

# Recent Hlsarna operational developments at the IJmuiden pilot plant

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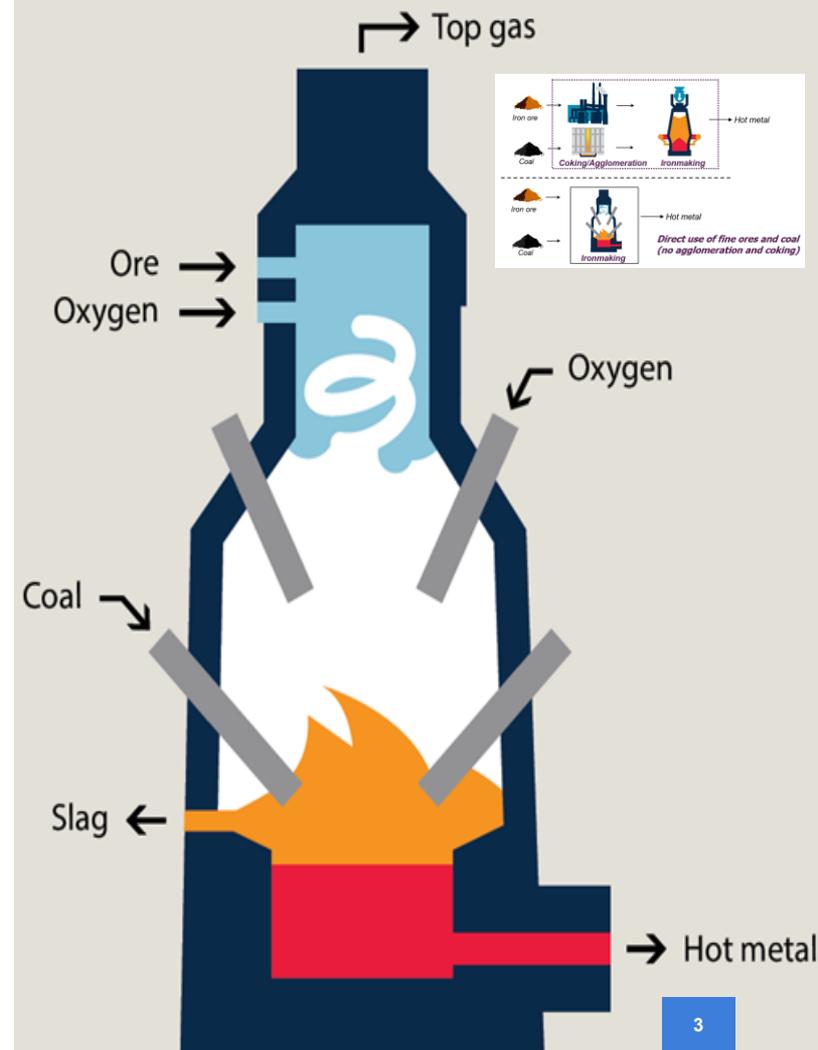
# Agenda

- Hlsarna process
- Recent plant upgrades
- Hlsarna achievements
- Key operational results
  - Infrared imaging inside reactor
  - Use of low-grade iron ore
  - Fossil carbon substitution
  - Valorisation of Hlsarna slag
- Scale-up – Industrial scale Hlsarna
- Conclusions



# Hlsarna – Process layout

- Fine 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 ore 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 liquid iron oxide to liquid hot metal and carburize 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.
- The top gas resulting from Hlsarna is a concentrated CO<sub>2</sub> stream, suitable for cryogenic CCUS.



