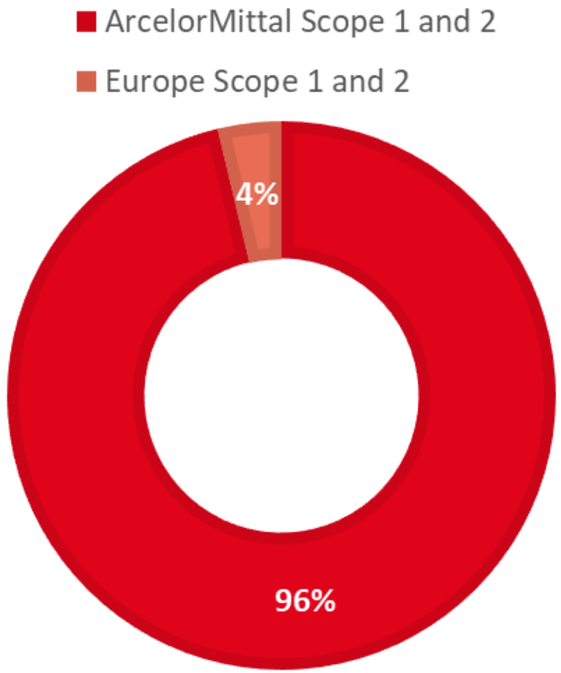


Source: Hydropower Sustainability Report.

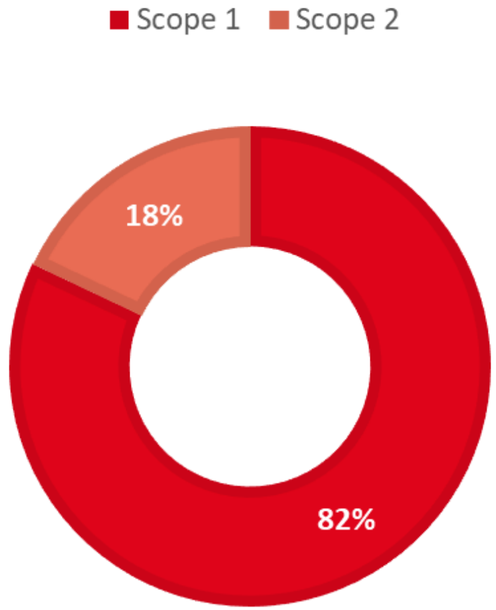
COMPARISON OF COMPANIES



ARCELORMITTAL (2022
)SCOPE 1: 193.04 MILLION TONES CO2EQ
SCOPE 2: 7.48 MILLION TONES CO2 EQ.
TOTAL: 200.53 MILLION TONES CO2 EQ.



JSW STEEL (2022)
SCOPE 1: 41.64 MILLION TONES CO2EQ.
SCOPE 2: 2.57 MILLION TONES CO2 EQ.
TOTAL: 44.21 MILLION TONES CO2 EQ.



HYDRO (2022)
SCOPE 1: 7.17 MILLION TONNES CO2EQ.
SCOPE 2: 1.57 MILLION TONNES CO2 EQ.
TOTAL: 8.74 MILLION TONNES CO2 EQ.

