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HIsarna

Breakthrough Technology to Meet Climate and Circularity Targets for the Steel Industry

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Together we make the difference

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TATA STEEL

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Shaping a sustainable society for generations to come

Our roadmap towards a sustainable future

Together we make the difference

1.1. Being a responsible steel supplier (in every sense)

Sustainability must underpin the entire value chain, not just the vehicle consumers drive

Responsible supply chains

Due diligence to avoid human rights or environmental risk e.g. child labour, conflict minerals

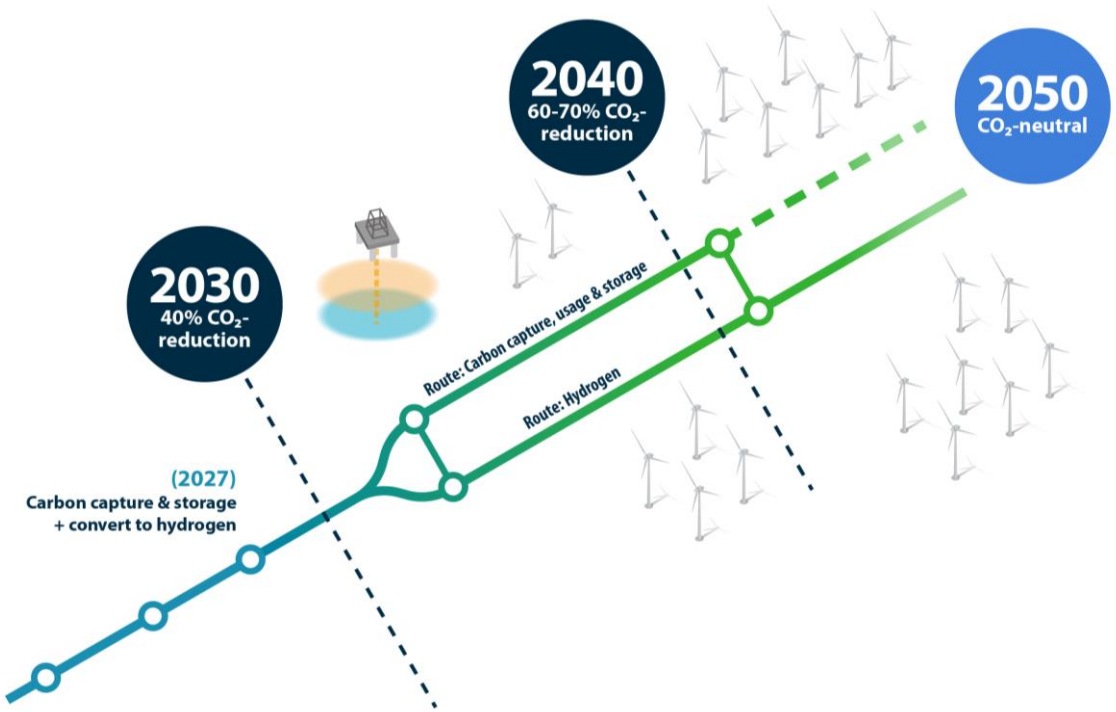
Circular economy

Responsible use of resources, reduction of waste; recovery and recycling at end-of-life

CO_2 performance

Mitigation of climate change by CO_2 reduction in extraction, processing, use and end-of-life

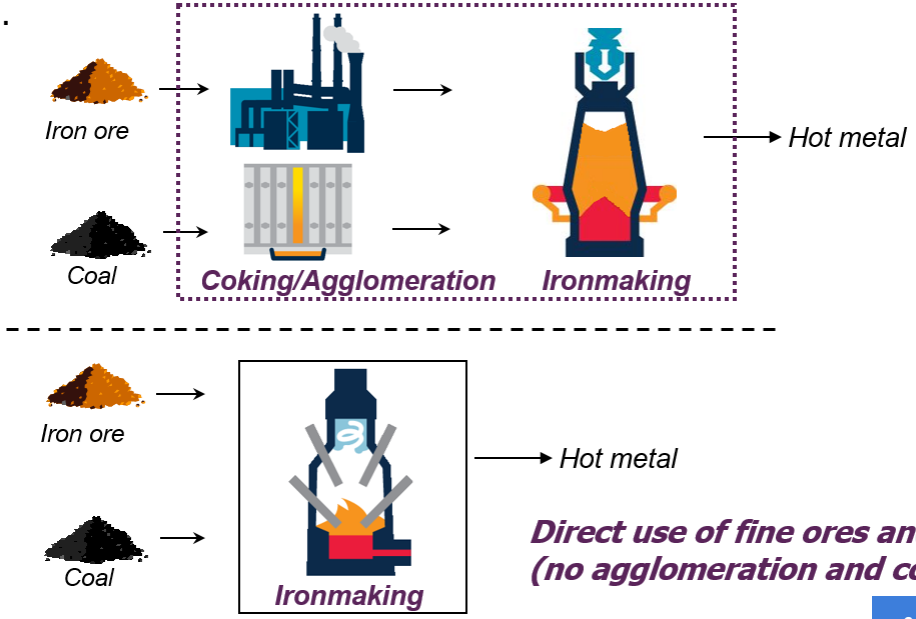
1.2. Leading in CO_2 neutral steelmaking



2.1. ULCOS and HIsarna development

- 2004: the ULCOS project started with the objective to achieve 50% reduction of the CO_2 emissions of steelmaking by 2050.
- HIsarna was one of the four options selected.

