TATA STEEL

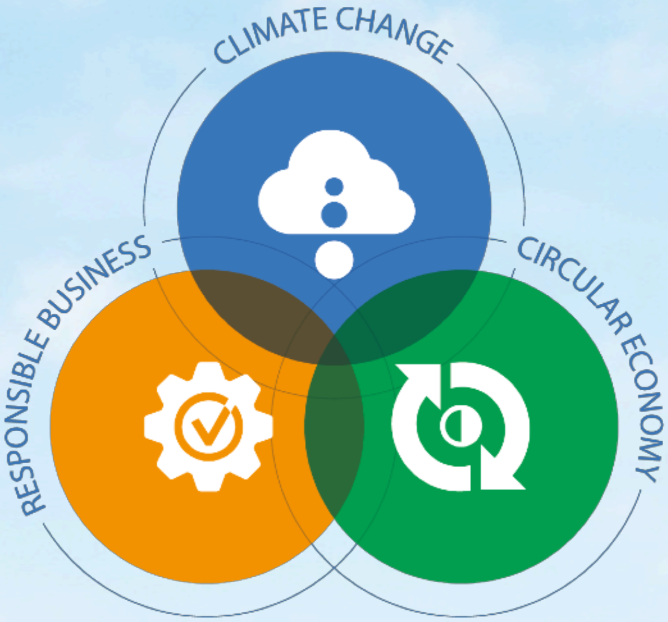
TATA

HIsarna

Demonstrating low CO_2 ironmaking at pilot scale

Together we make the difference

15 January 2019



OUR GOALS TOWARDS SUSTAINABLE STEEL:

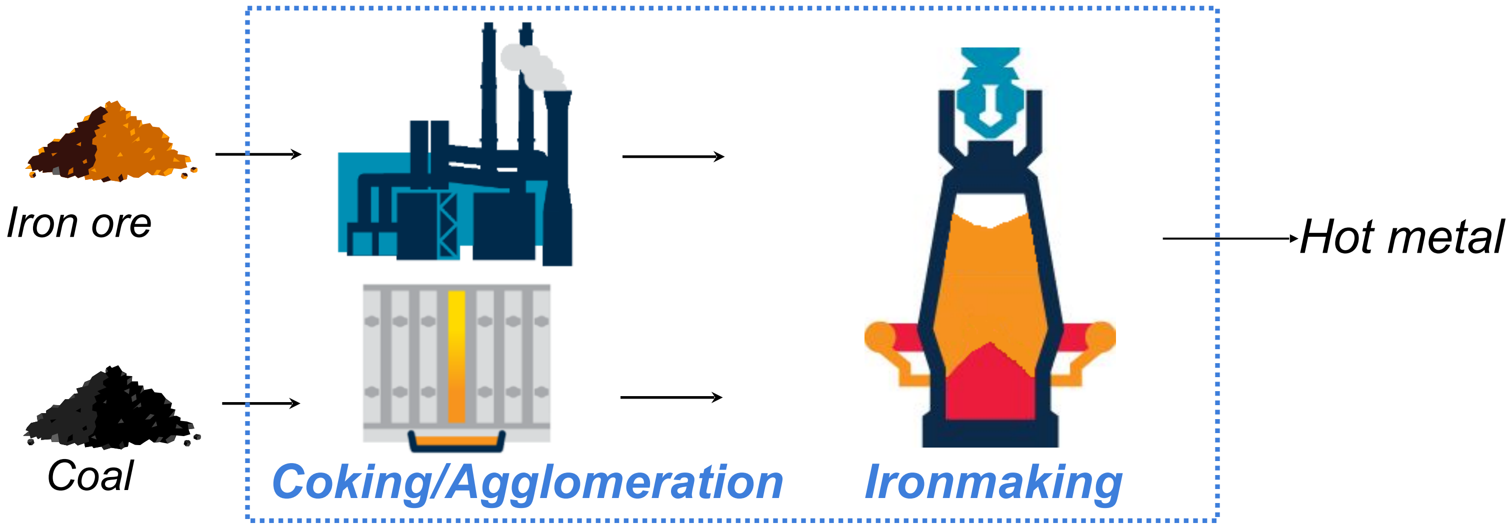
- To reduce our CO_2 emissions in line with national and European targets.
- To work with other industries and integrate our products and by-products into the circular economy ensuring nothing goes to waste.
- To continue to operate a responsible business, benefitting our people, partners, and society.