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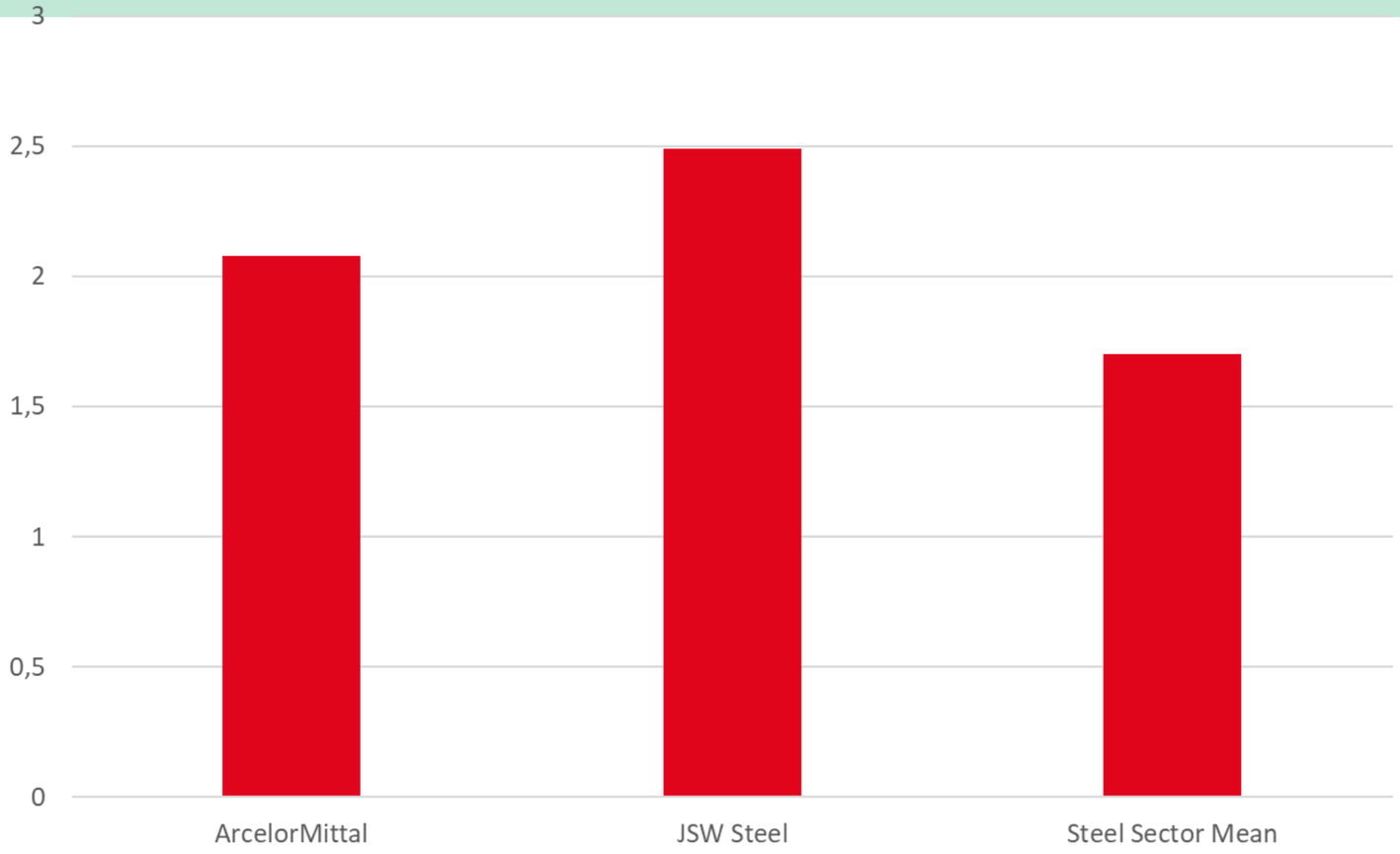
COMPARISON OF COMPANIES: STEEL

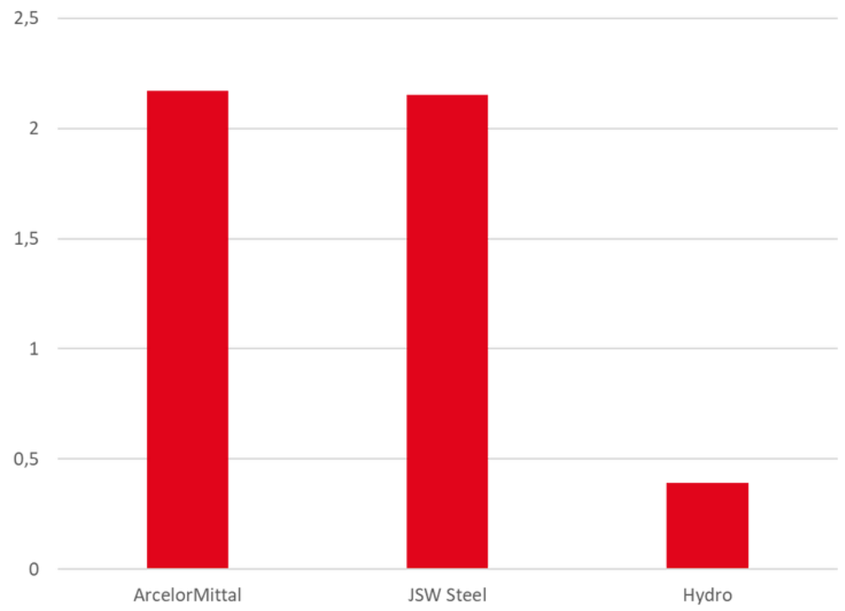
Greenhouse gas emissions intensity (tonnes CO2e per tonne of steel), fiscal year 2020:

- ArcelorMittal: 2.08JSW
- Steel: 2.49
- Sector average for the steel industry: 1.70



EMISSIONS INTENSITY PER UNIT OF REVENUE

Source: “Pathways” Initiative and ArcelorMittal Climate Action Report 2.