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# Hlsarna pilot plant – recent upgrades

- **New gas cooler**
  - Increase handling and cooling capacity of process gas.
  - Productivity increase.
- **SCR DeNOx plant**
  - Compliance with future stricter environmental regulations.
  - Increased duration of run (with activated carbon filters run duration was restricted to 5-7 days).
- **Natural gas injection lance**
  - Heat input during process stops.
  - Part replacement of coal.
- **Infrared camera inside reactor**
  - Process observations and monitoring



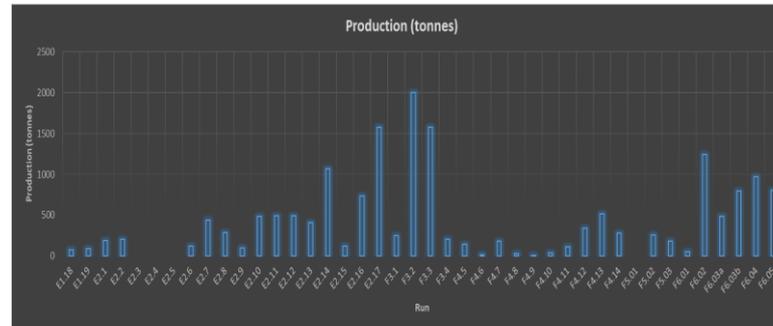
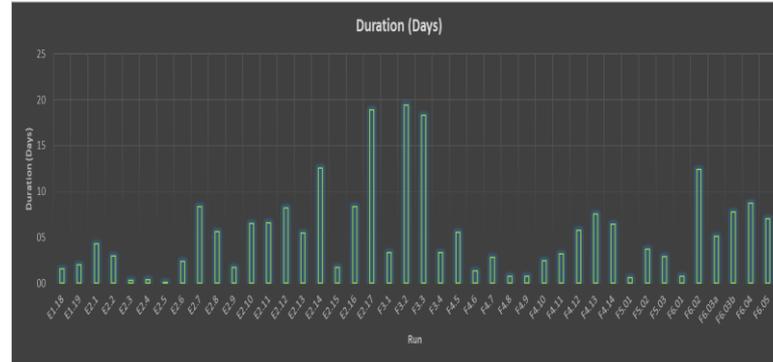
# Hlsarna pilot plant achievements: Operation

## Plant:

- 18 450 tonnes of hot metal produced
- 17 450 tonnes supplied to BOF plant
- Longest continuous run: 19.5 days
- Availability during long runs: 93%
- Highest productivity: 7.5 tHM/h
- Best daily production: 160 tHM/d

## Staff:

- Continuous presence of 5-shift rota: ~60 FTE
- Maintenance and project team: ~10 FTE
- Technology development team: ~10 FTE



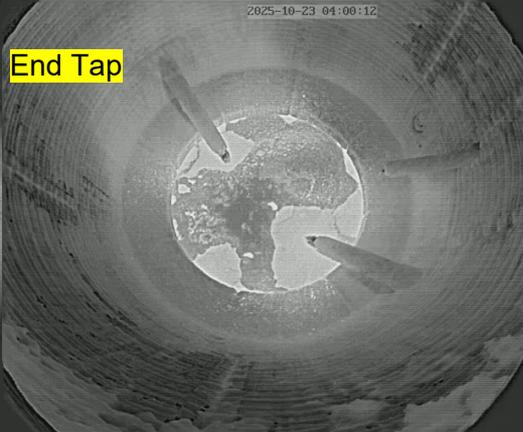
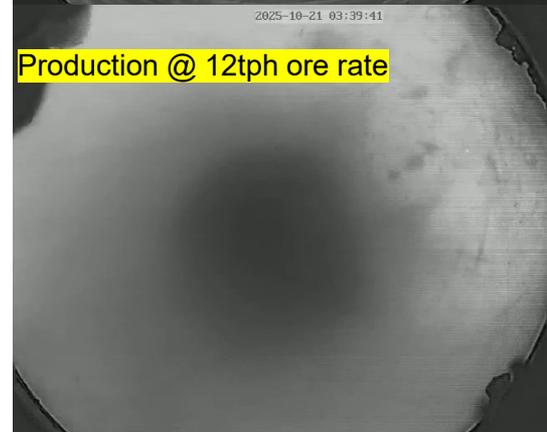
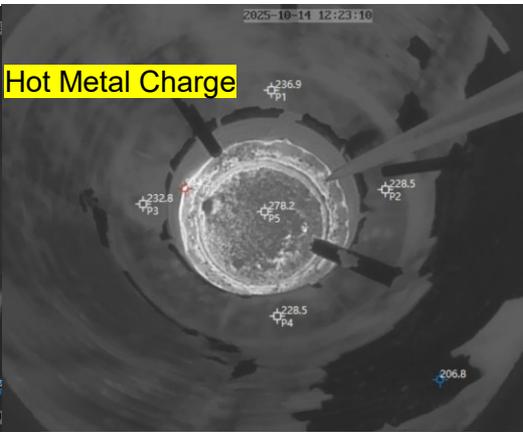
# Hlsarna pilot plant achievements: Technology