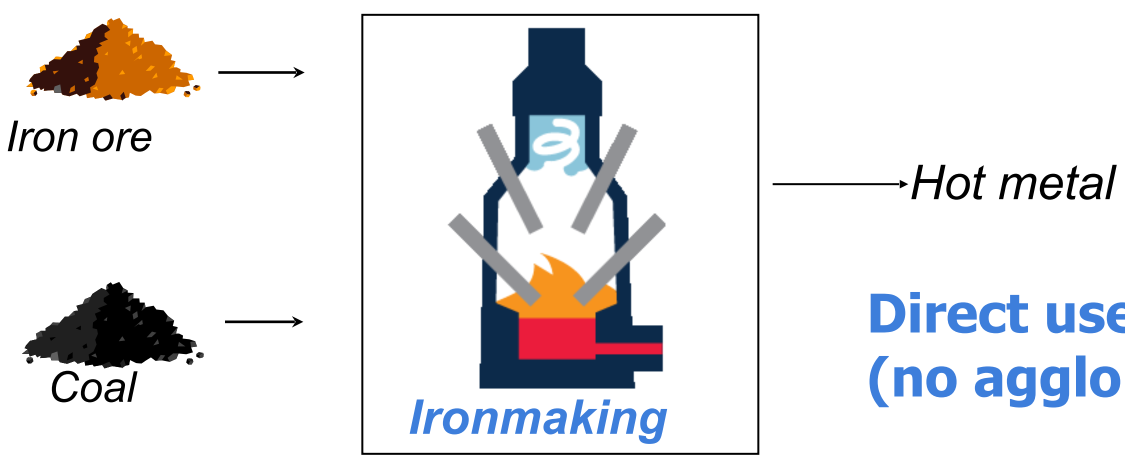
TATA STEEL

1.2 HIsarna development

- In 2004 several European steelmakers proactively started the ULCOS project with the objective to achieve 50 % reduction of the CO_2 emissions of steelmaking
- HIsarna is one of the four process development that originate from the ULCOS project.
- Since 2007 Tata Steel, Rio Tinto and ULCOS have been active developing this coal-based smelting reduction process.
- In 2010 a dedicated pilot plant was built at Tata Steel in IJmuiden (NL)
- To date over 75 mln Euro has been invested in this new technology.
- The HIsarna process offers a combination of **environmental** and **economical** benefits.

