SESSION 1: 9:00–9:10

ESTEP
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ESTEP workshop

SecCarb4Steel

Preparation and use of biogenic and non-biogenic secondary carbon carriers (SCC) in processes for iron and steelmaking

Analyzing the green hydrogen to green steel transition through the sustainability triple helix lens: reflections upon HYDRA (IT06) IPCEI

Pietro Gimondo[1], Filippo Cirilli[1], Alice Reina[1], Simona Pace[1], Antonietta Megaro[1]

[1] RINA-CSM

HYDRA Project

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HYDRA

An experimental platform to support EU steel industry decarbonization and the value chain improvement

HYDRA aims to develop an **industrial living platform** in which **develop, qualify and validate** the use of **hydrogen in the Hard to Abate industry** in order to support and boost the decarbonization process in the steel sector.

Funded by the European Union
NextGenerationEU

4 Work Packages:

- **WP1:** testing and qualification of materials and components interacting with hydrogen
- **WP2:** innovative process for the production of pre-reduced products using up to 100% hydrogen
- **WP3:** production of steel in electric arc furnace (EAF) with pre-reduced iron ore manufactured by direct reduction by hydrogen
- **WP4:** use of hydrogen in furnaces

HYDRA WP1: testing, qualification & training HUB

A permanent international research and development platform open to all stakeholders in the steel and energy industries

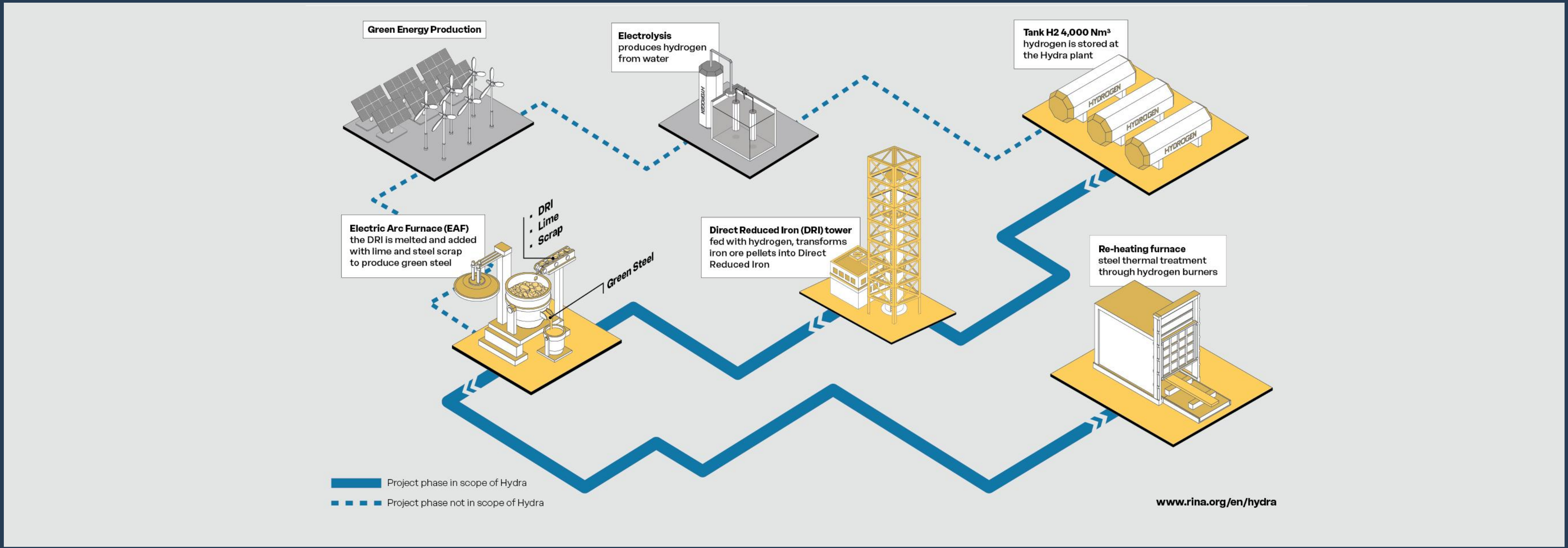
Testing and **qualification hub** For **hydrogen transportation** and **storage,** to support the transition to **100% hydrogen fueled steel production**

Training centre

Scheduled for completion by H1 2025

HYDRA project: WP2 & WP3

HYDRA WP2/WP3: experimental platform - DRI + EAF



The structure, scheduled for completion by 2025, will consist of a Direct Iron ore Reduction (**DRI**) tower using hydrogen as a reducing agent, an electric furnace (**EAF**) and burners development for reheating **furnaces**, integrating pilot activities with full scale industrial tests

HYDRA project: WP4

HYDRA WP4: application of hydrogen in hard to abate

Burners testing and development campaign at **pilot combustion station** and **descaling testing**

Product quality test **with different steel grades**, simulating natural gas and hydrogen combustion atmosphere