## Demonstrated:

- Maintaining a stable process at high ore injection rates
- Coal rate 726 kg/tHM at 7.5 t/h HM production
- Raw materials flexibility
  - Wide range of coal types:  
3-39% VM, 0.37-1.55% S, 5-14% ash, 58-85% fix C
  - Low grade iron ore  
Fe < 60%, Al<sub>2</sub>O<sub>3</sub> > 5%
- Recycling of BOF and EAF slag.
- Use of Hlsarna slag for cement applications.
- First injection of natural gas into the process.
- Online calculations for:
  - Slag inventory, slag viscosity, slag liquidus
  - Metal liquidus



# Hlsarna Process Stages captured – F6.04

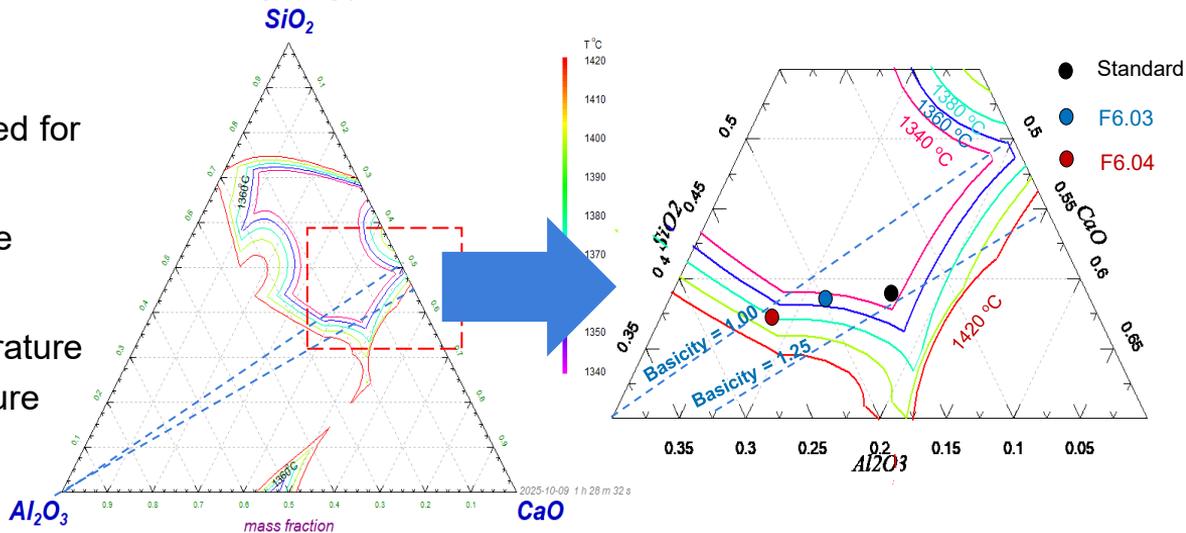


1. Live events inside the SRV captured.
2. Splashing slag in slag fountain SRV mode and production modes were captured.

# Low-grade ore

- Fe < 60% & Al<sub>2</sub>O<sub>3</sub> > 5%
- 750 tonnes of ore processed.
- New slag regime: Slag basicity lowered for high alumina slag.
  - Initial trials were done using bauxite additions<sup>[1]</sup>
  - Constant monitoring of slag temperature and viscosity vs. liquidus temperature for a changing slag composition.
- Achieved slag Al<sub>2</sub>O<sub>3</sub> concentration of nearly 25% whilst maintaining stable operation.