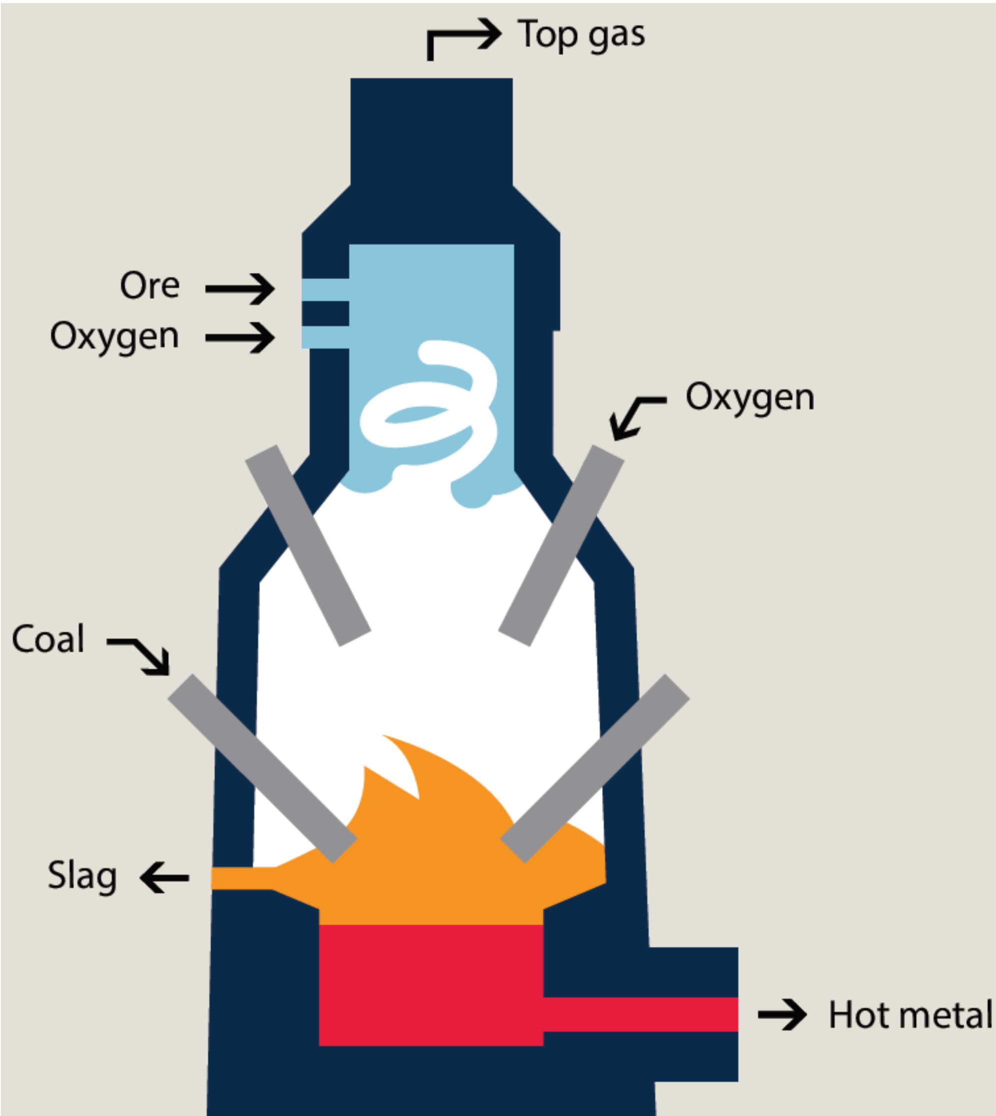
1.3 Comparison BF route - HIsarna





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

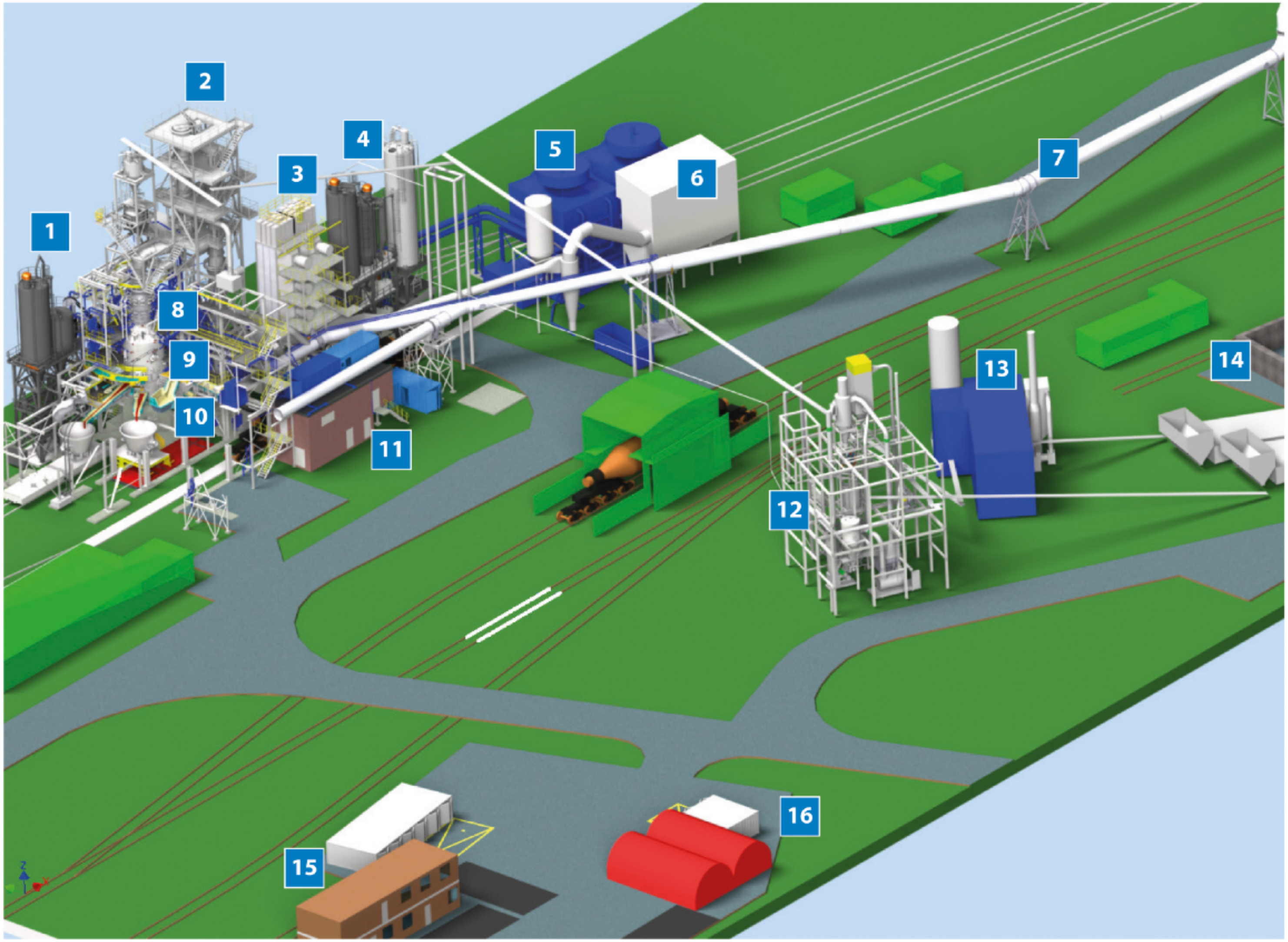
2.2 HIsarna – process layout