Burners test at industrial premises and new refractory materials

Definition of the best conditions for industrial process implementation by 2024

Potentialities of the experimental facility

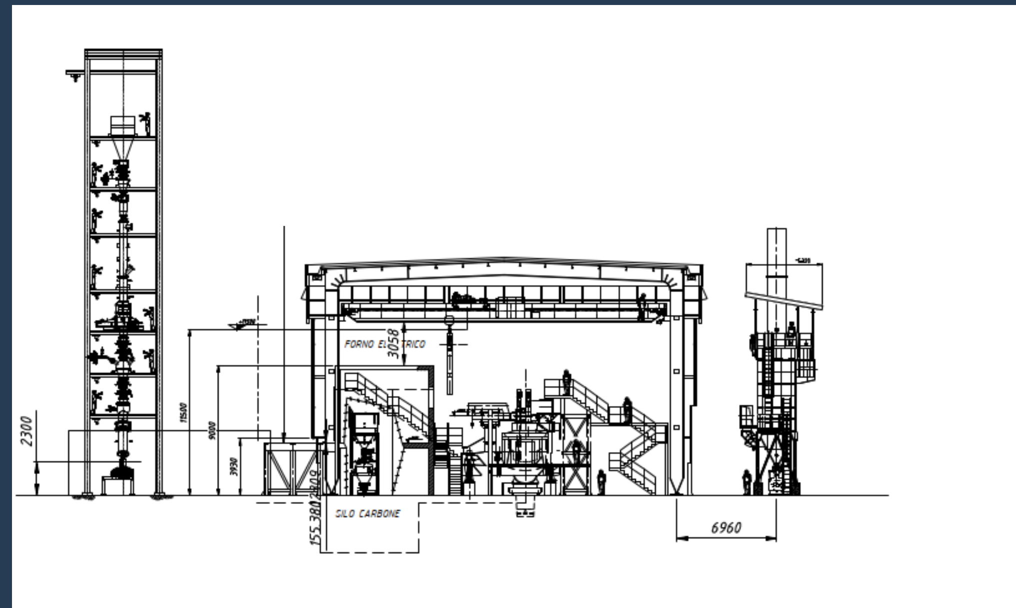
Plant potentialities

Direct Reduction Pilot Plant

- Test with pellets of different quality
- H2 / CH4 switch
- Process kinetic and efficiency
- Metallization degree (>94% expected)
- Process energy demand as function of operating practices
- Advanced training hub

Electric Arc Furnace (EAF) plant

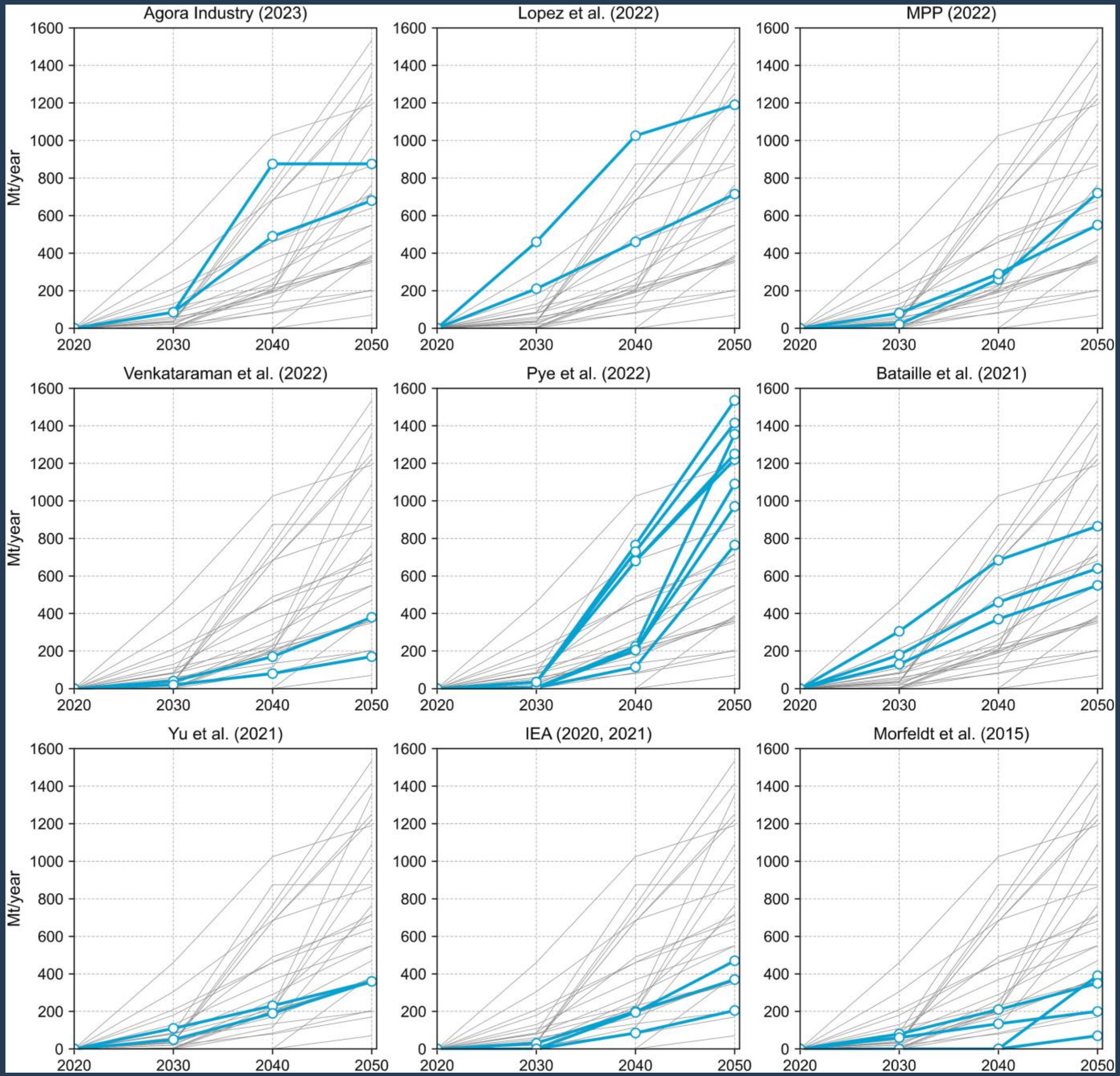
- Test with DRI at different C percentage
- H2 Burning
- DRI quality and different Slagging practice
- Slag foaming
- Secondary carbon carriers injection to replace coal
- Process energy demand as function of operating practices
- Advanced training hub