SiO<sub>2</sub> - CaO - Al<sub>2</sub>O<sub>3</sub> - MgO - FeO - O<sub>2</sub>  
 Projection (A-Slag-Liq), p(O<sub>2</sub>)=10<sup>-10</sup> atm, MgO/Z (g/g)=0.06,  
 FeO/Z (g/g)=0.05, Z=(SiO<sub>2</sub>+CaO+Al<sub>2</sub>O<sub>3</sub>+MgO+FeO), 1 atm



[1] D J Gavel; S Boina; C Zeilstra; A S Reddy; H K A Meijer; J W K van Boggelen;  
 Hlsama@ Ironmaking; Demonstrated Operations with High-Alumina Slag. STIS V, 9–12 December 2025, Bengaluru, India: IISc Bangalore.

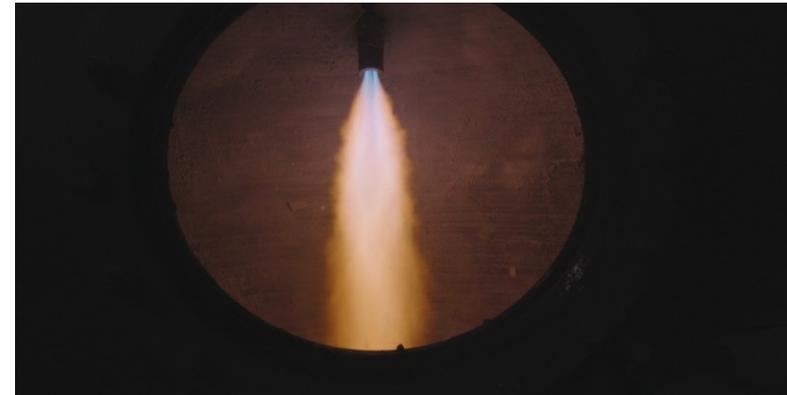
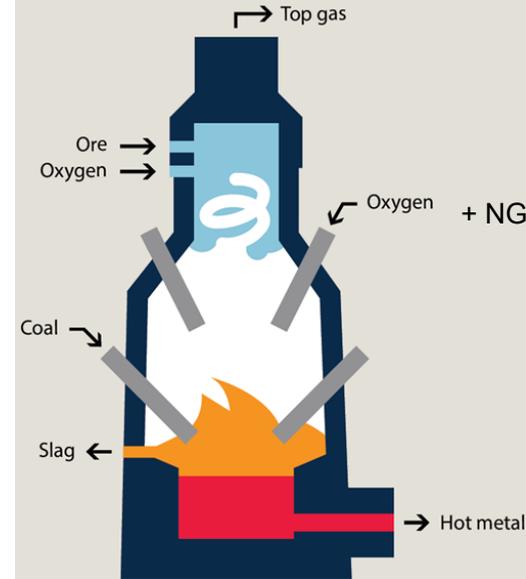
ANA Analysis Time	Slag tap Temp °C	Metal Temp °C	B2	Al2O3	MgO	Fe	MnO	Liquidus °C	Liq temp 5% solid °C	Slag Superheat °C (5% <sub>s</sub> )	Viscosity (T-Slag)	Viscosity (T-HM)
● 07:01	1,443	1,394	1.079	23.172	4.486	4.797	3.644	1,404	1,386	57	3.80	5.22
● 09:13	1,484	1,388	1.079	22.864	4.715	4.213	3.734	1,402	1,388	96	3.00	5.54
● 11:03	1,477	1,376	1.079	23.867	4.438	4.360	3.688	1,409	1,391	86	3.26	6.31
● 12:56	1,493	1,363	1.053	24.834	4.397	4.152	3.691	1,416	1,389	104	3.21	7.61
● 15:17	1,472	1,368	1.006	24.864	4.486	4.912	3.598	1,420	1,375	97	3.68	7.39