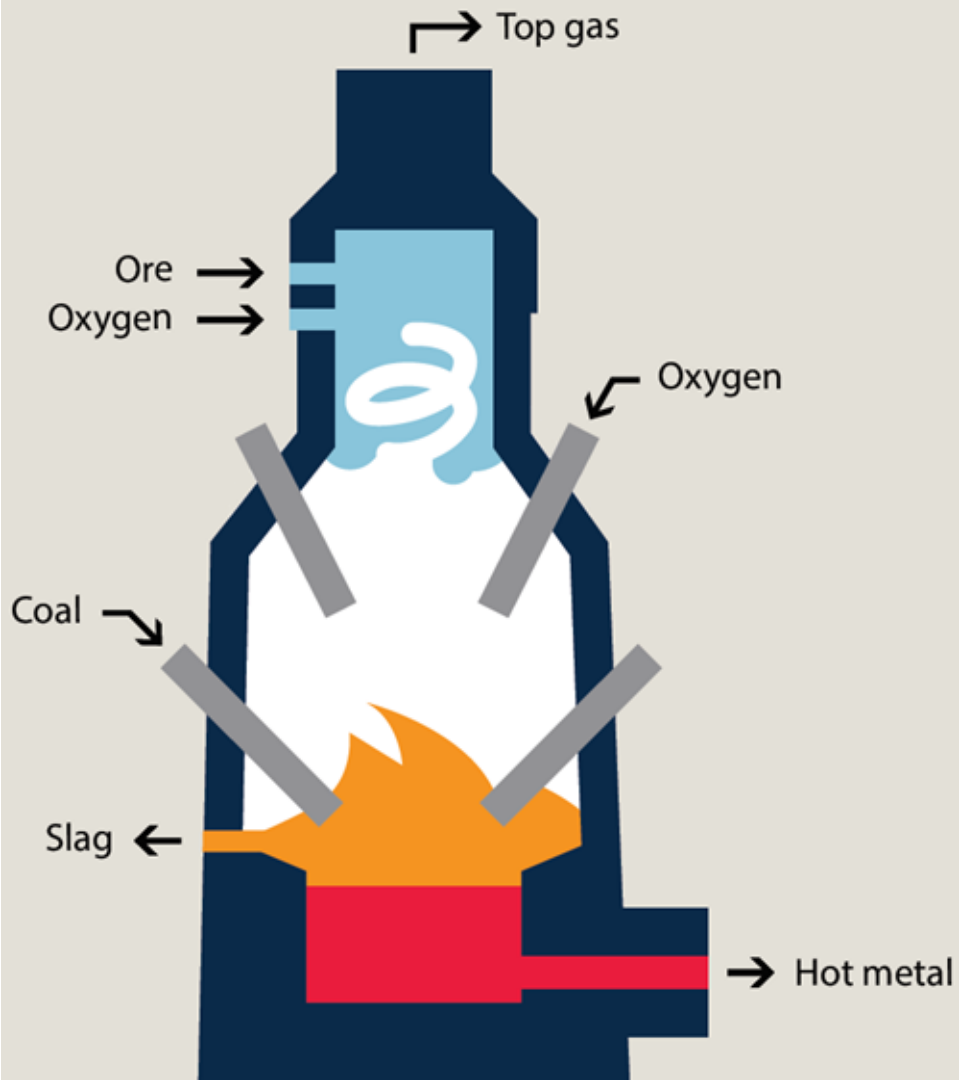
- Since 2007 active development of this process.
- 2010: the pilot plant was built.
- 2011 – 2014: four pilot plant campaigns
- 2015 – 2017: Major upgrade
- 2017 – 2019: 5th campaign
- 2021 onwards: 6th campaign



Direct use of fine ores and coal (no agglomeration and coking)

