Strategic Research Innovation Agenda (SRIA) of the Clean Steel Partnership

ESTEP & CSP Infoday 7 June 2023 - Krakow

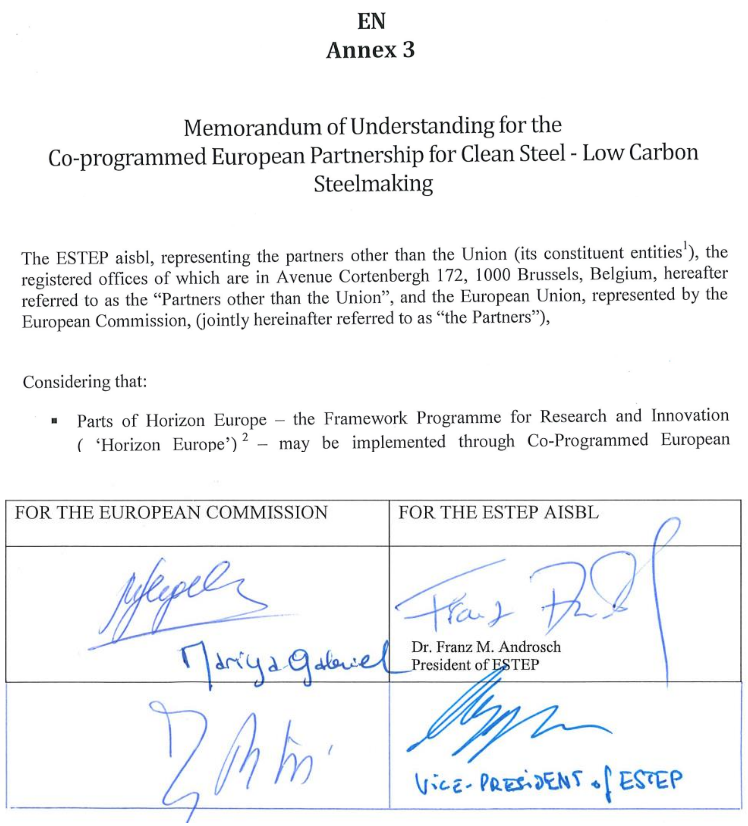
P.Lafontaine – Program Director

The Clean Steel Partnership

European Steel Technology Platform

Strategic Research Innovation Agenda & MoU

MoU


EN
Annex 3

Memorandum of Understanding for the
Co-programmed European Partnership for Clean Steel - Low Carbon Steelmaking

The ESTEP aisbl, representing the partners other than the Union (its constituent entities[1]), the registered offices of which are in Avenue Cortenbergh 172, 1000 Brussels, Belgium, hereafter referred to as the "Partners other than the Union", and the European Union, represented by the European Commission, (jointly hereinafter referred to as "the Partners"),

Considering that:

- Parts of Horizon Europe – the Framework Programme for Research and Innovation ('Horizon Europe') [2] – may be implemented through Co-Programmed European

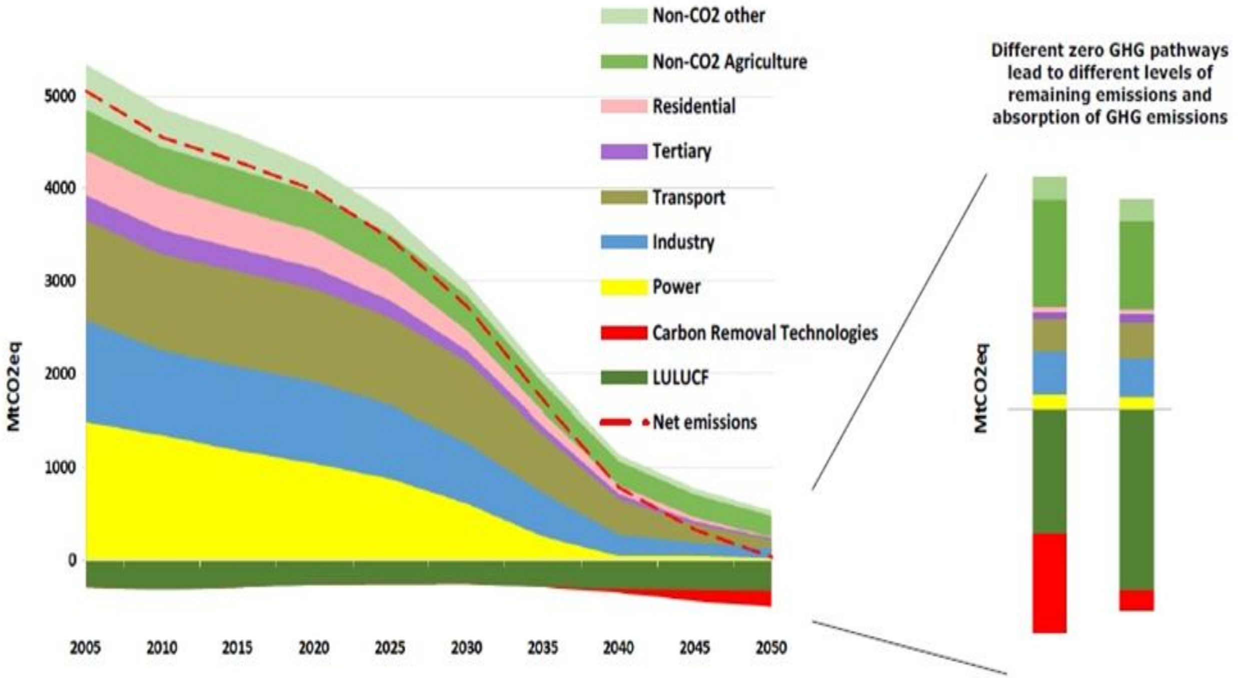
FOR THE EUROPEAN COMMISSION	FOR THE ESTEP AISBL
	Dr. Franz M. Androsch President of ESTEP
	Vice-President of ESTEP

SRIA

Clean Steel Partnership – CSP

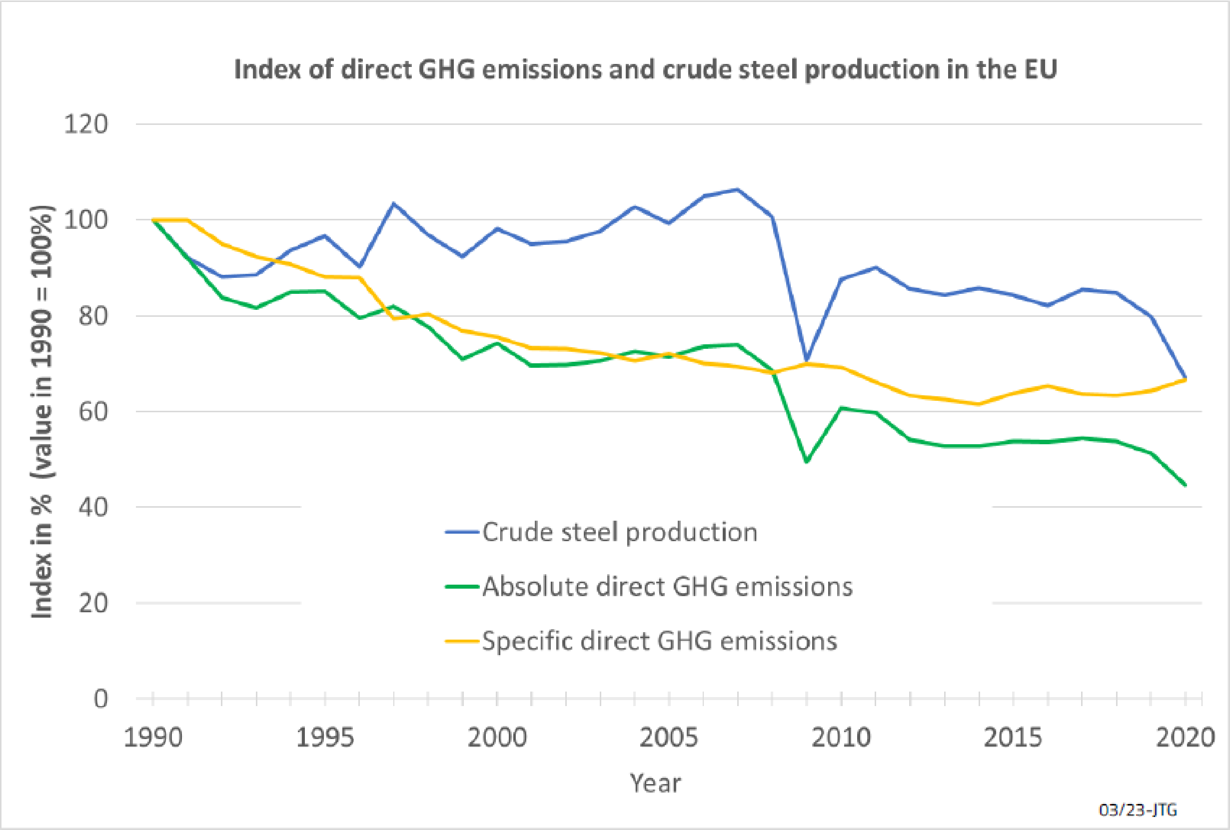
- Horizon Europe (2021-2027)
- **Co-programmed** Partnership
- Two financial funding pillars
  - Horizon Europe
  - Assets of Research Fund for Coal and Steel (RFCS)
- Established by **Memorandum of Understanding** (MoU)
  - ESTEP
  - DG RTD & DG Grow
- SRIA explains in detail the **intended activities of CSP**
- **SRIA adopted** by the Partnership Board of the Clean Steel Partnership on 13 December 2021
- **SRIA Update** end 2023/beginning 2024