Moreover, the site of Castel Romano is equipped witrh laboratories for R&D activities to support with basic studies the pilot plants utilization

Secondary carbon carriers in HYDRA Project

Green hydrogen is not perceived as a short-term solution



Source: Watari, T., & McLellan, B. (2024)

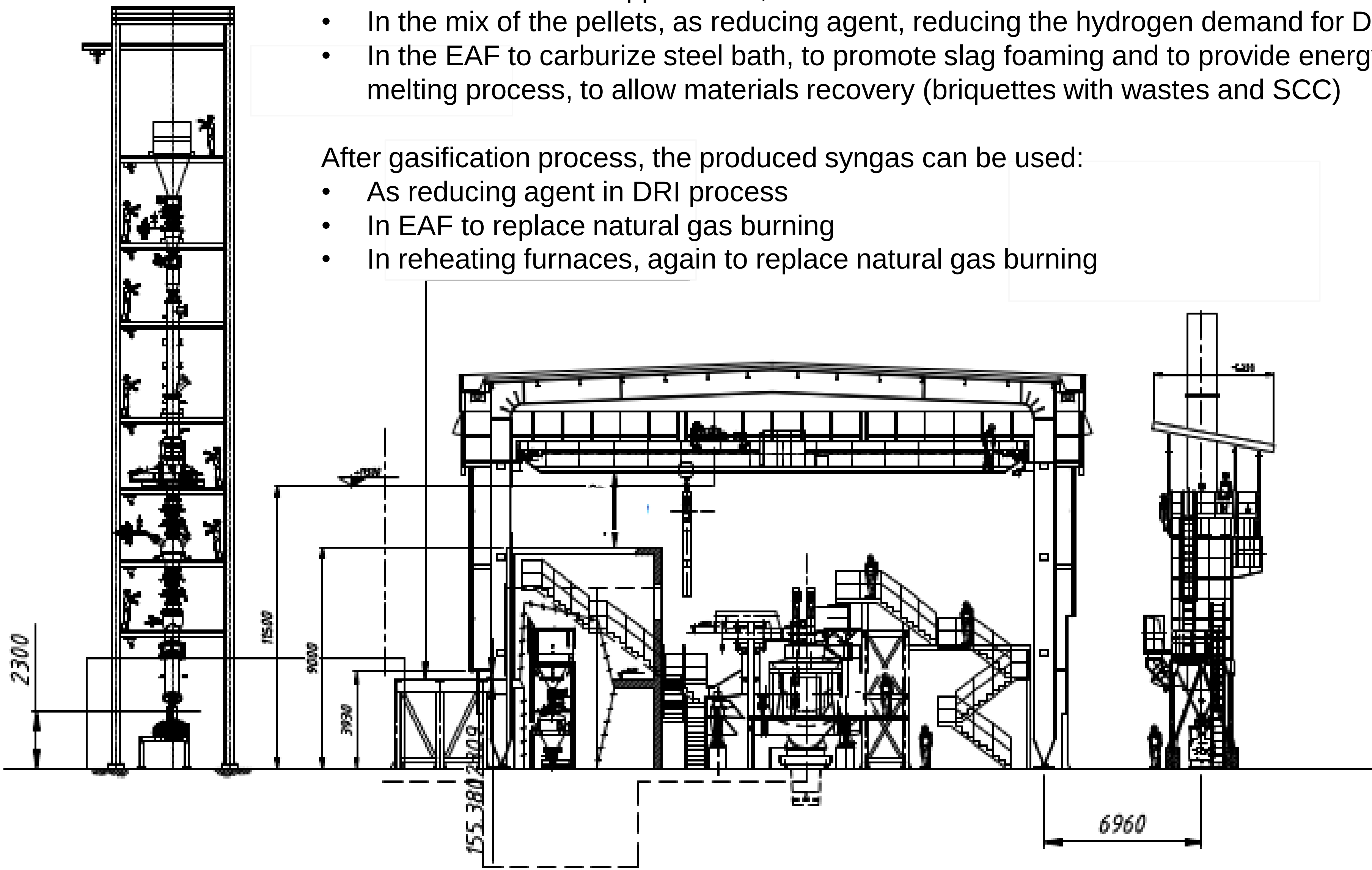
It is positioned as a major long-term objective within the evolving landscape of the global steel industry