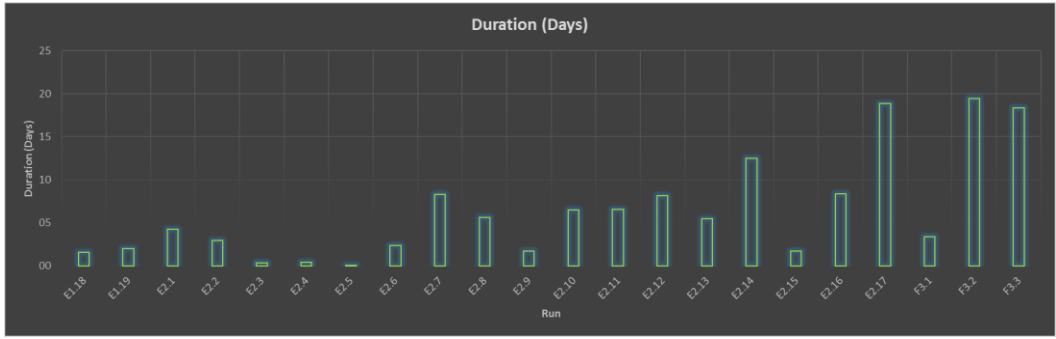
2.2. HIsarna – process layout

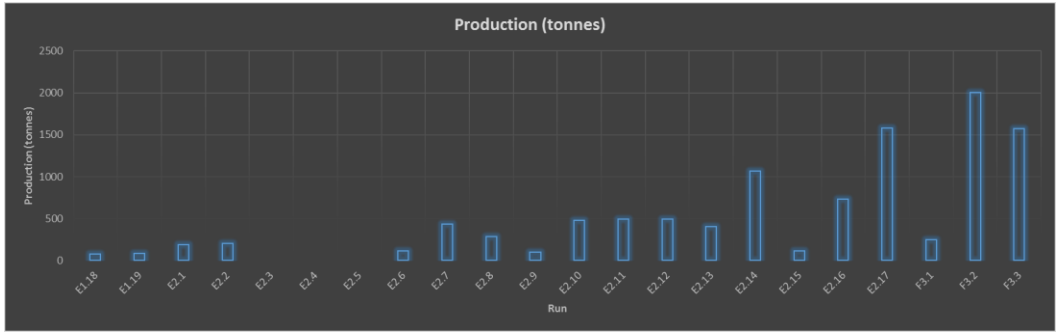
- Iron ore is injected into the smelt cyclone, together with oxygen.
- Hot CO rich gas from the SRV is combusted in the smelt cyclone, increasing the temperature and causing the iron to melt and partly pre-reduce.
- The molten and partly reduced iron ore will form a liquid film along the wall of the cyclone after which it drops down into the slag layer in the SRV.
- Granular coal is injected in the slag layer. This will fully reduce the iron ore to liquid hot metal and carburise the hot metal bath.
- The reduction reaction produces CO gas. This is partly combusted with oxygen in the space between the top of the slag and bottom of the cyclone, in order to generate heat.
- The splash and turbulence resulting from the injection processes ensure part of this heat is transported to the slag and metal bath.



2.3. HIsarna pilot plant achievements – Operation

- Plant in operation since 2011
  - Initially short campaigns
  - Full 5 shift rota since 2017
- 11 800 tonnes of hot metal produced
- 11 000 tonnes supplied to BOF plant
- Integrated in steel production route in 2018
- Longest continuous run: 19.5 days
- Availability during long runs: 93%
- Average production rate: 4.3 tHM/h
- Significant plant upgrades
  - Coal drying and grinding facility
  - Ore drying facility
  - New bag filter plant
  - Wet SOx scrubber





1.3. HIsarna pilot plant achievements – Technology

Demonstrated:

- Designed process capability and energy efficiency
- Stable process
- > 50% reduction in CO_2 emission intensity[1]
  - Use of 50% scrap charge
  - > 40% coal replacement by sustainable biomass
- > 85% CO_2 in process gas (CCU/S ready) [1]
  - Use of CO_2 as carrier gas for injection
- Recycling of 100 tonnes of BOF slag[2]
- Use of low grade raw materials[3]
- Proof of principle for Zn recycling[3]
- Wet granulation trial of HIsarna slag

[1] Horizon 2020, LoCO2Fe, Development of a Low CO2 Iron and Steelmaking Integrated Process Route for a Sustainable European Steel Industry, Grant Agreement 654013

[2] C. Zeilstra et al., "The use of LD-slag as a fluxing agent in the Hisarna process", Proceedings of the 6th International Slag Valorisation Symposium, 1-5 April 2019, Mechelen, Belgium. pp. 325-328.

[3] H.K.A. Meijer et al., "HIsarna Experimental Campaigns B and C," European Commission, Brussels, 2015.