Vision - Context



- **Tackle two major challenges: fighting against climate change and ensuring sustainable growth for the EU.**
- In line with the **European Green Deal**, the Clean Planet for All strategy and the Paris Agreement
- **Moving towards climate neutrality by 2050**, a zero-pollution ambition for a toxic-free environment and a circular economy.
- **Decarbonising the steel sector is vital to a thriving, sustainable, and circular EU economy**.
- A **European partnership** offers a wide range of opportunities:
  - Achievement of an EU climate-neutral steel production;
  - Export of low-carbon steel making technologies to external markets;
  - Less dependence on fossil energy and feedstock;
  - Securing of the EU strategic industry's value chains;
  - Know-how spill-overs to other industries;
  - Smart use of resources and realisation of a circular economy model.

Vision – R&D&I issues and the need for partnership



Source: EUROFER calculations, based on Eurostat data

- Efforts made so far, for **decreasing energy and CO_2 intensity of steel production**, need to be stepped up and integrated into a single-minded and coherent framework, which can be better managed via a partnership.

- **A partnership is needed** to ensure that available technologies are deployed by overcoming the following barriers to R&D&I investments:
  - **Key bottlenecks**: the transition from pilot phase to industrial-scale deployment, long investment cycle, high capital intensity and competitive global market;
  - The '**funding gap**' between research and deployment of technologies calling for significant support of the public sector;
  - External and wider industry factors: requirement of zero-carbon electricity and hydrogen, availability of geological storage of CO_2, carbon leakage outside the EU.

Vision – R&D&I General Strategy

Achieve significant reductions of CO_2 emissions in the steel industry with **two general technological pathways** for decarbonization:

- **Carbon Direct Avoidance (CDA),** covering technologies to avoid emitting carbon during steelmaking.

- **Smart Carbon Usage (SCU),** consisting of ways to use the carbon from steel production for other applications, via carbon capture, utilisation, and storage (CCUS) and process integration (PI).

Overarching these two general pathways are **Circular Economy (CE)** projects, working for example on the recycling of steel, the usage or recycling of residues, and resource efficiency.

	Circular Economy Enhancing the recycling of steel (e.g. scrap in BOF/EAF*) and its by-products, Resource efficiency *BOF= Basic Oxygen Furnace EAF= Electric Arc Furnace			
Pathways/ Groups	**Smart Carbon Usage (SCU)** Process Integration with reduced use of carbon (+CCS)	**Smart Carbon Usage (SCU)** Carbon Valorisation/ Carbon Capture and Usage (CCU) (+CCS)	**Carbon Direct Avoidance (CDA)** Hydrogen	**Carbon Direct Avoidance (CDA)** Electricity
Description	Integration of process steps and internal use of process gases	Using CO/CO2 from steel mill as raw material (Chemical conversion of CO/CO2)	Use of renewable electricity in basic steelmaking, e.g. production of H2 to replace carbon	

Vision - Ambitions

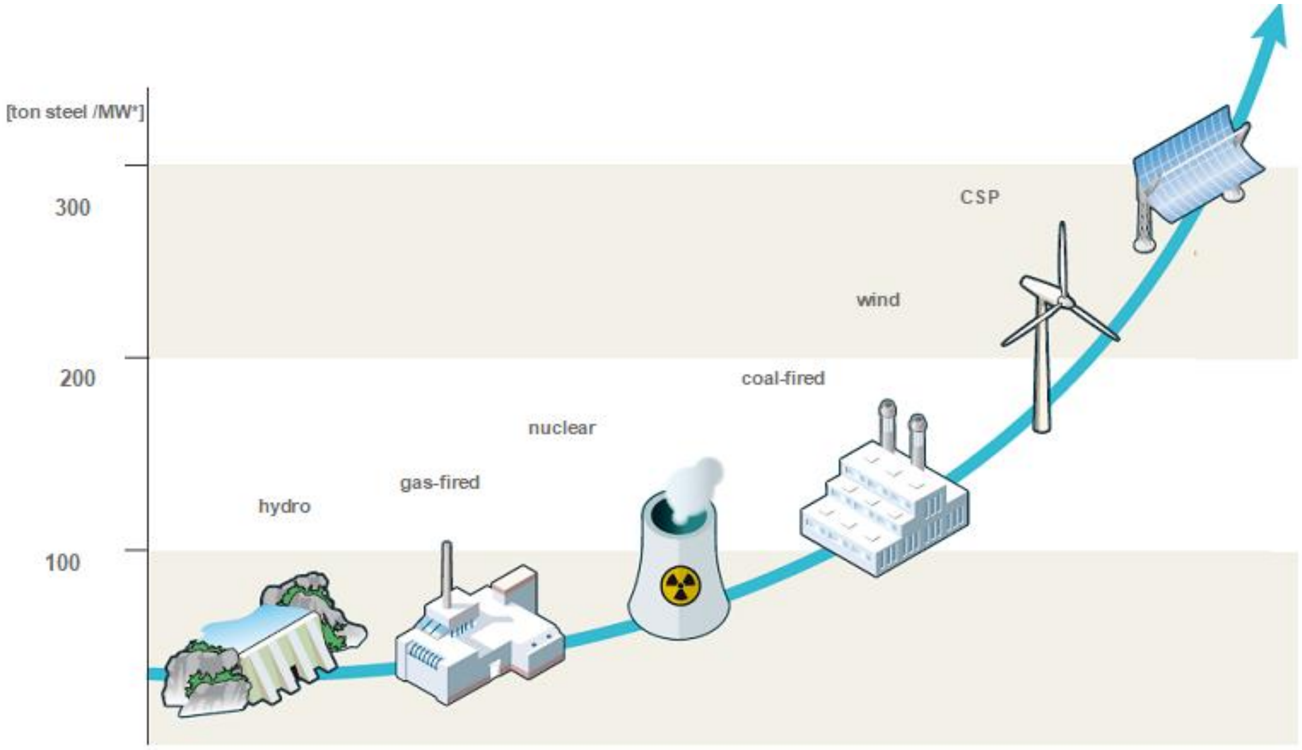
The Clean Steel Partnership

Long-term vision for CO_2 emissions reductions compared to 1990 levels:

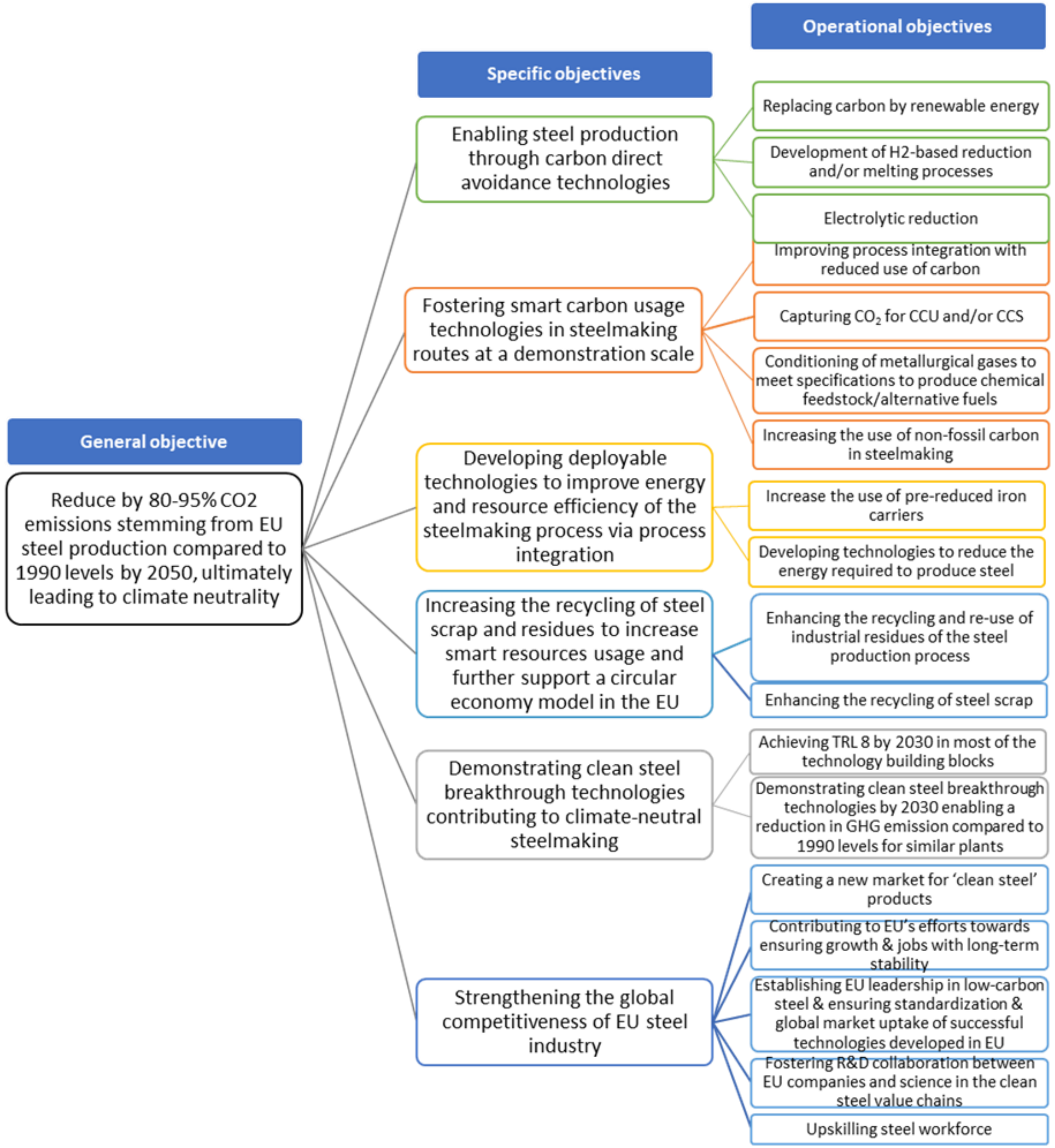
- Develop technologies reducing CO_2 emissions from steel production by 50% by 2030 compared to 1990 levels; and
- Reduce CO_2 emission by 80-95% by 2050 compared to 1990 levels, ultimately achieving climate neutrality.

Immediate and intermediate ambitions consist of piloting and demonstrating breakthrough technologies that can significantly reduce the impact of steel production on the climate footprint.

The achievement of sustainable growth will depend largely on the EU spearheading global efforts on **renewable energy**. Steel is an essential material in modern energy solutions, which is why clean steel will be instrumental to reach this common vision.



Vision - Objectives



General objective of the Partnership

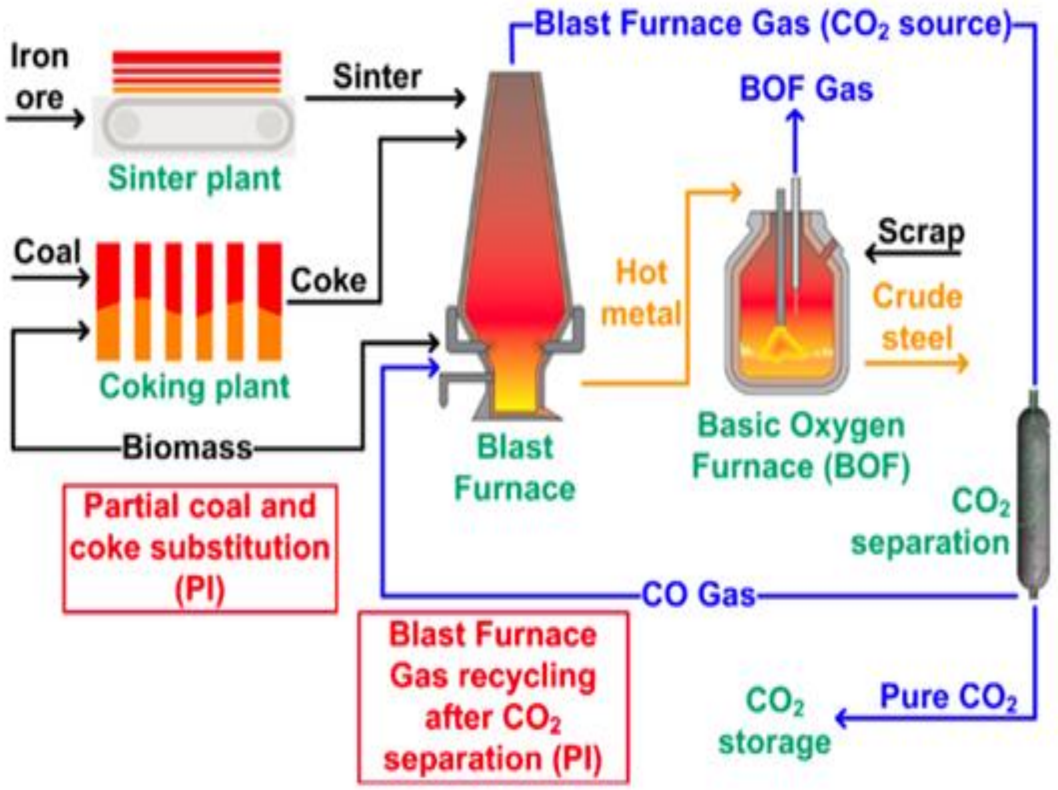
- develop technologies at TRL8 to **reduce CO_2 emissions stemming from EU steel production by 80-95% compared to 1990 levels by 2050**, ultimately leading to climate neutrality.
- **preserving the competitiveness and viability of the EU steel industry** – both for BF-BOF and EAF routes and including the wider steel value chain
- making sure that EU production will be able to meet the **growing EU demand for steel** products.

The Clean Steel Partnership has set **specific and operational objectives** that are to be **achieved in 7 to 10 years**.
This timeframe is **determined in accordance with the framework of the Horizon Europe Programme**, which runs from 2021 to 2027.

Carbon Direct Avoidance (CDA)

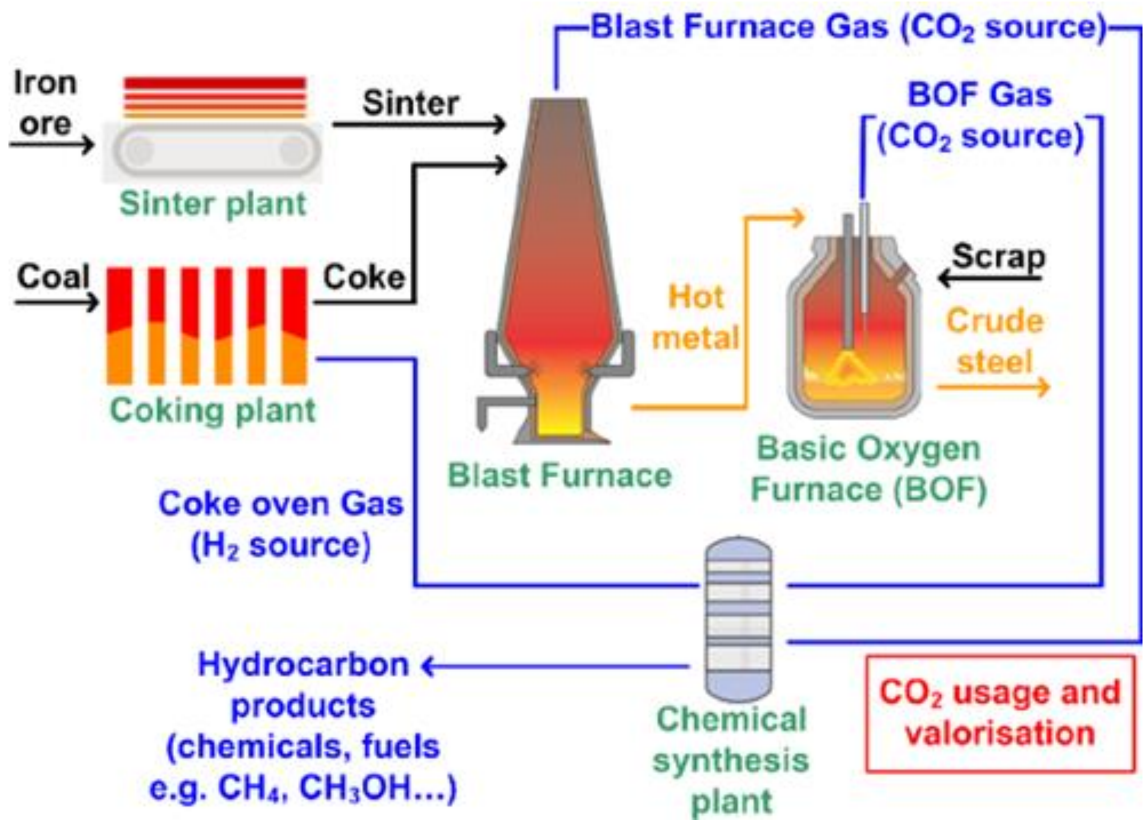
- CDA includes technologies that **avoid carbon emissions during steelmaking**.
- CDA mainly relies on steel production processes based on **hydrogen and green electricity**.
  - Carbonaceous sources can be switched to green hydrogen-based sources.
  - The Blast Furnace (BF)- Basic Oxygen Furnace (BOF) route can be substituted by the **Electric Arc Furnace (EAF) route** for crude steel production and contribute to CDA.
  - Hydrogen can be produced via water electrolysis powered by **green electricity**.
  - **Green hydrogen** is then used to reduce iron ore in a **Direct Reduction (DR)** shaft
  - Direct use of green electricity for ore reduction: **iron ore electrolysis**.