SCC can have several applications, as solid materials:

- In the mix of the pellets, as reducing agent, reducing the hydrogen demand for DRI process
- In the EAF to carburize steel bath, to promote slag foaming and to provide energy to the melting process, to allow materials recovery (briquettes with wastes and SCC)

After gasification process, the produced syngas can be used:

- As reducing agent in DRI process
- In EAF to replace natural gas burning
- In reheating furnaces, again to replace natural gas burning



Their utilization does not require drastic modification of plant configurations and can be used in Integrated Steel Route, EAF Steel production and also in the Direct Reduction processes.

The utilization of SCC in the DRI+EAF production route can bring significant advantages in:

1. **In case of DRI production, polymers (and in general SCC) can decrease the process hydrogen demand**

2. **In EAF melting process, the polymers can be injected replacing (up to 100%) pulverised coal**

Circular Economy can contribute to the achievement of the ambitious target of steel production decarbonization, reducing in parallel the dependency on virgin raw materials.

SCC utlization in pelletes for DRI production is studied in literature, but few examples available. **A conservative value of 10% reduction of hydrogen demand** has been used for economical evaluations

SCCs utilization in EAF is described intensively in literature. **A coal demand of 10-20 kg/t used with SCCs substitution ratio of 1.5 is considered**

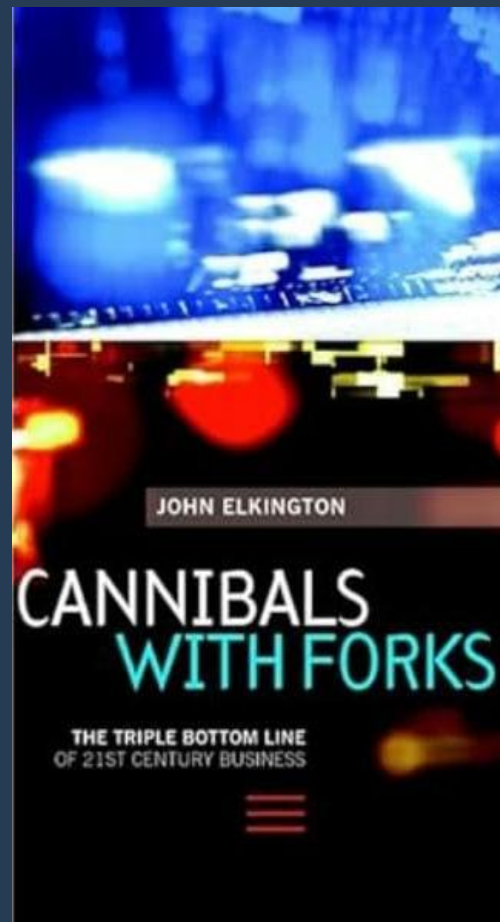
Re-reading HYDRA project through the Triple Helix of Sustainability lens

- The HYDRA project emerges as one of the most ambitious initiatives in the steel sector, aiming to facilitate the transition to net zero emission steel production.
- The shift from green hydrogen to green steel is a key to achieving sustainable steel production, replacing traditional coal with a low-emission alternative.
- This initiative can be described by using a multidimensional approach to sustainability.

The Triple Bottom Line (TBL) to assess a business's impact on social, environmental, and economic aspects

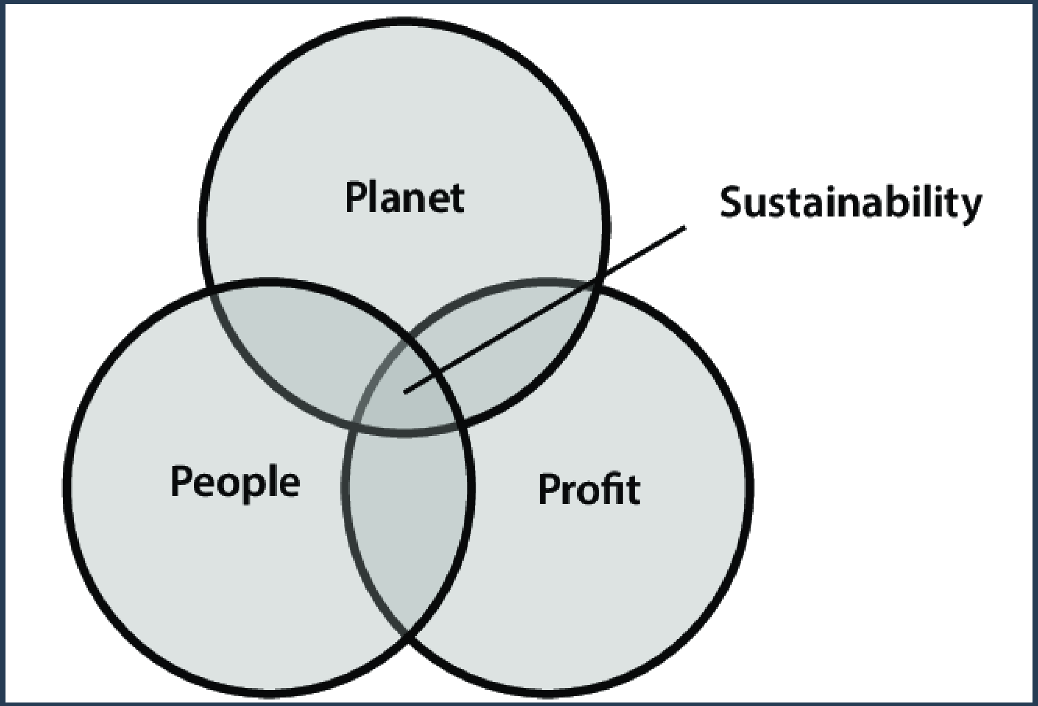
What is TBL?