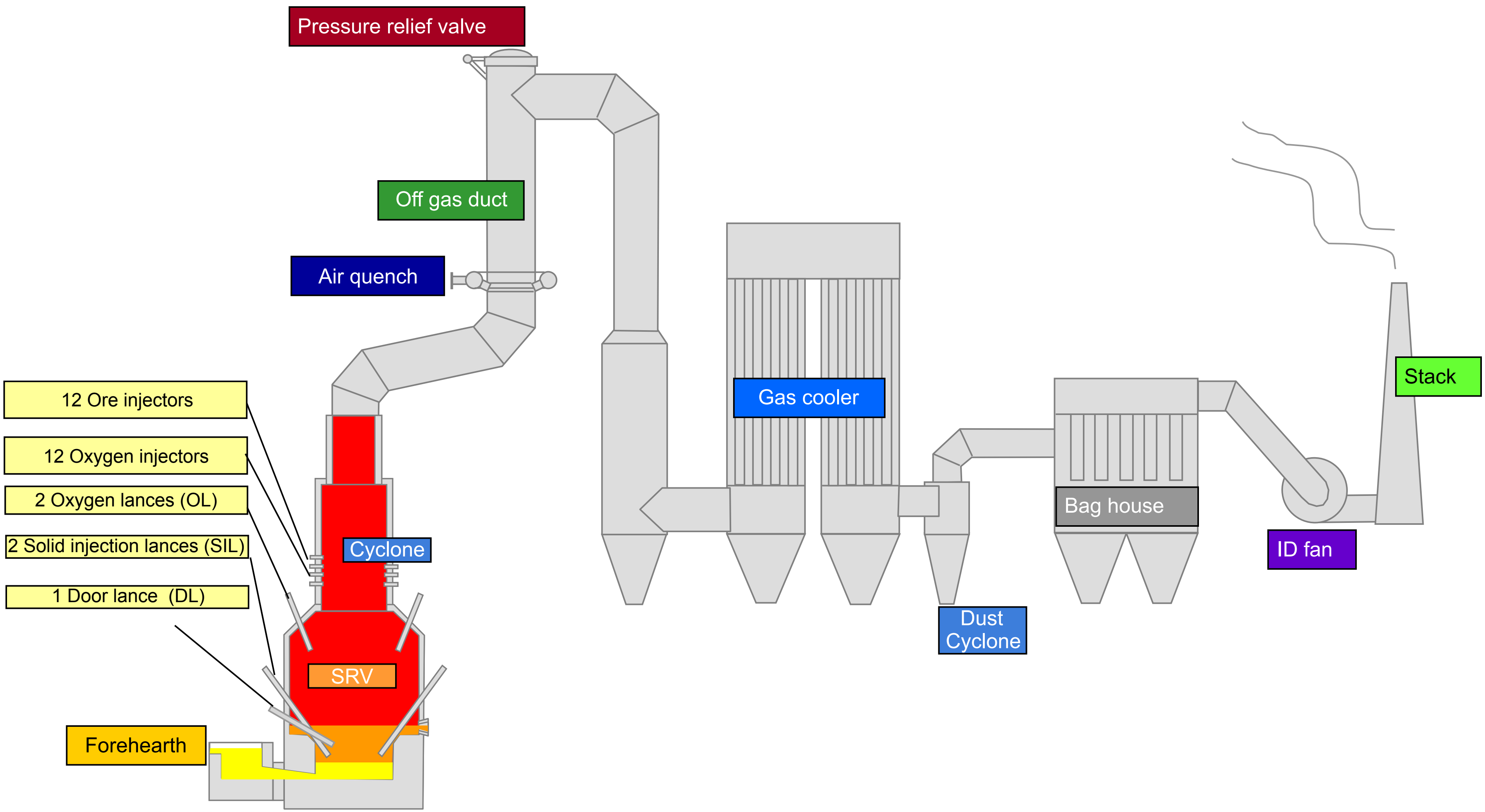
- Iron ore is injected into the smelt cyclone, together with oxygen.
- Hot CO rich gas from the SRV is combusted in the smelt cyclone, increasing the temperature and causing the iron to melt and partly pre-reduce.
- The molten and partly reduced iron ore will form a liquid film along the wall of the 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.