Smart Carbon Usage(SCU) via Process Integration(PI)



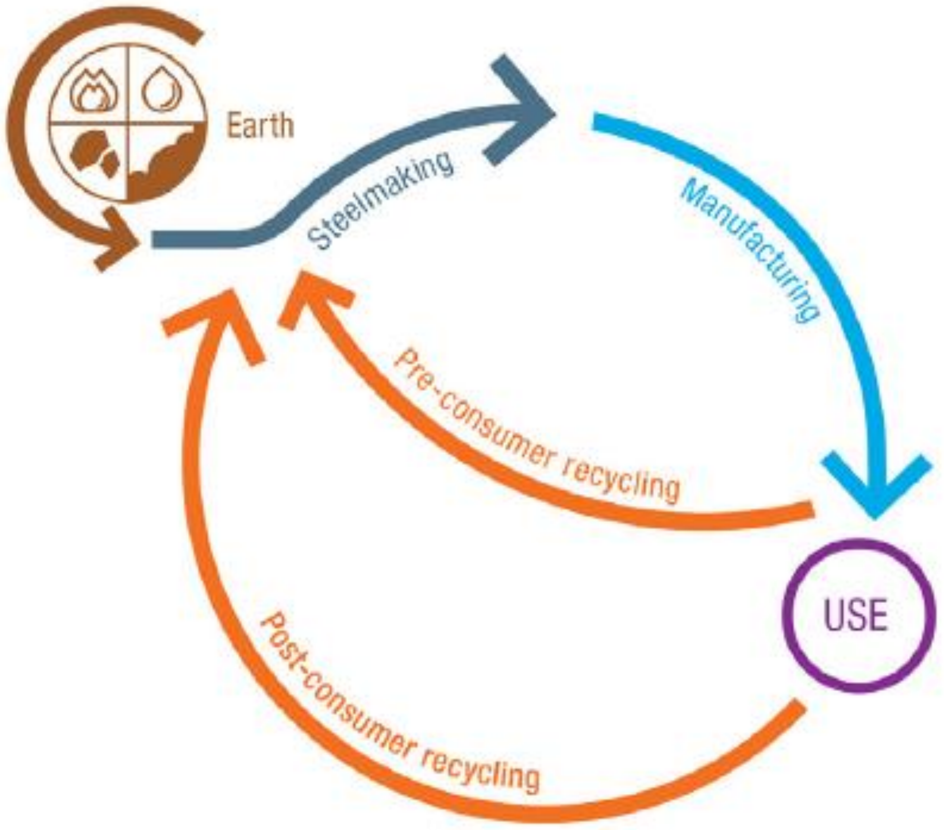
- SCU-PI allows **reducing fossil fuel** (coal, natural gas, etc.) used in both BF-BOF and EAF steel production and, in turn, **curtailing CO_2 emissions** generated by the steel industry.
- Several technology options may contribute to the SCU-PI in conventional steel plants
  - **replacement of coal by natural gas , biogas, biomass , hydrogen, or electricity,**
  - **increase of the scrap/hot metal ratio,**
  - **replacement of iron ore or scrap by available hot briquetted/direct reduced iron,**
  - **advanced management of the energy streams and process gases (e.g. off gases released from EAF/BF-BOF)**.
- Various solutions are possible for SCU-PI in BF-BOF plants
  - **recycling of CO** recovered from Blast Furnace gas back into the Blast Furnace for metallurgical use

Smart Carbon Usage(SCU) via carbon capture, utilisation and storage (CCUS)



- SCU--CCUS encompasses technologies that help avoid carbon emissions to the atmosphere.
  - **options for utilising the CO and CO_2 in steel plant gases or fumes as raw material** for the production of/integration into valuable products.
  - **production of fuels or base chemicals from steel mill gases**. CO2 originates from the BF and the BOF gases and hydrogen from coke oven gas can be used for **hydrocarbon production**, through a chemical hydrocarbon synthesis process. The final products can be chemicals and fuels that can be used by other industries.

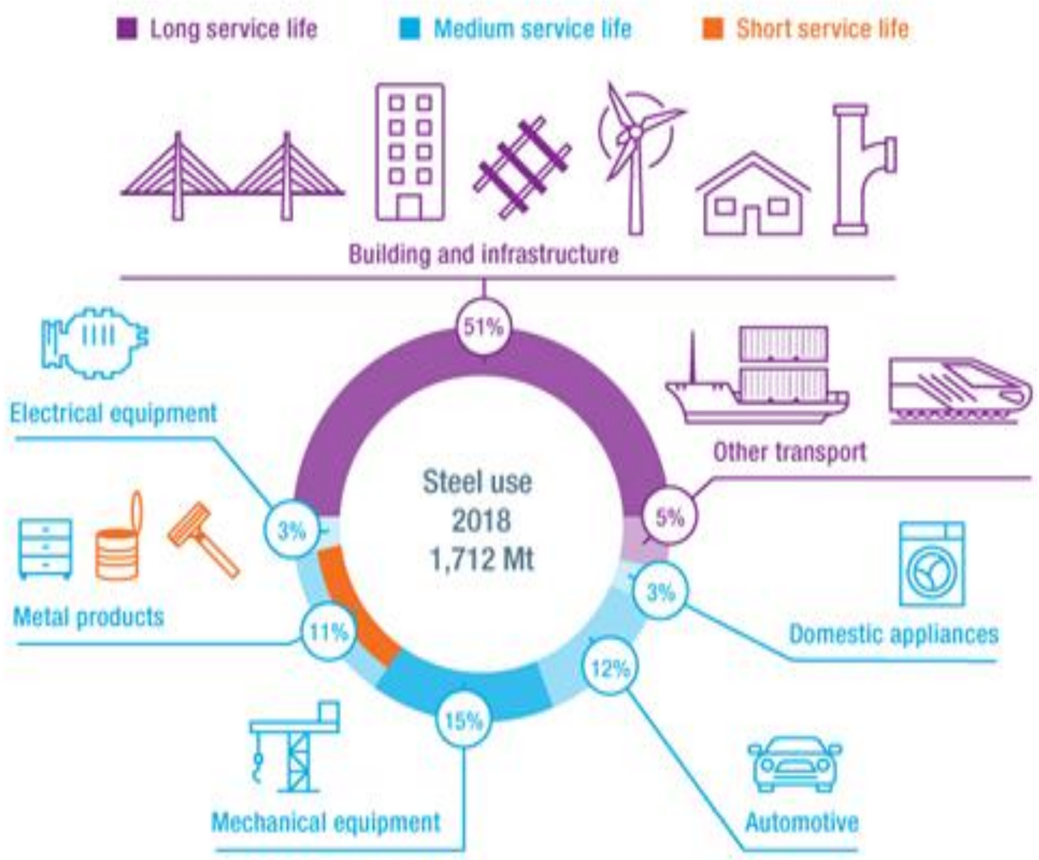
Circular Economy (CE)



Circular Economy (CE)

- enhance the recycling of steel (e.g. scrap in BOF/EAF and residues) and resource efficiency.
- **scrap utilisation through scrap sorting and improved removal of scrap pollution** with new detecting technologies
- **utilisation of all residues from steel production internally or in other sectors** like dust in the non-ferrous sector or slags in the cement sector.
- substitution of fossil materials with **alternative carbon-bearing materials and alternative reductants** (e.g. biomass , plastic, rubber, syngas from wastes)
- technologies that identify and **make use of waste heat sources**.
- Mitigating water scarcity through **water efficiency and recirculation**