"The triple bottom line is about more than just profit. It's about creating sustainable value for society and the environment" (Elkington)



“The Triple Bottom Line is not about trading off one dimension for another but about optimizing all three. It’s about creating value for shareholders, but also for stakeholders and society as a whole” (Elkington, 2018)

TBL means:



The entrepreneur is considered as a “driver” with a need for appropriate instruments, a steering wheel and an inspiring vision (Karlsson et al., 2019).

From an environmental perspective

95% reduction in CO_2 emission

The HYDRA project aims to reduce CO_2 emissions from steel production by up to 95%, from an average of 1.9 tons of CO2 per ton of steel to a few kilograms, significantly mitigating the industry’s environmental footprint.

Circular economy benefits

SCC utilizes waste materials (e.g., plastics, industrial residues), minimizing landfill use and emissions from waste disposal.

Lower hydrogen demand

Using SCC reduces the total need for green hydrogen, optimizing renewable energy usage and lowering overall energy consumption. Integrating SCC can also mitigate dependency on green hydrogen, reducing risks from potential shortages or reliance on non-renewable electricity.

Facilitates green transition

A hybrid SCC-hydrogen approach allows a gradual shift towards decarbonized steelmaking, balancing innovation with resource availability.

From a societal perspective

Improved air quality and public health

Reducing CO_2 emissions and other pollutants improves air quality in industrial areas, reducing the incidence of respiratory and cardiovascular diseases.

Increasing the social acceptability of heavy industry

The adoption of green processes improves the public perception of the steel industry, strengthening **social consensus** and facilitating the integration of industrial activities into local communities. Such an ambitious project can serve as an example to raise awareness among citizens, institutions and other industries about the importance of decarbonisation and sustainable practices.

Contribution to climate justice

Reducing the environmental impact of heavy industries, often located near vulnerable communities, decreases environmental inequalities and promotes more equitable development.

Green job creation

The adoption of innovative technologies such as DRI (Direct Reduced Iron) and EAF (Electric Arc Furnace), and the use of Secondary Carbon Carriers, can stimulate the growth of skills and jobs in the clean technology and resource management sectors.

From an economic perspective

Relevant reduction in dependence on fossil fuels in EAF

Replacing coal with recycled polymers and green hydrogen in EAF process reduces the use of fossil fuels. In the **EAF** process, the use of polymers instead of coal (**15-30 kg** /t of polymers) represents a direct reduction in CO2 emissions (30-60 kg/t) and coal consumption.

Optimisation of the use of renewable resources

The use of green hydrogen in the DRI process makes it possible to achieve steel production with almost zero emissions, exploiting renewable energy for hydrogen generation. The integration of recycled polymers reduces plastic waste, contributing to a circular economy: for every ton of steel produced, the insertion of polymers can reduce the demand for coal and contribute to the recovery of up to 30,000 tons of recycled plastic for a production of 1 Mt*.

**internal estimation*

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From an economic perspective

Increased efficiency of production processes

The 10% reduction in hydrogen consumption (8000 tons out of 80000 tons for 1Mt production) thanks to polymers can lead to an overall energy efficiency of the process through improved raw material management and the combined use of waste and raw materials.

Reduction in long-term operating costs

Production with green hydrogen, although initially more expensive, becomes competitive thanks to the decrease in renewable energy prices. The cost of polymers is significantly lower than that of hydrogen:

- Green H_2: 6-7 €/kg (Source: BloombergNEF).
- Polymers: estimated at 0.1-0.2 €/kg.

Efficiency of the production process - forecast

DRI+EAF process (1 Mt production)

- **DRI (Direct Reduction)**

  Requires 1.4 Mt of iron ore (pellets).

  H_2 consumption: approx. 80000 tons.

  SCC Usage - Solid materials (e.g. polymers): possible reduction of H_2 consumption by 10%, replacing 8,000 tons of hydrogen with 30,000 tons of polymers.

  Costs:

  - Green H_2: 6-7 €/kg (Source: BloombergNEF).
  - Polymers: estimated at 0.1-0.2 €/kg.