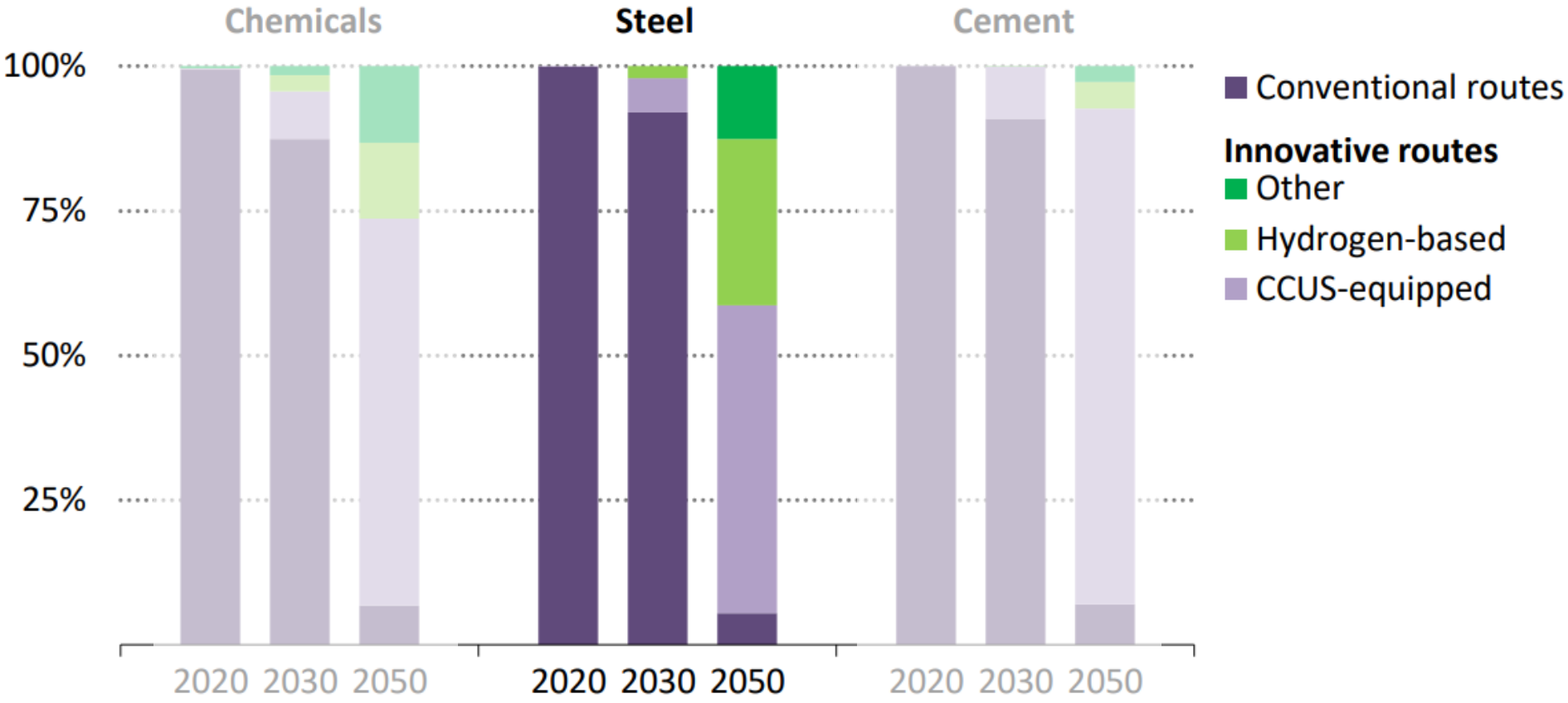
2.4. Key Challenges

- Improve equipment and plant reliability
  - Refractory wear – Limiting run length
  - Injection systems – Limiting productivity and availability

- Expand the range of raw materials with stable operation
  - Use of lower grade ores
    - Low Fe, high P, Zn containing, etc
  - Use of wide range of coal types

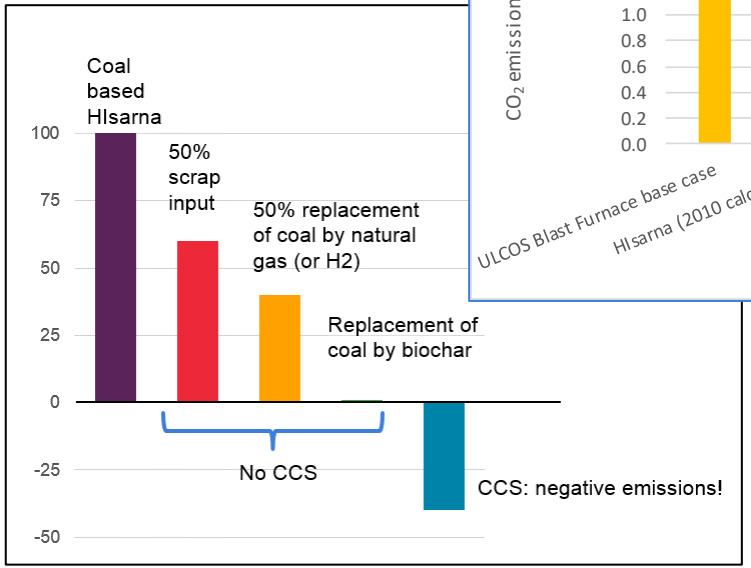
- Further define parameters for upscaling

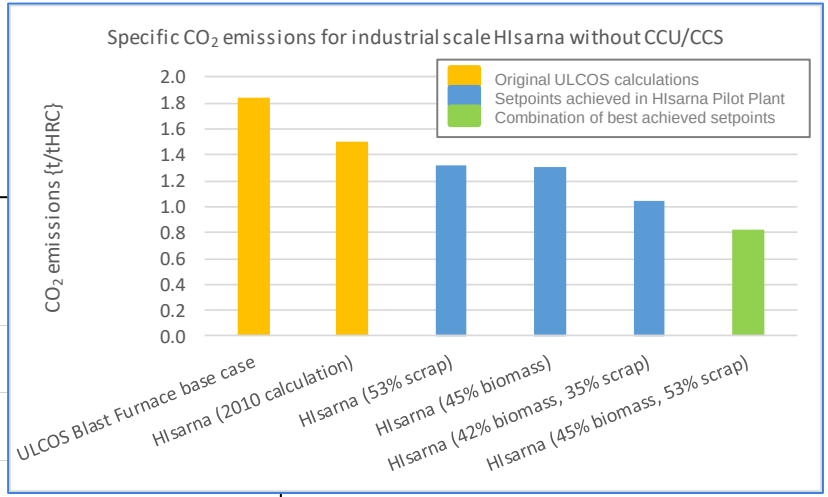
CO_2 reduction



Source: IEA (2021) Net Zero by 2050 A Roadmap for the Global Energy Sector. All rights reserved.