Combinations – Drivers,enablers & support actions



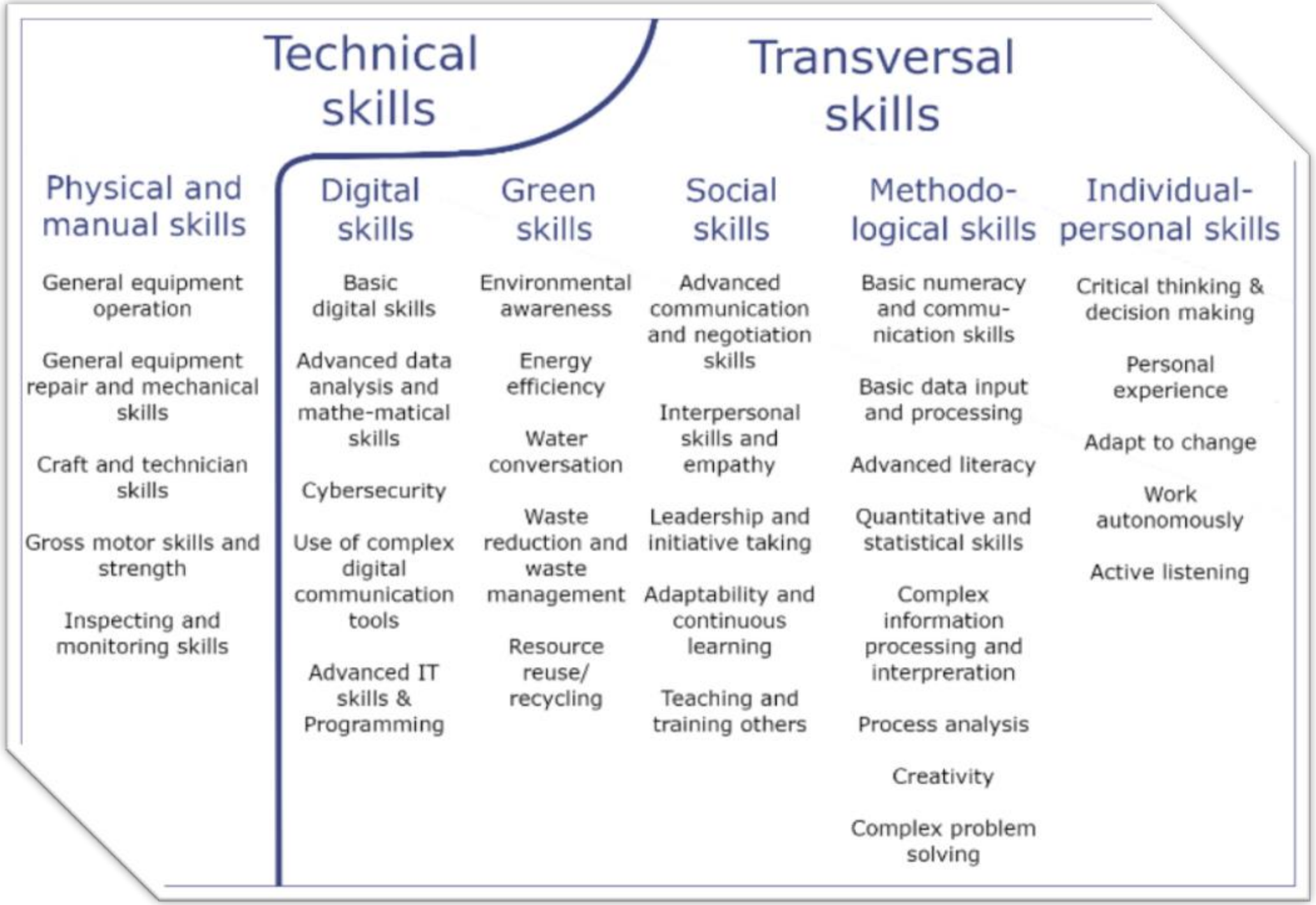
Combinations of technologies

- **bringing together, coordinating, and making the most of different solutions and technologies**.
- **combination of different technologies** has the full potential to generate larger CO2 reduction than any single pathway or technology.

Drivers, enablers and support actions

- **integration of the latest technologies such as artificial intelligence and digital solutions into the industrial production**.
- **synergies with EU and national programmes** that enable the **upskilling of the steel workforce**
- fostering R&D&I **collaboration** between EU companies participating in the clean steel value chain
- **creation of a new market for clean steel products**, the **uptake of successful technology** developed in the EU and, more generally, the **global competitiveness of the EU steel industry**.

A large scale of skills categories are involved



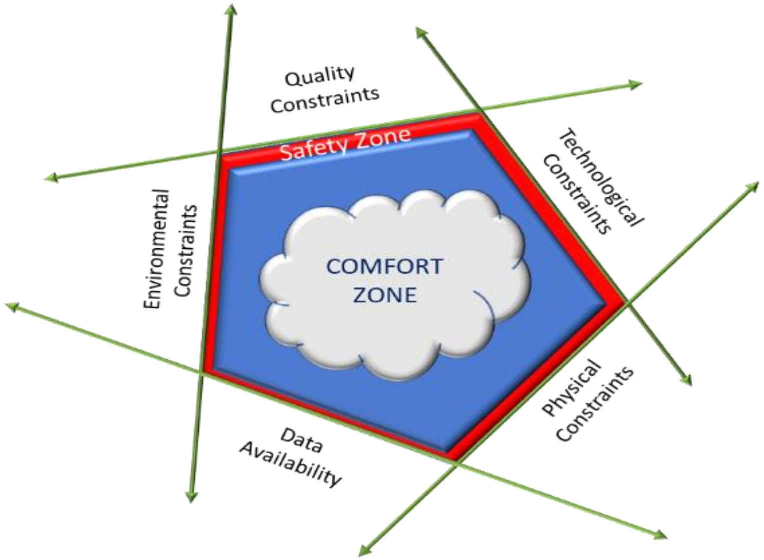
Source : ESSA Blueprint

The Clean Steel Partnership’s mission is a steel industry driven **proactive adjustment of the future skills** based on demands developed by the industry and for the industry.

The **main objectives** are :

- Proactive skills adjustments.
- New training and curricula requirements.
- Political support measures.
- Successful sectoral upskilling schemes.
- Efficient management of knowledge.
- Improve recruitment and retention.
- Design of a digitalisation plan for supporting effectiveness and quality of training and learning