  Potential saving (1 Mt production): **8%**

- **EAF (Electric Arc Furnace)**:

  Non-biogenic SSC polymers can be used as a substitute for coal (10-20 kg of coal per ton of steel); it means that 16,000-32,000 tons of polymers are required for 1 Mt of steel produced:

  Costs:

  - Coal: 200 €/t.
  - Polymers: estimated at 100-200 €/t.

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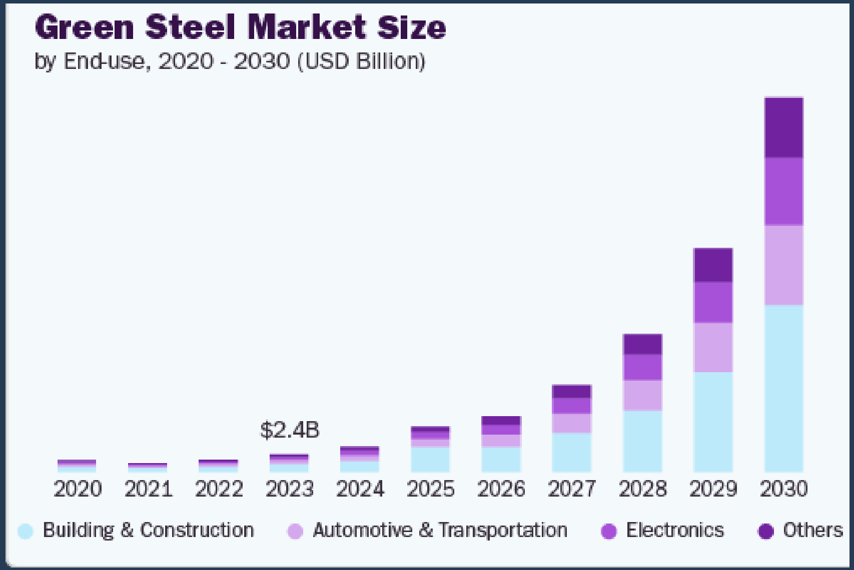
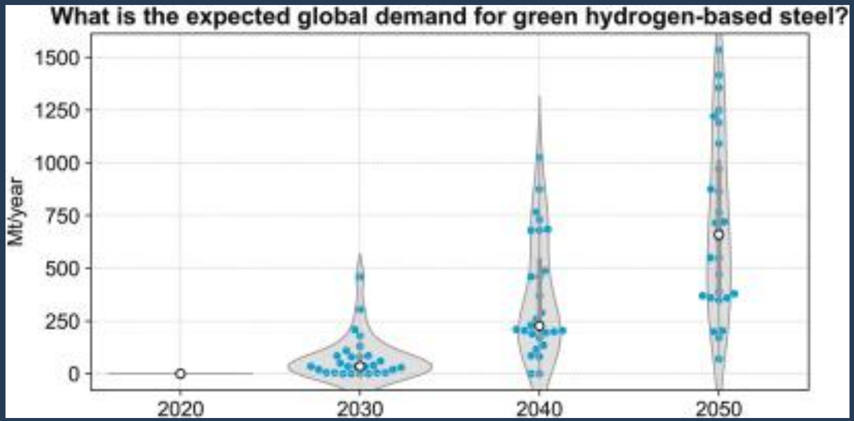
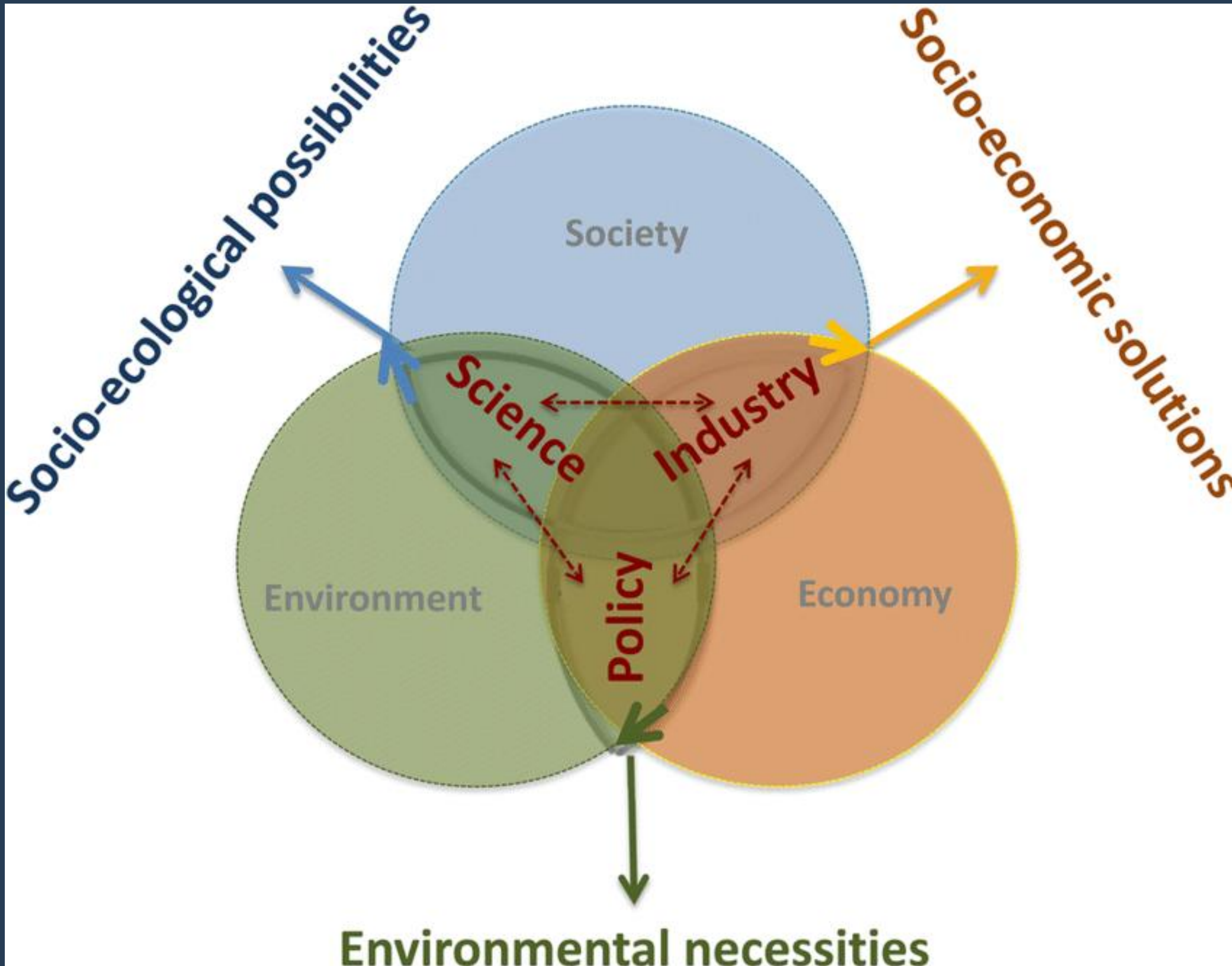
Market forecasting