HIsarna Pilotplant

1. Alternative raw materials storage silos
2. Off-gas duct
3. Gas cooler
4. Coal and lime storage silos
5. Cooling towers
6. Bag filter
7. Secondary dedusting
8. Smelting cyclone
9. Smelting reduction vessel
10. Fore hearth
11. Control room
12. Coal grinding, drying and screening
13. Ore drying and screening
14. Raw materials storage
15. Offices
16. Workshop



3.1. HIsarna pilot plant schematic



3.2. HIsarna pilot plant

Achievements

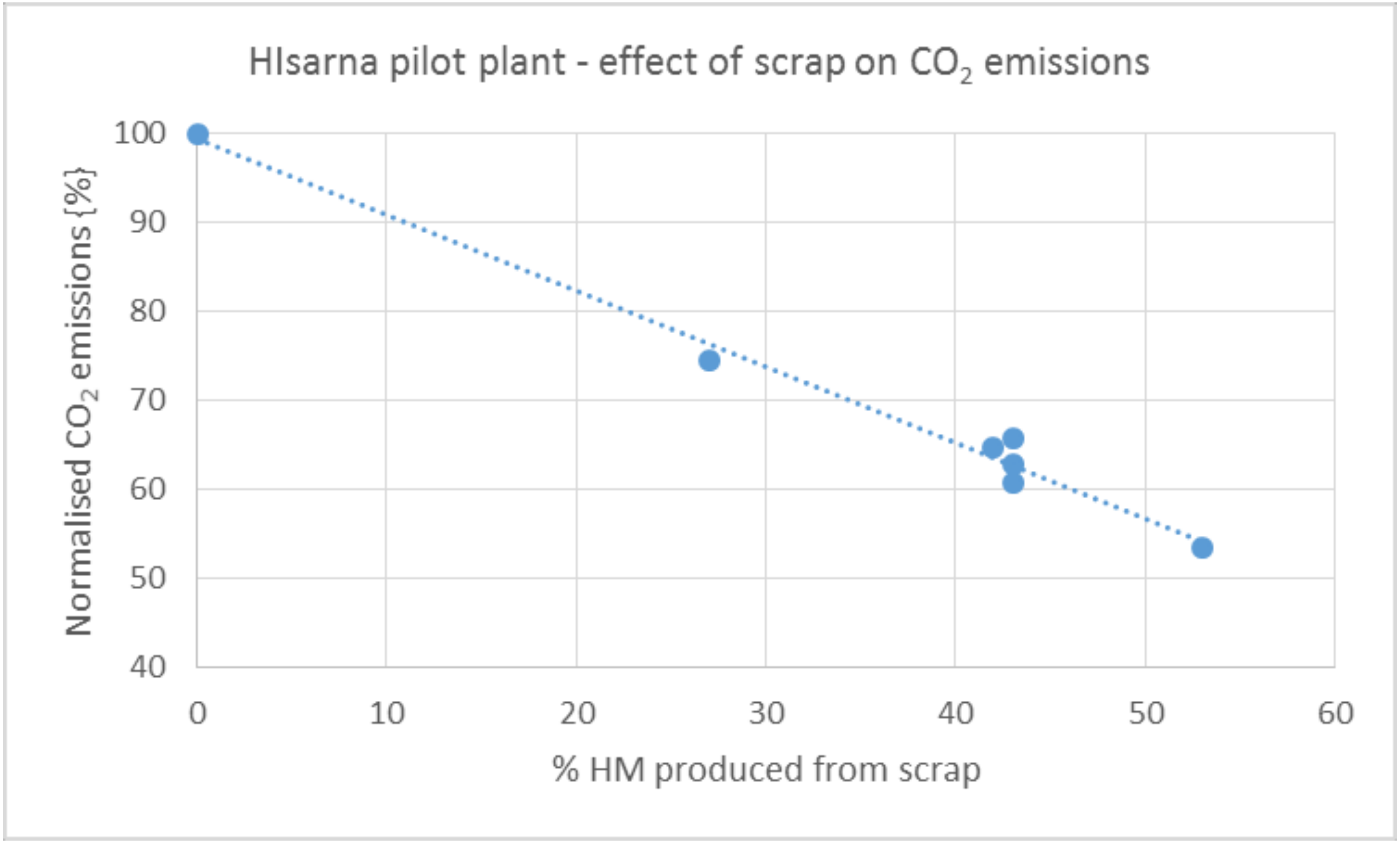
2017 - 2018

- Target:
    - Demonstrate CO_2 reduction of 35% without carbon capture
    - Use of 40% sustainable biomass
    - Use of 35% scrap