Digitalisation is a major driver and a mandatory step

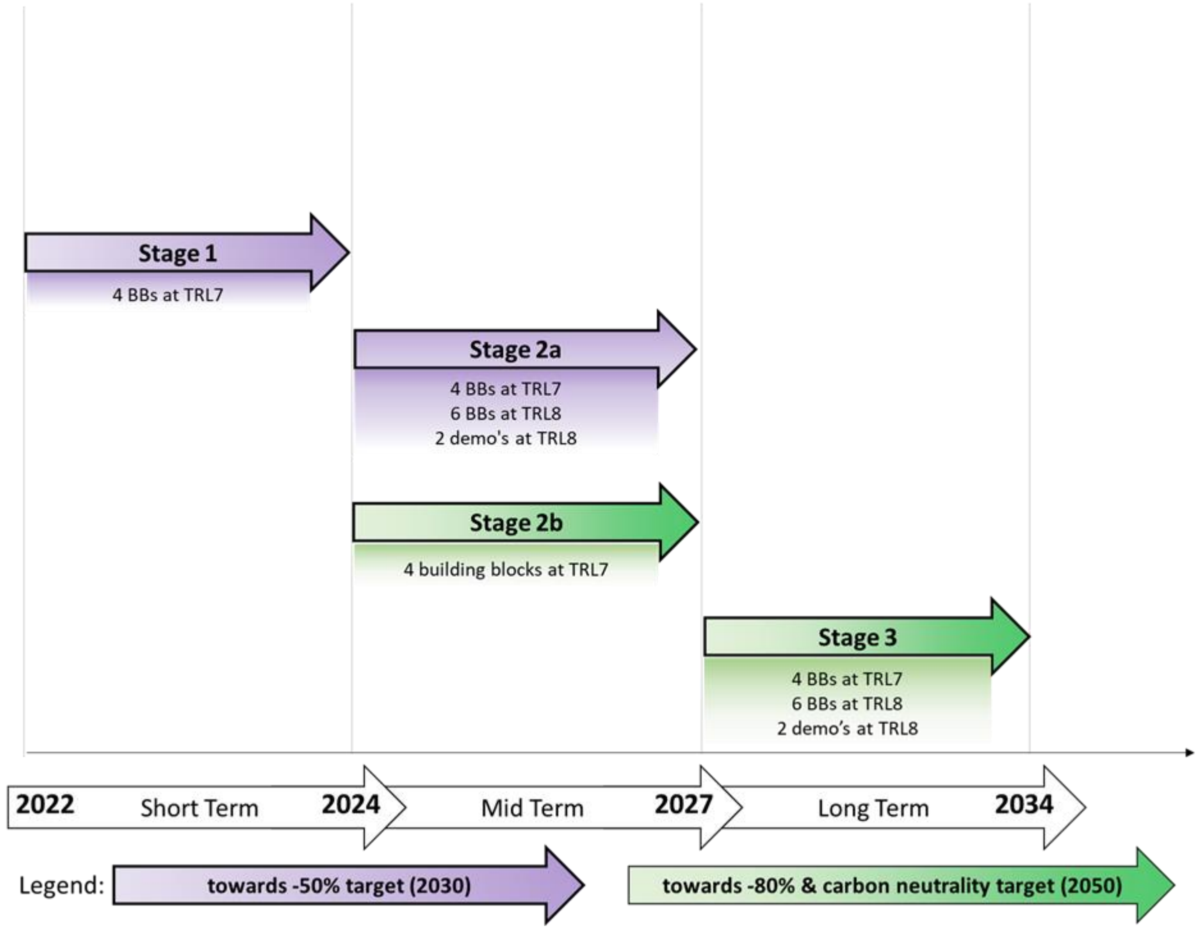


Digitalisation represents a major driver and a mandatory step for Sustainable Manufacturing for both societal and industrial point of view with its high **potential of decarbonisation forecasted to be in the range of 20%** .

The steel industry being an energy-intensive sector and, at the same time, **an automation-intensive** sector, there is a general agreement on foreseeing the continuation of such growing trend in the future because the effective and efficient transition needs monitoring, controlling and optimally managing manufacturing processes to ensuring the balanced environmental footprint and sustainability in general.

The disruptive role of **Artificial Intelligence** and **Machine Learning** supported by its infrastructural technologies of **Cloud Services** and **Internet of Things** (IoT) becomes evident by 2030. A **comfort zone** will be created within constraints for quality, technology, physical environment, and data availability

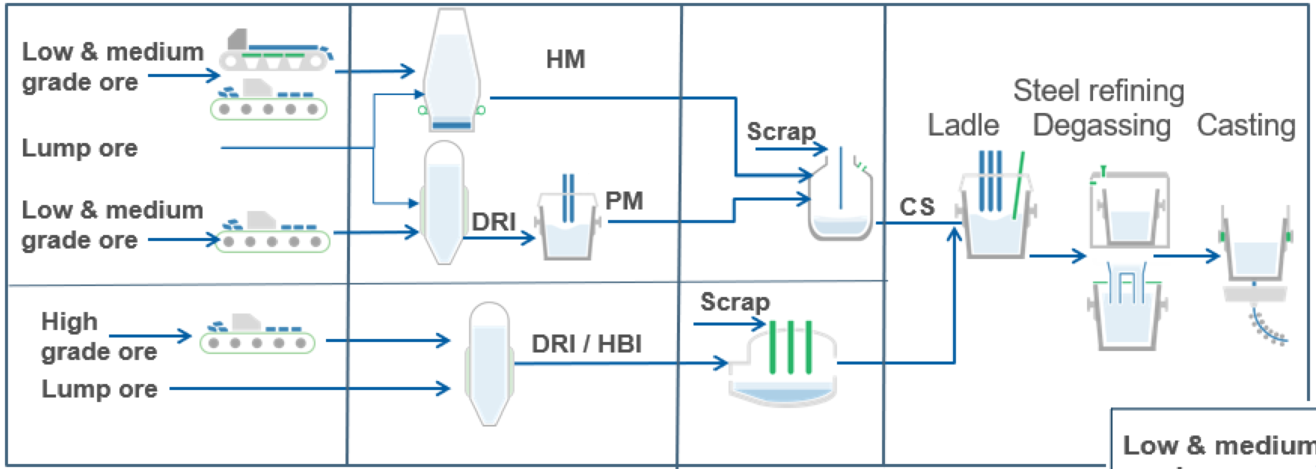
Timeline – Multistage approach



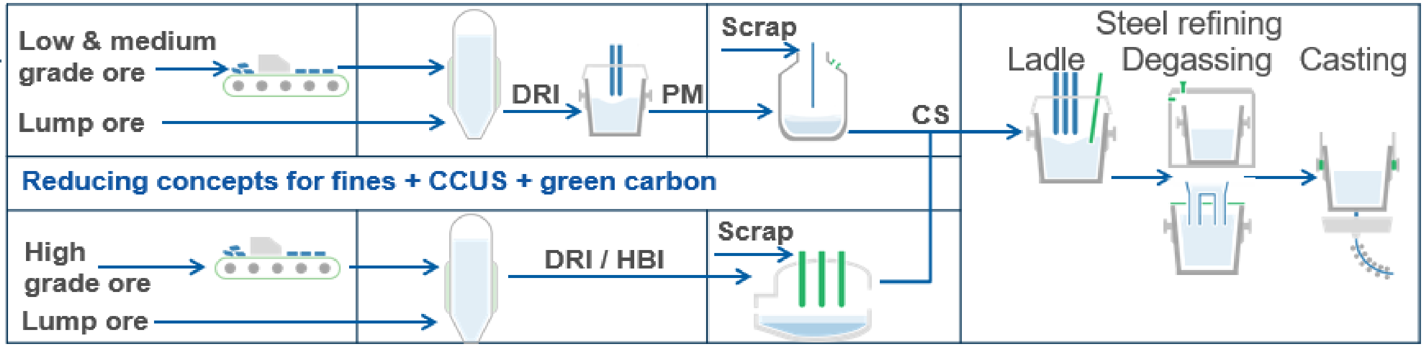
- **High capital intensity, long payback periods and investment cycles between 20 and 30 years** are major obstacles to accelerate carbon mitigation in the steel industry.
- The Clean Steel Partnership proposes a **three-stage approach** to address these challenges by dividing the investments into different phases and allow for a smooth transition towards clean steelmaking in the EU.
  - **Stage 1** (short- to medium-term impact measures) targets projects that generate ‘immediate’ CO_2 reduction opportunities
  - **Stage 2** (medium-term impact measures) focuses on those projects that may not be implemented ‘immediately’ in the installed base, but allow for a quick migration (evolution) towards improved processes.
  - **Stage 3** (medium- to long-term impact measures) looks at those projects that can ‘revolutionise’ the steel industry

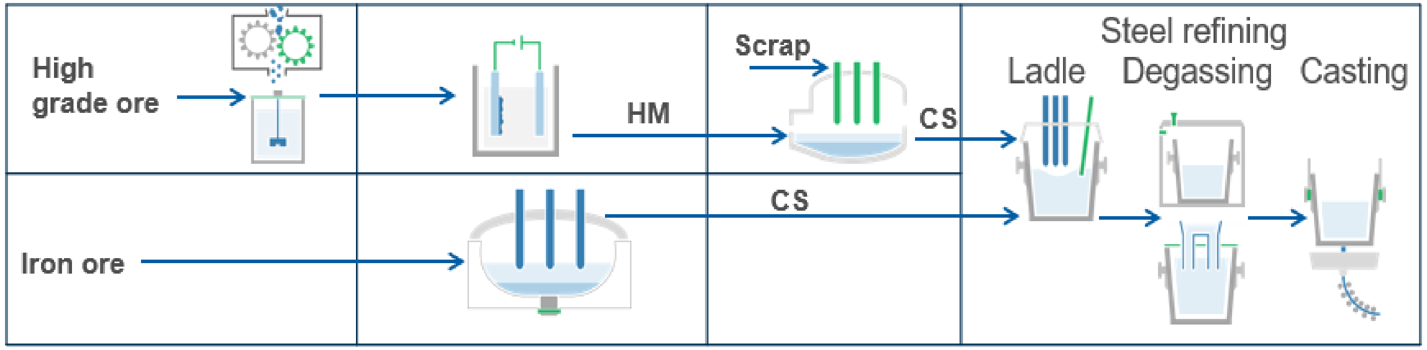
Co-existence of traditional and breakthrough technologies

Near term (2030) Mid term (2040) Long term (2050)



New technologies like **direct reduction of iron and iron electrolysis** will gradually replace existing technologies in parts of the production process