3.1. HIsarna and CO_2 reduction – CO_2 benchmark calculations using the CO_2 tool[3]





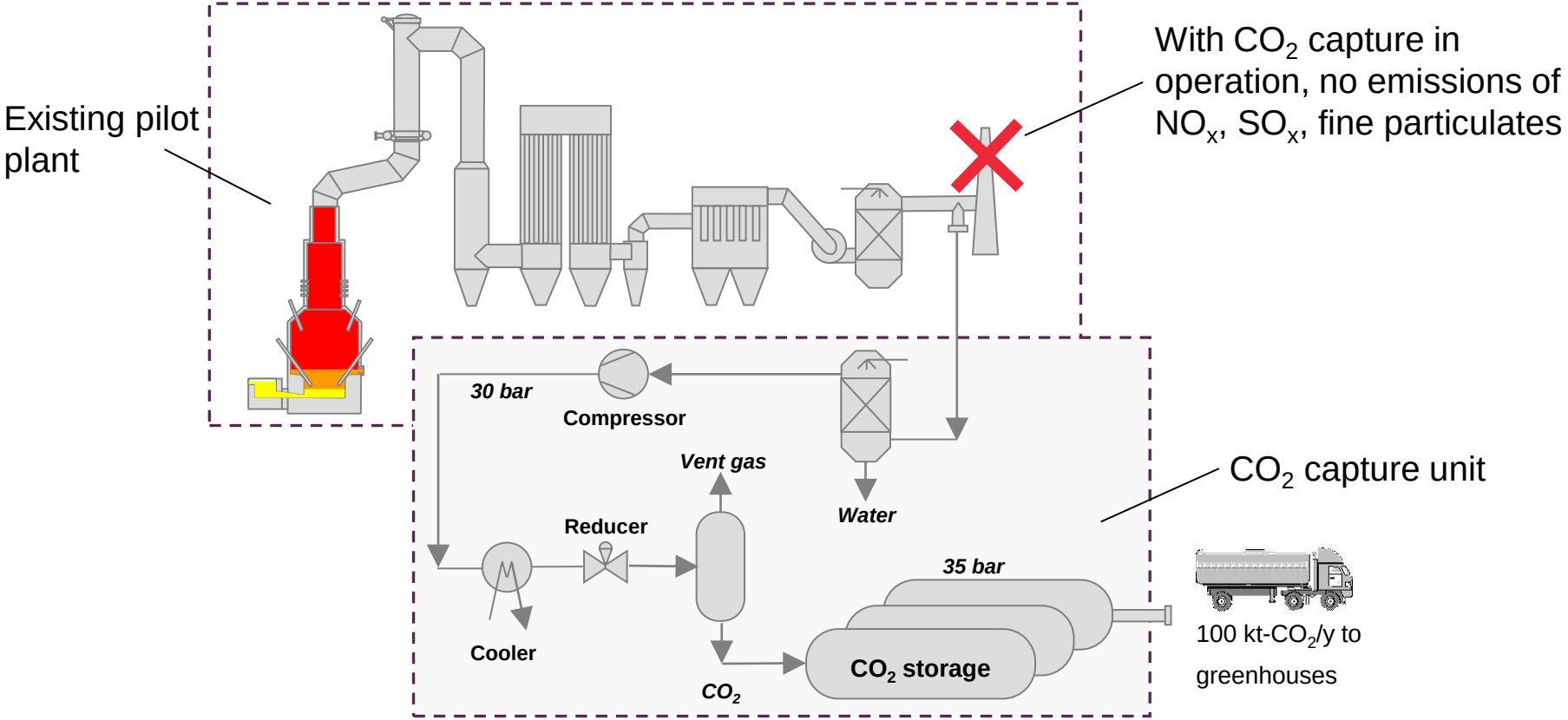
More than

50%

CO_2 reduction possible, without CO_2 capture technology

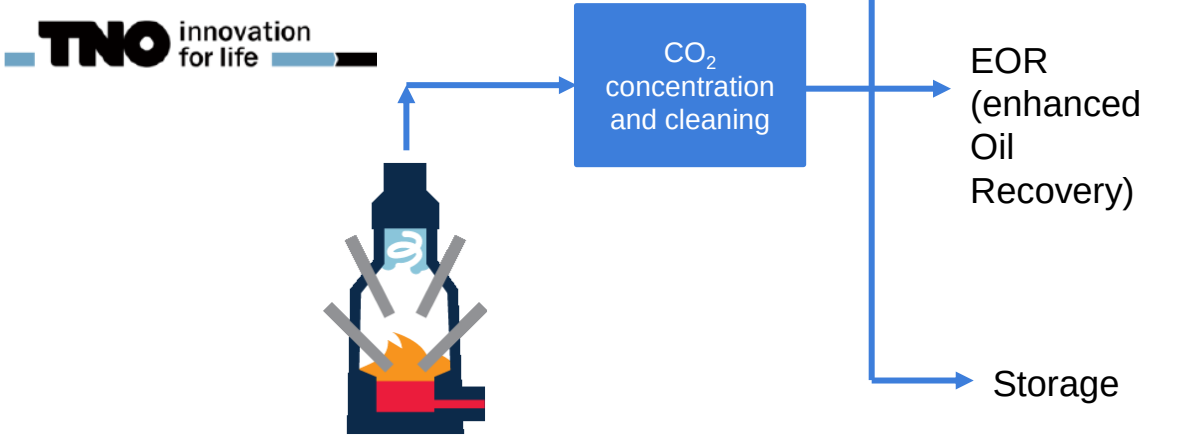
[3] J.P. Birat, J.P. Lorrain, Y. de Lassat, "The 'CO2 Tool': CO2 emissions & energy consumption of existing & breakthrough steelmaking route," *La Revue de Métallurgie*, pp. 325-336, Sept 2009.