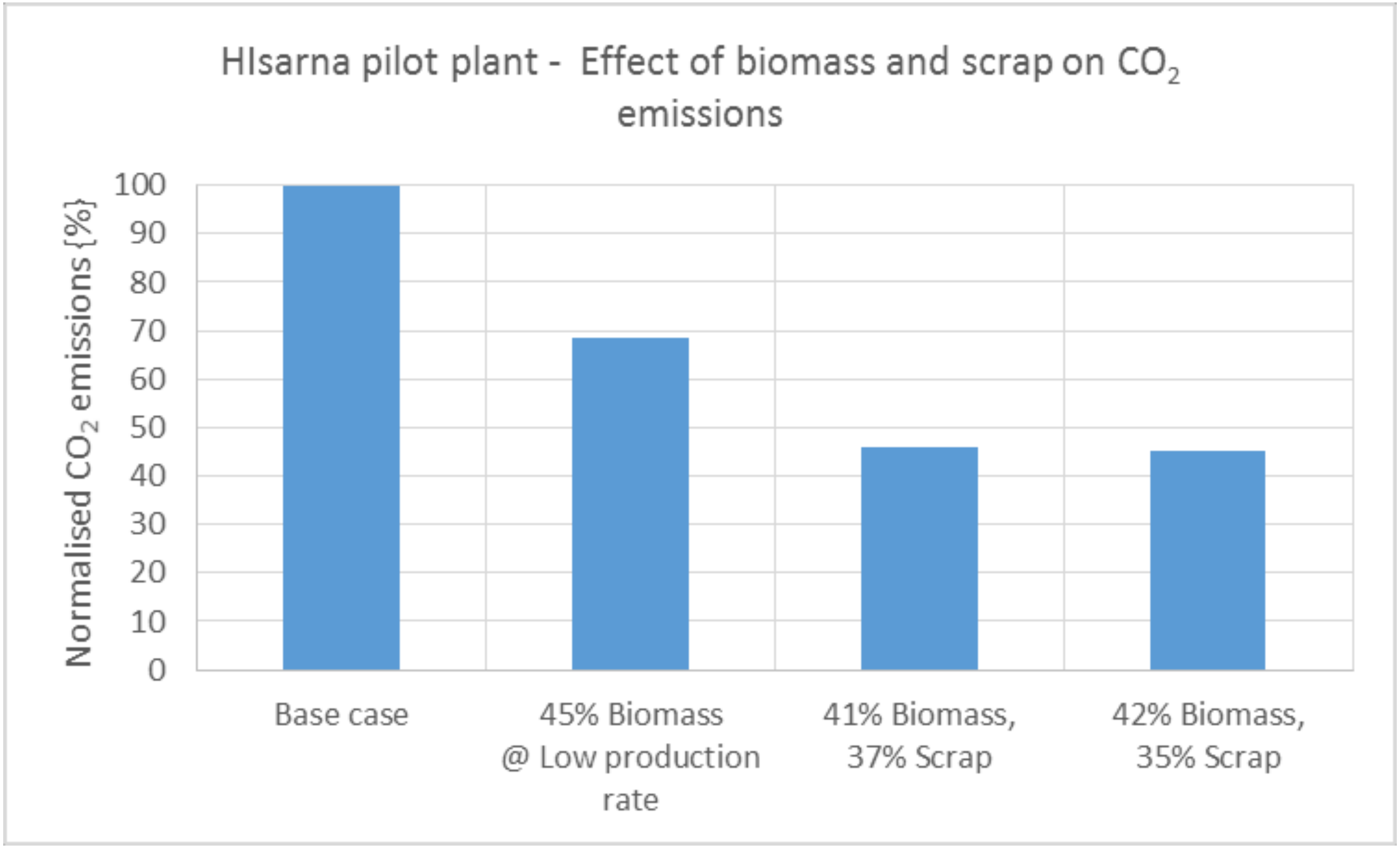
- Biomass:
    - Charcoal
        - Low ash, low density
    - Injected through 1 coal injection lance

- Scrap:
    - Shredded scrap and punchings
    - Semi-continuous feeding under gravity

3.4 Using scrap in HIsarna



3.5 Using scrap and biomass in HIsarna



3.7. Continued development programme

Current experimental work in pilot plant:

- Focus on operational and equipment aspects
- Testing equipment endurance
- Demonstrating long term process stability

- Dutch Government support
  - DEI (Demonstratie Energie Innovatie)

Further technology development:

- Recycling of galvanised steel scrap
- Recovery of Zn (circular economy)
- CO_2 capture at the pilot plant
- Demonstration plant engineering studies

4. Conclusions

HIsarna is a breakthrough technology offering significant environmental and economic benefits. HIsarna will be an enabler for a sustainable global steel industry:

- Demonstrated reduction of CO_2 emissions by more than 50%, without carbon capture technology
    - >80% possible with carbon capture
- Reduction of NO_x, SO_x and fine dust emissions
- Reduced steelmaking costs
    - Low Si, low P hot metal
    - 0.007% P achieved in hot metal
- Maximise reuse of steel scrap
    - Close the Zn loop for galvanised steel

Acknowledgements

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Hot metal production

Regular slag tap and slag sampling

End tap

4.5 Ti-V-P recovery from slag

The HIsarna process can be used to create slags rich in Ti, V and/or P depending on the raw materials selection.

The contents of these compounds in the slag could be such that economic recovery of these products is feasible.

This offers an opportunity to access different raw materials and have a more varied value chain.

4.4 By-product recycling

HIsarna can use Fe rich process dusts and sludges from other process as a raw material.

These include BOF sludge and BF dust, also those with a high Zn fraction. This was succesfully done for the first time in campaign D (2014)

If these dust streams are high in Zn, HIsarna can be used to achieve high levels of Zn enrichment in the process dust, to the levels that Zn smelters can use it as a raw material.

This also opens the opportunity to use large volumes of Zn coated scrap in the BOF and enrich the dust via HIsarna.