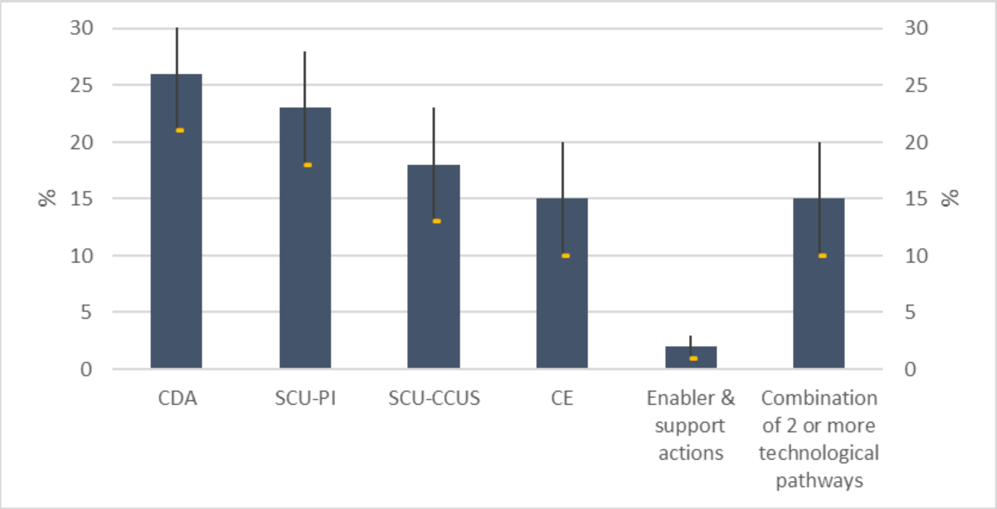




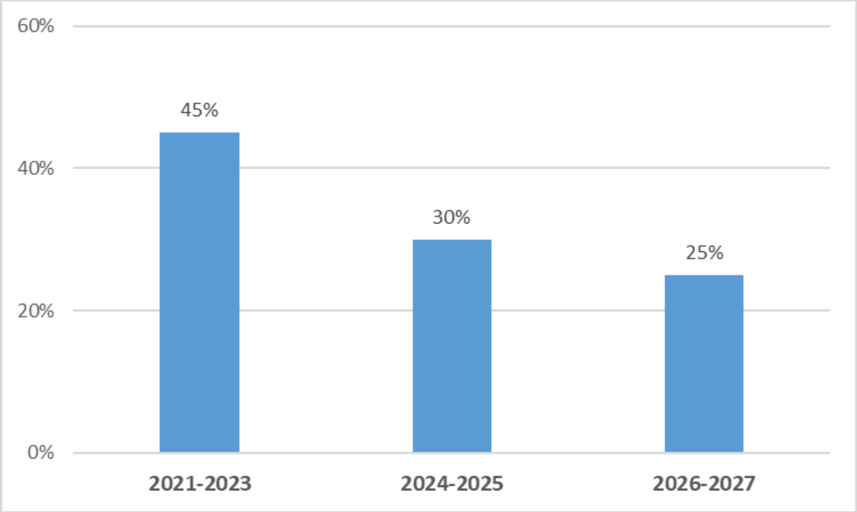
Sinter plant
Pellet plant
Blast furnace (BF)
Direct reduction (DR) plant
Basic Oxygen Furnace (BOF)
Electric Arc Furnace (EAF)
Electric Smelter (Submerged Arc Furnace)
Grinding
Leaching
Iron electrolysis
Molten oxide electrolysis

HM Hot Metal
DRI Direct Reduced Iron
PM Pre Melt
CS Crude Steel
HBI Hot Briquetted Iron
CCUS Carbon, Capture, Utilization and Storage

Budget



Budget split over areas of intervention (%)



Budget split over groups of years (%)

- **Total resource requirement is estimated at around EUR 3 billion during 2021-2030,** followed up by a multiple of these resources, to ensure that the technologies are deployed and rolled out.
- Collaboration among steel producers is expected to bring reasonable **synergies** compared to the company by company approach, reducing **the investment need to approximately EUR 2.55 billion**.
- The collective investments needed from the public and private side for the **period 2021-27, is estimated at EUR 2 billion.**
- The remaining **EUR 0.55 billion** will be allocated to the period 2028-30, during which projects will still be completed.
- The expected investments to be managed within the **scope** of the Clean Steel Partnership are worth **around EUR 1.4 billion** during 2021-27.
- Major private funding would match public funding from the Union, such as **Horizon Europe and the Research Fund for Coal and Steel and from other EU funded programmes and the Member States**

EU Clean Steel Partnership - Characteristics

- Partnership in the frame of Horizon Europe (HEU) in 2021 to 2027/2030
  - Unique setting due to synergies of public financial pillars (HEU + **R**esearch **F**und **C**oal+**S**teel)
  - Memorandum of Understanding signed by ESTEP + European Commission (RTD+Grow)

- CSP-Budget: € 1.4 billion
  - €350 million from Horizon Europe
  - €350 million from assets of the ECSC* in Liquidation (source of RFCS funding)
  - At least matched by steel sector (expected €1.000 million)

- Projects
  - size: € 10-100 million
  - Developments starting at TRL 6 to end up with TRL 8 (Technology Readiness Level)
    exceptional start at 5 to end up with at least TRL 7
  - 2 + 2 demonstrators showing CO_2 emission reduction potential of at least 50% (80%)

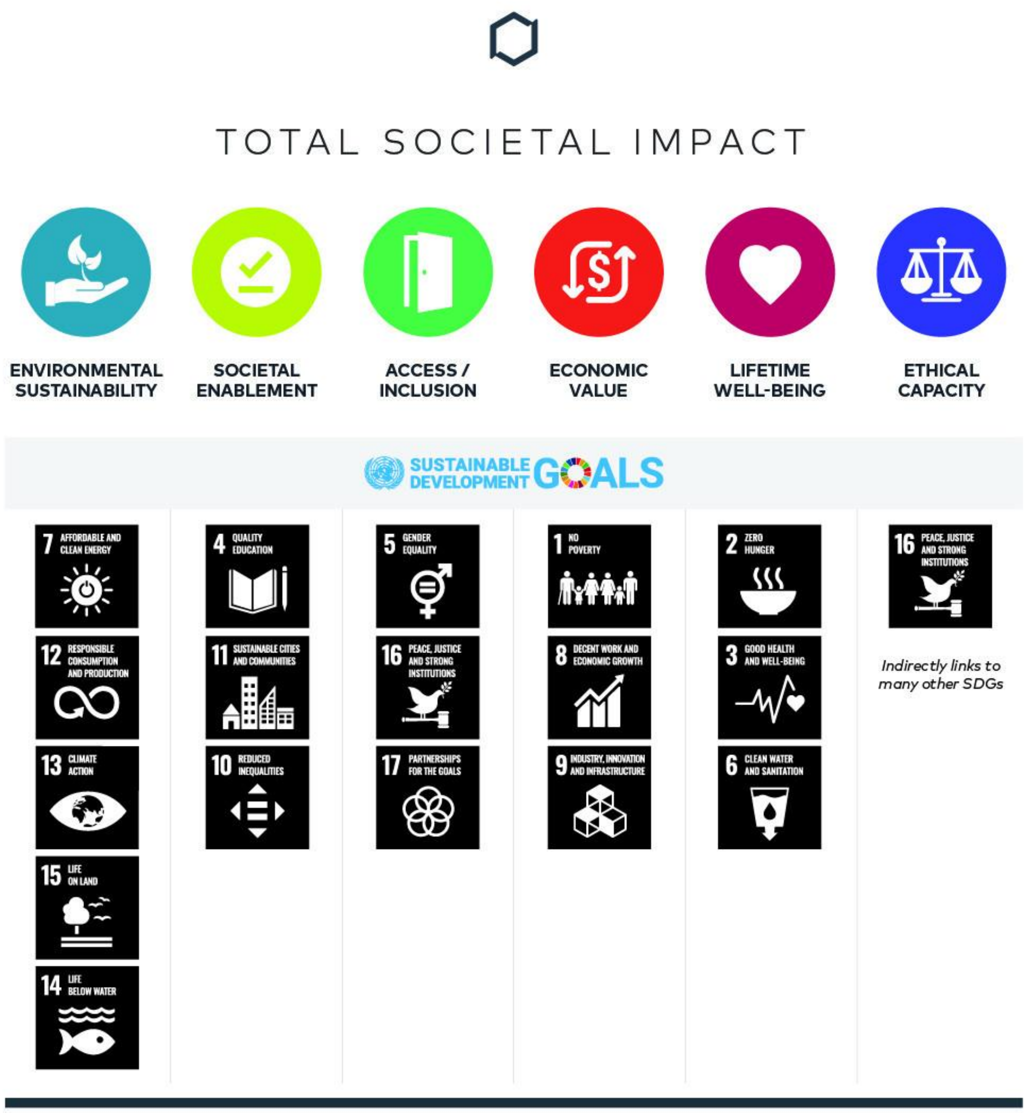
- CSP actions aligned with Areas of Intervention
  - Carbon Direct Avoidance (CDA)
  - Smart Carbon Usage (SCU)
  - Circular Economy
  - Enablers: Digitisation and Social Innovation