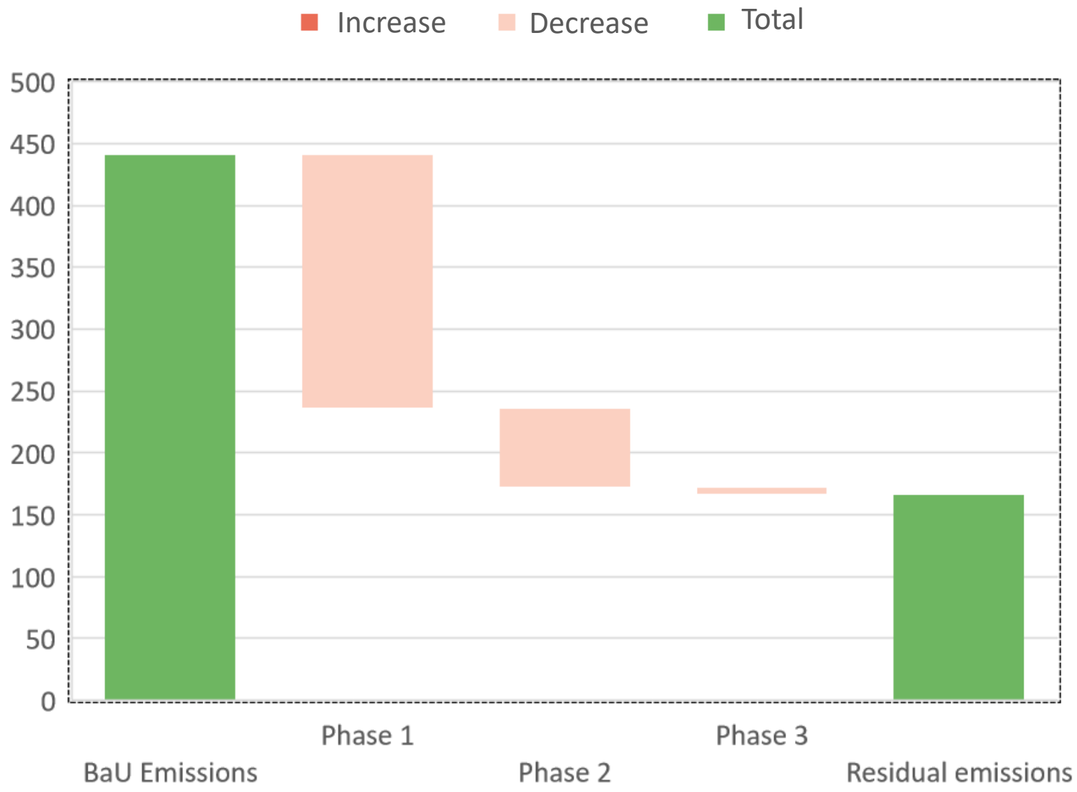
Carbon intensity based on revenues (million tonnes CO2-eq per billion USD), fiscal year 2022:

- ArcelorMittal: 2.17 million tones CO2 per billion USD (revenue 78.844 billion USD).
- JSW Steel: 2.15 million tonnes CO2 per billion USD (revenue 20.54 billion USD).
- Hydro: 0.39 million tones CO2 per billion USD (revenue 22.307 billion USD).

*The fiscal year 2022 was chosen to align the metrics of the three companies, although data for the fiscal year 2023 was available.

MINE ZERO PATHWAY 1: ESTABLISHED TECHNOLOGY

Reduction in emissions on an annual basis for each phase of Pathway 1 (thousand tons of CO2-equivalent).



An ideal case: copper production from mine to metal, located in remote Western Australia with a remaining mine life of 25 years.

- Prioritization of electricity production from renewable sources onsite.
- Electrification of thermal processes and use of natural gas.
- Diesel remains in the mix, offsetting remaining emissions.
- Approximate percentage of emissions they can reduce using currently available technologies.

Total capital expenditure (CAPEX): $744 million

Source: cefc and mriwa

MINE ZERO EXAMPLE (ALUMINUM): PARTNERSHIP RIO TINTO ELECTRIFICATION

RioTinto

Carbon free aluminium smelting a step closer: ELYSIS advances commercial demonstration and operates at industrial scale

- Industrial Research and Development Centre in Saguenay, Quebec, Canada.
- Production of carbon-neutral aluminium: smelting chambers operating on electric current.
- Commercial demonstration in 2023.
- Goal: make the technology available for installation starting from 2024 + large-scale production from 2026.

Source: cefc and mriwa

EXAMPLE (HYDROGEN): H2 GREEN STEEL.

H2 green steel

- Located in Boden, Sweden.
- Produces environmentally friendly steel using end-to-end digitalization, electricity from non-fossil sources, and green hydrogen.
- Gigascale electrolysis (green hydrogen production), DR reactor, electric arc furnace reduces CO2 emissions by 95%.
- Commitment to build a large-scale environmentally friendly steel production factory by 2025.

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