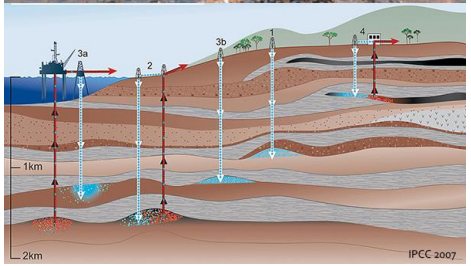
3.2. HIsarna pilot plant with CO_2 capture unit



3.3. HIsarna and Carbon Capture Technology

- TNO carried out a technical and economical evaluation of CCS/CCU at a HIsarna Demo plant[4].



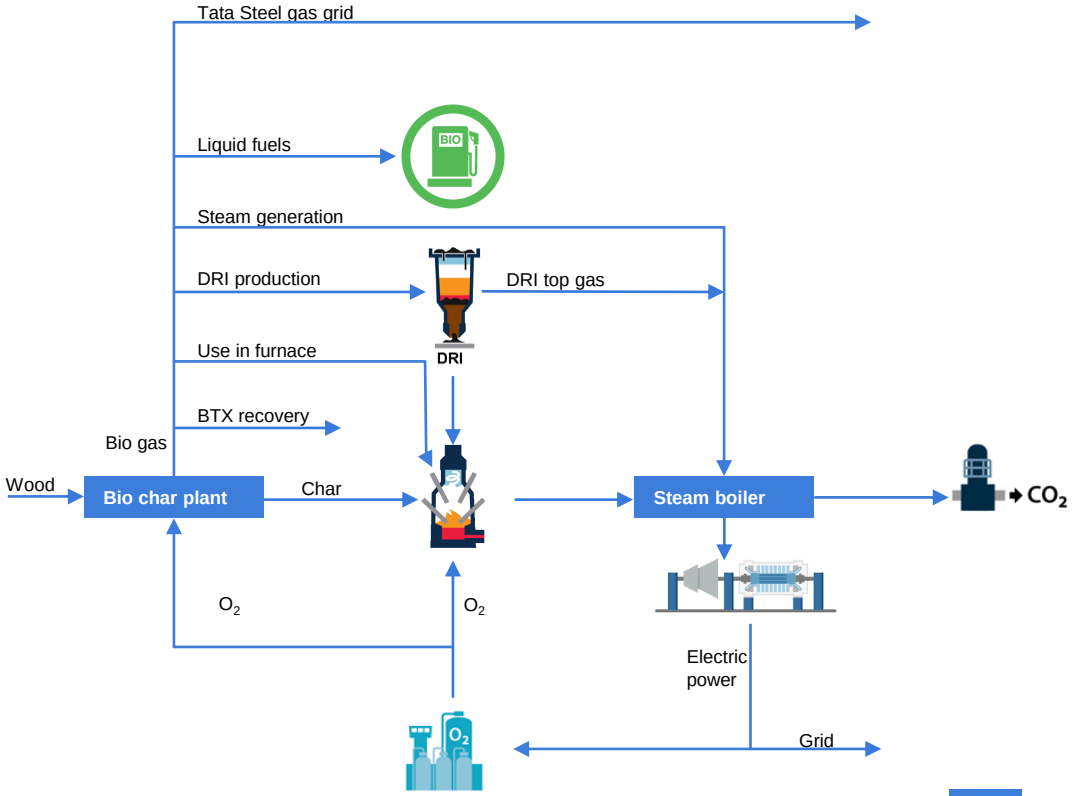


[4] S. Santos, K. Meijer, J. van der Stel, P. Broersen, J. Monteiro, P. van Os, "CO_2 Capture in Combination with the HIsarna Process", Proc. Of METEC/ESTAD 2019, 24-28 June 2019, Duesseldorf, Gemany

3.4. Fossil carbon substitution

- Research ongoing to substitute fossil carbon with sustainable and renewable energy carriers

- Production of bio char[5]
- Part replacement of solid carbon
  - Bio gas
  - Natural gas
  - Hydrogen



[5] Top Sector Energie, "Bio-Coal CO_2-negatieve staalproductie", contract number TEEI119001.