- The global green steel market size was estimated at USD 2.45 billion in 2023 and is projected to grow at a CAGR of 56.7% from 2024 to 2030 (grandviewresearch.com).
- 12 leading green steel companies serving the Earth in 2024 (climatesort.com).
- Market price: the premium for green steel is conventionally identified in a range between 150 and 250 euros per tons. (siderweb.com)
- By 2050, global demand for green hydrogen-based steel is projected to reach 660 Mt (Watari & McLellan, 2024).







Source: Barile et al., 2015

Triple Helix of Sustainability dynamics

The dynamic movement of the helix relies on the interactions among the three key actors and on their ability to integrate data and information that reflect their distinct mandates and the various dimensions of sustainability.

- Policymakers should create an enabling environment that, informed by scientific evidence, allows companies to grow, innovate, and transform sustainably.
- Companies, within the knowledge and resource constraints they face, should implement the most appropriate business process models and technologies to remain profitable, sustainable, and compliant with existing laws and regulations and the overall institutional framework within which they operate.
- Academia should conduct analyses and generate evidence on what works, what does not, and provide options for improvement, both through scientific research and by offering direct advice to government entities and companies.

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Triple Helix of Sustainability dynamics

The potential dynamic movement of the helix in HYDRA project:

- Policy makers can enable companies to grow, innovate and transform sustainably by providing funds: HYDRA is a research, development and innovation project coordinated by RINA and approved by the European Commission and the MIMIT (Ministero delle Imprese e del Made in Italy) to decarbonize the steel production process through hydrogen-related technologies. The project, which is part of the IPCEI (“ Important Project of Common European Interest”) funded by the European Union - NextGenerationEU.
- Company: Rina-CSM through HYDRA is able to contribute to the objectives of the European Green Deal and the European Hydrogen Strategy by supporting low-emission energy production and the recycling of materials, aiming to create a sustainable steel model. Rina-CSM, with HYDRA project, is embedded in a network of relationships with other companies to implement and explore innovative experimental activities.
- Academia: HYDRA project includes active collaboration with universities to develop and carry out advanced research initiatives.

Conclusion:

Wise and sustainable decisions stem from seeing the bigger picture
- embrace a holistic perspective to lead with clarity and purpose -