basket of technologies

*ESCS: European Coal and Steel Community

Impacts on industry and society

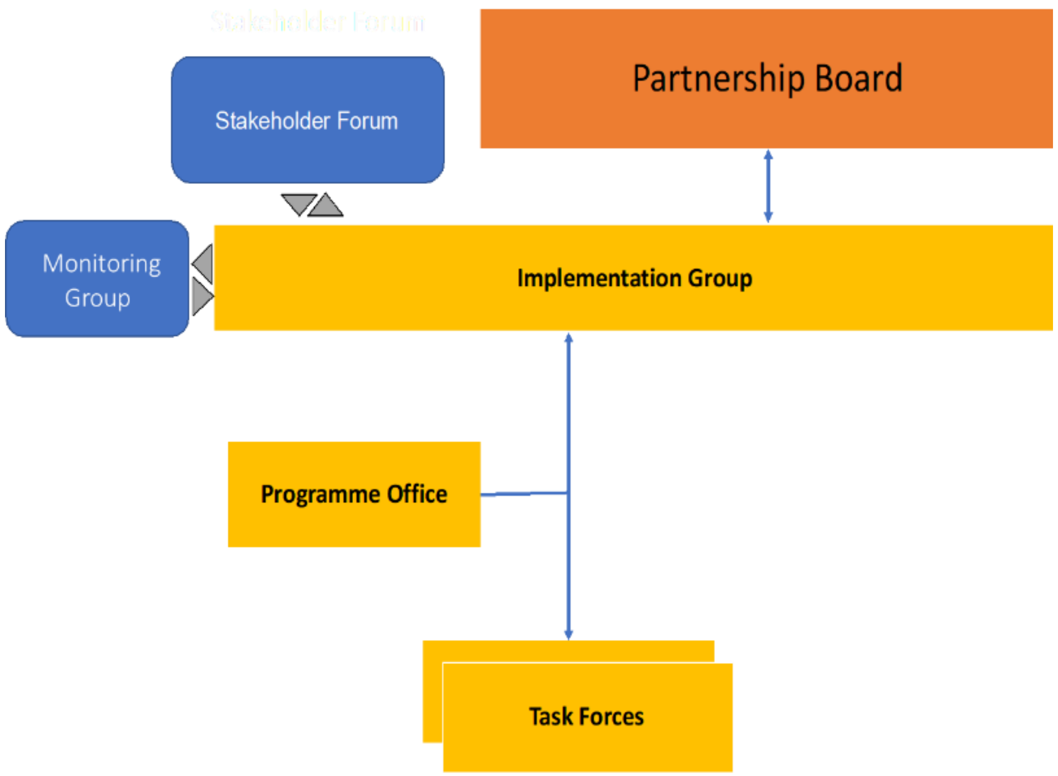
- The objectives and impacts of the Partnership are in line with **the pathways of Horizon Europe**
- Contribute to **the Sustainable Development Goals** 3, 8, 9, 12 and 13 under the United Nation's 2030 Agenda
- Impacts in various areas, such as:
  - **CO_2 reduction**: new technologies will be deployed that could reduce emissions from EU steel production by 50% by 2030, compared to 1990 levels;
  - **Industry and EU competitiveness**: The support for the deployment of the decarbonisation technologies will allow the **EU to remain a global leader** in the steel industry and to reinforce its knowledge-based competitive advantage;
  - **Resource efficiency**: coordination of technological progress in the use of steel scrap and by-products, leading to an enhanced, larger use of those resources;
  - **Jobs and skills**: the Partnership will support the preservation of high-quality jobs in the steel making value chain.



EU added value and additionality of the Partnership

- The EU added value of the Partnership is obtained through a **coordinated approach across stakeholders, technologies, production routes, and Member States**; leverage of private investments; timely and well-planned intervention and clear exit strategy to phase out from public support for R&D&I.
- The Partnership can generate other forms of additionality by **cross-fertilising** both suppliers and customers and collaborating with other Partnerships and research programmes under Horizon Europe.
- The Partnership will **contribute to R&D&I Missions of Horizon Europe** on climate-neutral and smart cities; soil health and food; and on adaptation to climate change including social transformation.
- **Spill-overs** in other value chains and industries will be generated via clean steel as input and by trickling know-how down the value chain.

Governance model



- The ‘**Partnership Board**’ (including representatives from both the public and private side) discuss and approve the periodic Work Programmes and ensure compliance with the vision, ambition, objectives, and research programme laid down in the multiannual Roadmap.
- The ‘**Implementation Group**’ is the general assembly of the Partnership. It discusses the technical needs and research progress, identify the R&D&I needs, discuss and propose the Work Programmes to the ‘Partnership Board’, coordinate revisions to the Roadmap, and share conclusions with Task Forces.
  - The ‘**Monitoring Group**’ advises on improvements on the current research development.
  - The ‘**Stakeholder Forum**’ provides feedback on potential revisions to the multiannual Roadmap and on the social and environmental impacts of activities under the Partnership.
- The ‘**Task Forces**’ define future short- to mid-term R&D&I needs related to the different technological pathways and propose the content of the periodic Work Programmes to the Implementation Group.
- The ‘**Programme Office**’ supports coordination and communication activities, measures and reports on KPIs, organises events and promotes the Partnership.

Openness and transparency

- The decarbonisation of the steel industry requires a **coordinated approach across all countries, technologies, and steel plants**. The impact of the Partnership will be maximised by **involving all relevant stakeholders** and **remaining open to new partners.**
- ESTEP and the Clean Steel Partnership **are open to the entire European steel value chain community**, i.e. to all EU based steel stakeholders comprising steel producers, steel processors, customers, suppliers, plant builders, research and academia, and civil society representatives.

Monitoring and assessing progress

PARTNERSHIP'S KEY PERFORMANCE INDICATORS

KPI NAME	UNIT OF MEASUREMENT	BASELINE	TARGET 2023	TARGET 2025	TARGET 2027	AMBITION >2027
RESOURCES (INPUT), PROCESSES AND ACTIVITIES						
Steel industry involvement – financial	% of project budget to steel producers (average)	new	>50 %	>50 %	>50 %	N/A
Steel industry involvement – inclusiveness	% of CO_2 represented by CSP project partners[1]	new	>50 %	>60 %	>85 %	>95 %
R&D collaboration science-EU steel companies	# external research stays funded by the Partnership	new	N/A	>5 in 4 technology fields	N/A	>10 in 3 technology fields
Joint calls with other partnerships	# joint calls	new	N/A	Min 2	N/A	Min 5
OUTCOMES						
Energy use per tonne	%	TBD	N/A	-5 % at TRL7	N/A	-10 % at TRL8
CO_2 capture for CCU/CCS	% capture rate	TBD	N/A	90% at TRL 6	N/A	95 % at TRL 8
Scrap recycling	% low quality scrap input share	TBD	N/A	+25 % at TRL 6	N/A	+50 % at TRL8
Breakthrough in technology building blocks	% projects TRL7	TBD	N/A	Min. 50 %	N/A	Min. 85 % (Min. 75 % TRL8)
Upskilled labour force	# dedicated programmes	0	N/A	Min. 1	N/A	Min. 3
IMPACTS						
EU market share clean steel products	% of clean steel out of total EU steel demand	N/A	N/A	Acceptance of definition of clean steel and its products	TBD	Start of roll-out of clean steel and its products
Global market share EU technology providers	% growth	2020	N/A	+5 %	N/A	+10 %
Gross Added Value clean steel production	% growth	2020	N/A	+1 %	N/A	+2 % in 2030
CO_2 emission reduction	t CO_2e / t CO_2e_1990	1990	N/A	N/A	N/A	-55 % in 2030

[1] This % indicates the share of CO_2 from CSP project partners in the overall CO_2 emissions of the steel industry in the EU

- A range of **Key Performance Indicators (KPIs)** has been developed to monitor and assess the progress of the Partnership's specific and operational objectives. Each KPIs is accompanied by targets

- Within each KPIs, **deployment and TRL of the technology** is the most important indicator to measure whether the introduced innovations generate their expected impacts

- Analysis of granted CSP projects in the framework of the Horizon Europe and RFCS calls 2021-22 shows a good contribution of the proposed technologies

Next Steps

- SRIA provides **guideline for future call topics** of CSP
- **Update of SRIA** by end of 2023 - beginning of 2024
  - Joint effort of CSP members
  - Involvement of CSP stakeholders
- Contribution to **conferences and events**
- **Publications**