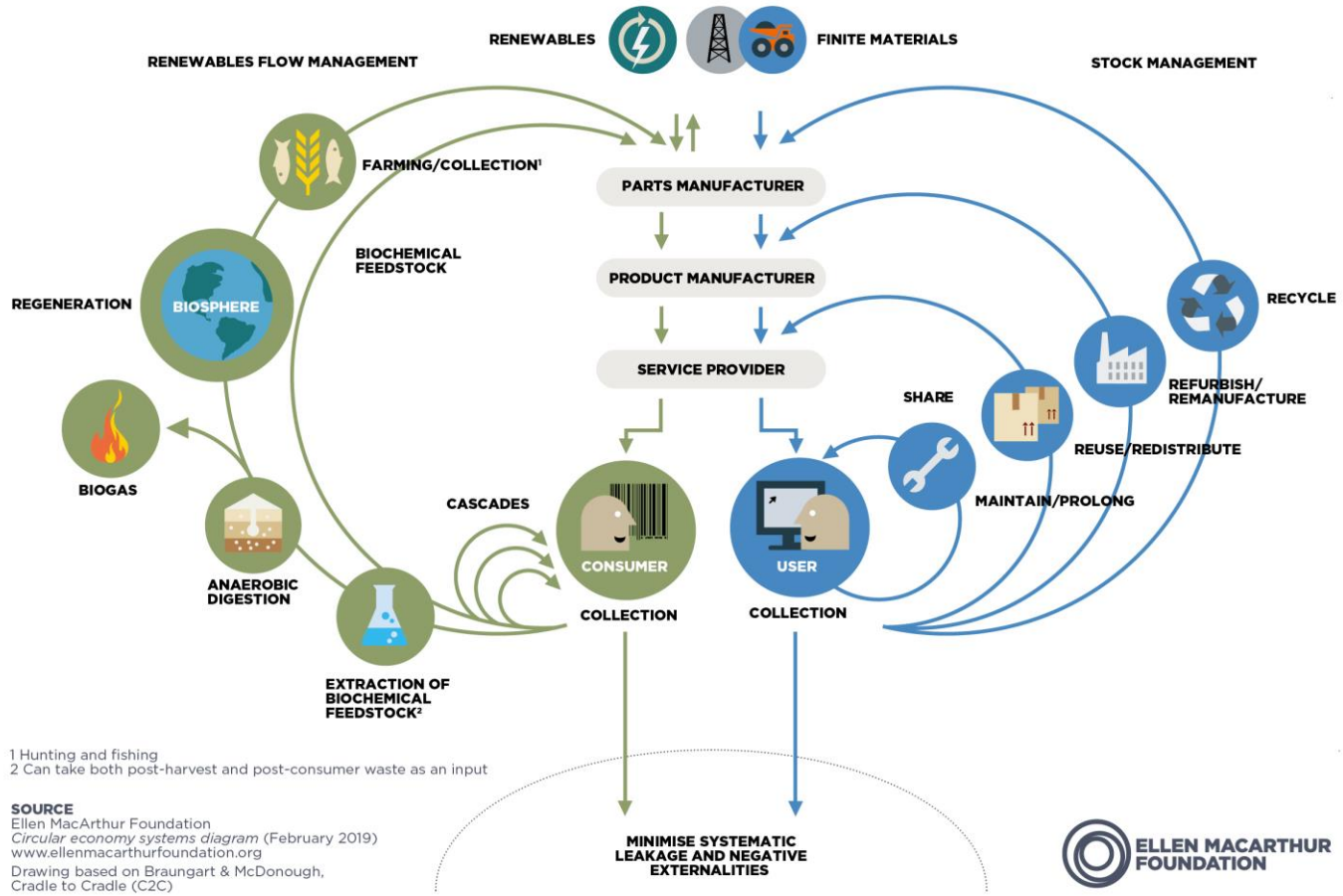
3.5. Further development

- **Climate change:**

- Combine HIsarna with CO_2 capture, starting with the pilot plant
  - Without capture future targets can't be achieved
  - Pilot plant is the ideal testing ground for carbon capture technology
  - Explore possibilities for CO_2 usage
    - Greenhouses
    - Chemical industry
    - Synthetic fuels

- Maximise substitution of fossil carbon requirement
  - Sustainable biocoal
  - Introduction of natural gas and hydrogen into process

Circular economy



4.1. To waste or not to waste?

Preferred option

Waste processing

Last resort

Image source: https://ec.europa.eu/environment/topics/waste-and-recycling/waste-framework-directive_en

4.2. To waste or not to waste?

- Ambition in the European union: to become a fully circular economy, towards a “Zero-waste” society.

- The European Waste Framework Directive defines the basis management principles, sets an order of preference and defines waste vs. by-products[6].

Within this framework, EU member states have room for their interpretation and legislation.

[6] https://ec.europa.eu/environment/topics/waste-and-recycling/waste-framework-directive_en

4.3. Waste and circularity - consequences

- New processes and technologies are required to achieve both the climate and circular economy objectives of the EU or even globally.
- For any new process being developed, the circularity requirements should be considered and fully assessed at the early development stages.
- Legislation needs to be harmonised and administration simplified.
- HIsarna offers, in addition to a significant reduction in carbon footprint, an opportunity to valorise by-products to a great extent.