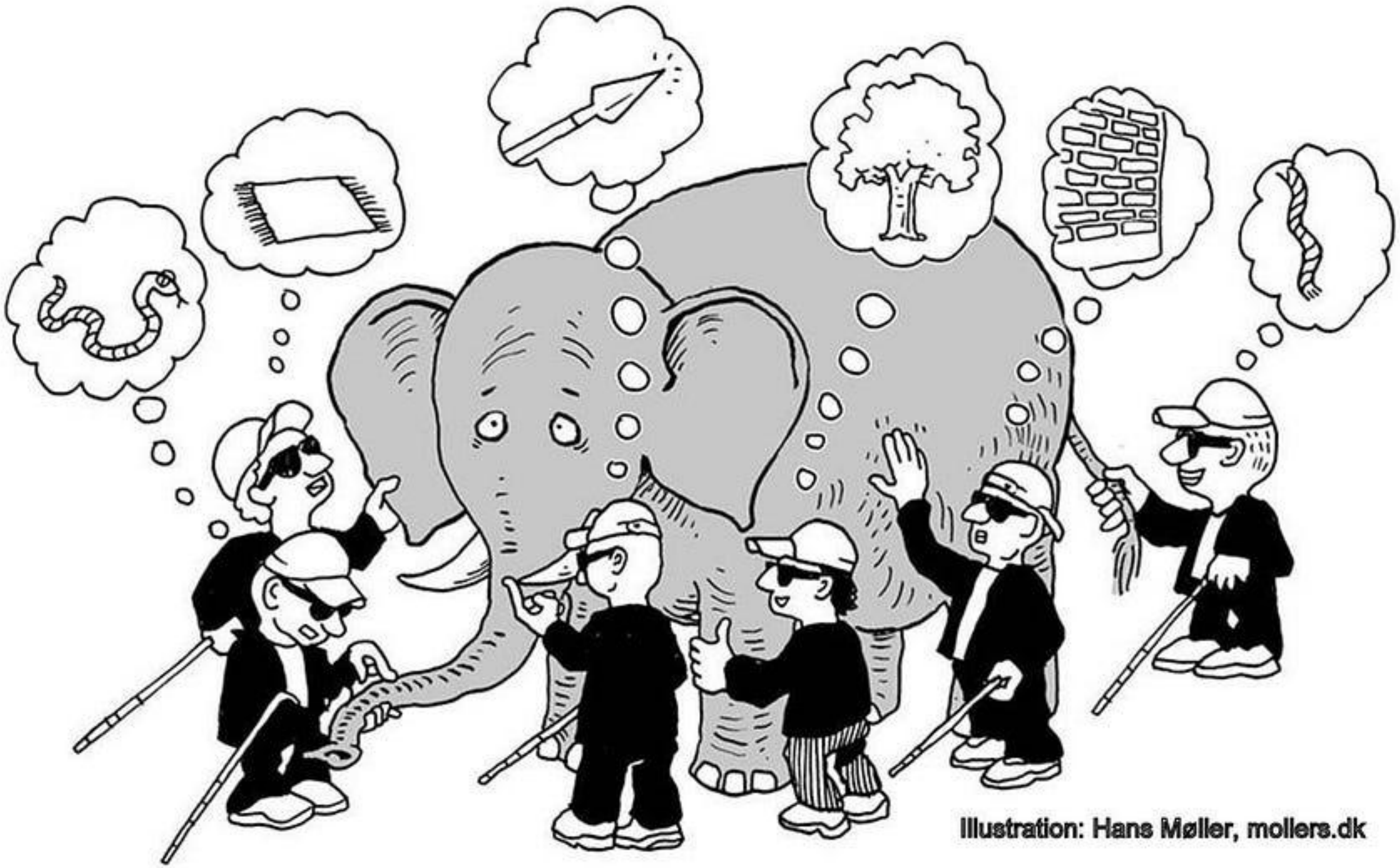
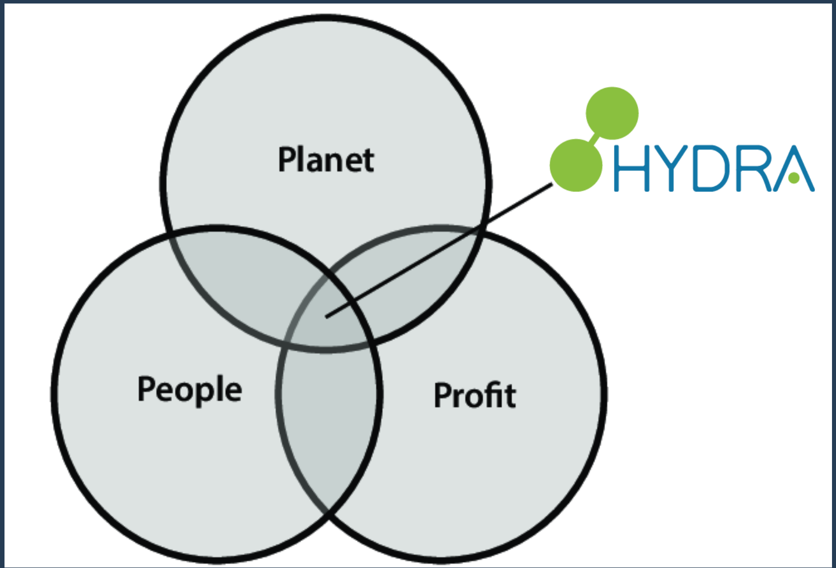


Illustration: Hans Møller, mollers.dk

Thank You for Your Attention

We look forward to your questions and discussions



Filippo Cirilli, PhD

Deputy Manager · RINA Consulting – CSM S.p.A.

filippo.cirilli@rina.org

Antonietta Megaro, PhD

PNRR Research & Innovation Business Support Advisor . RINA Consulting – CSM S.p.A.

antonietta.megaro@rina.org