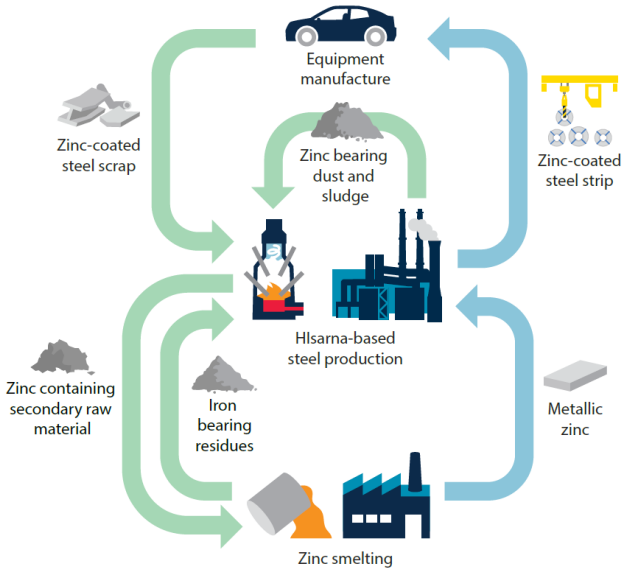
Foto: Ruud Niesten.

4.4. The ReclaMet project[7,8]

Supported by

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

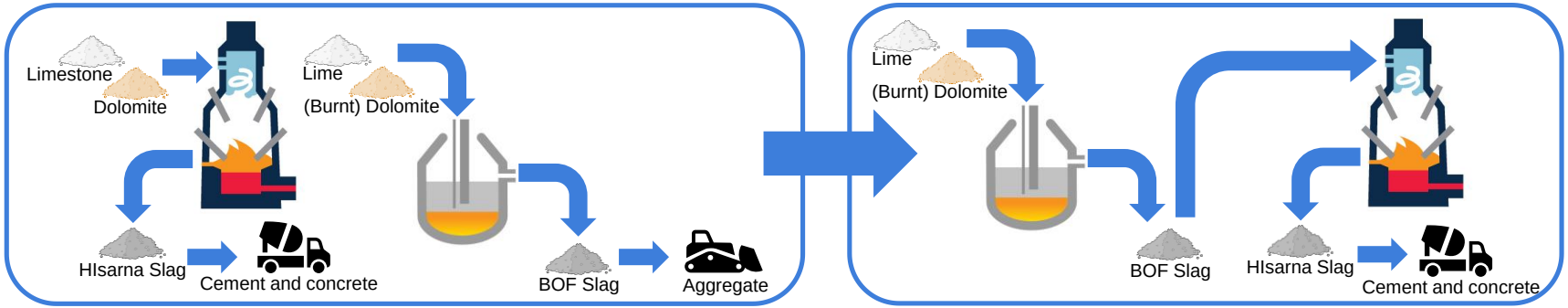
- Project running from 01-04-2018 to 31-12-2021
- Main objectives
  - Valorisation of manufacturing reverts
    - Avoided landfilling
    - Circular economy
  - Use of Zn-rich steel scrap in the steel industry
  - Secondary Zn oxides for the zinc industry
- Challenges
  - Material input: potential re-oxidation of FeO in input materials like BOF sludge
  - HIsarna process: dust quality (zinc concentrate)



[7] EIT RawMaterials, ReclaMet: Reclaiming valuable metals from process residues with the HIsarna process; Area 2: Acceleration, Segment D2.2: Upscaling, Grant number 17209.
[8] Hage, J.L.T., Wang, X., et al, 'Metal recovery from secondary raw materials through the HIsarna process – the EIT-RM ReclaMet project', presentation, ESTEP 2020, 13th November 2020

4.5. Increasing the value of slags

- The HIsarna process requires flux additions in the form of CaO and MgO.
- As part of the H2020 LoCO2Fe project, plant trials were performed to:
  - Replace most of the lime with limestone and dolomite.
  - Replace this limestone and dolomite with LD-slag[9].
- Benefits:
  - Reduced use of virgin minerals.
  - Moving from a low value aggregate application to a high value cement making application.



[9] C. Zeilstra et al., “The use of LD-slag as a fluxing agent in the Hisarna process”, Proceedings of the 6th International Slag Valorisation Symposium, 1-5 April 2019, Mechelen, Belgium. pp. 325-328.

4.6. Further development

- **Circular Economy and HIsarna:**

- Combining both iron ore and scrap based metal production in HIsarna, maximising scrap use across the route
- Close the Zn loop in the steel industry
- Use slag from other processes as fluxing agent
  - Reduce the requirements for virgin flux materials
  - Maximise the value of any materials already in circulation

- Besides the recovery of Zn HIsarna offers the potential to recover other components:
  - Phosphates
  - Alkalines
  - High value metals

5. Conclusion

- HIsarna is a breakthrough technology offering significant environmental and economic benefits. HIsarna will be an enabler for a sustainable global steel industry:
- It allows a reduction of CO_2 emissions
  - more than 50%, without CO_2 capture technology
  - >95% possible with CO_2 capture
- It can be emission free / environmentally neutral
  - no CO_2, NO_x, SO_x, dust
- It enables building a circular economy
  - Close the loop for Zn coated steel
  - Maximise value of various mining and manufacturing reverts
  - Use of CO_2 as input for other processes through CCU

6. Acknowledgements

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SILC-II initiative, LoCO2Fe project
Grant agreement ID: 654013
https://cordis.europa.eu/project/id/654013

EIT RawMaterials, ReclaMet project
EIT Project Agreement No:17209
https://eitrawmaterials.eu/project/reclamet/

Topsector Energie
Project number TEEI119001
https://projecten.topsectorenergie.nl/projecten/bio-coal-co2-negatieve-staalproductie-00033204

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Connecting matters

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TOPSECTOR ENERGIE
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Do you have any questions?

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