# Fossil carbon substitution

Research ongoing to substitute fossil carbon

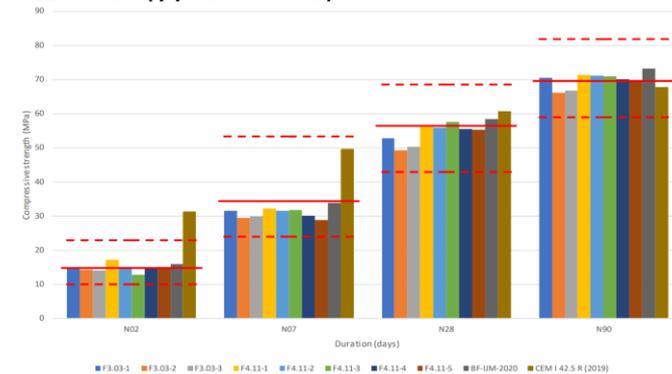
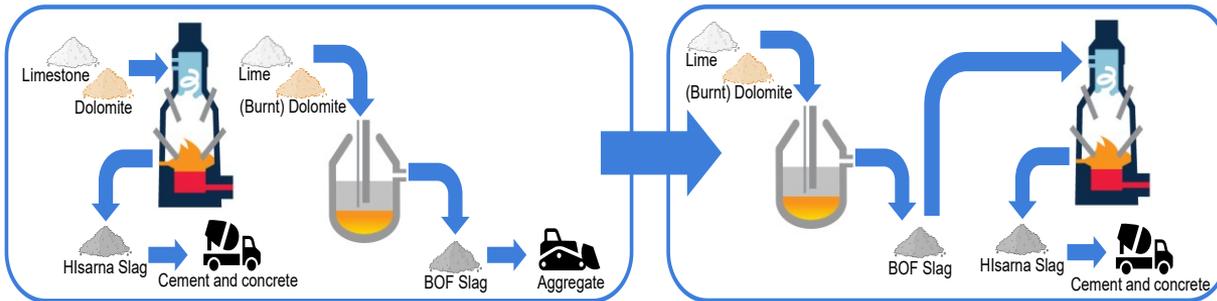
- Sustainable and renewable char/coal
  - Aiming to achieve 100% bio char use
  - Demonstrated 45% replacement of coal with bio char in the past<sup>[2]</sup>
- Part replacement of solid carbon with (bio)methane or hydrogen
  - Injection of NG in the SRV top space, together with oxygen.
  - Achieved >15% coal replacement at low production rates during first commissioning test.

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



# Increasing the value of slags

- The Hlsarna 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 BOF or EAF slag<sup>[3]</sup>.
- Benefits:
  - Reduced use of virgin minerals.
  - Moving from a low value aggregate application to a high value cement making application.
- Status:
  - Successful use of BOF slag as standard flux<sup>[4]</sup>. (800 tonnes BOF slag & 100 EAF slag processed).
  - Successful testing of Hlsarna slag in cement and concrete<sup>[5]</sup>.



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

[4] D J Gavel; S Boina; C Zeilstra; A Srinivasa; H K A Meijer; J W K van Boggelen (9 April 2025). Fluxing Hlsarna ironmaking process with steel making slag. 9th International Slag Valorisation Symposium. Leuven, Belgium: KU Leuven.

[5] C Zeilstra; J Small; C Teerhuis; A Ehrenberg; M Bruin (10 April 2025). Investigation of Slags Arising from the Hlsarna Ironmaking Process in Building Materials Application. 9th Int. Slag Valorisation Symp.. Leuven, Belgium: KU Leuven.

# Scale-up

- On 10 December 2025 Tata Steel announced that its board approved the commencement of engineering work and regulatory approval process to set up a 1Mtpa demonstration plant in Jamshedpur.<sup>[6-8]</sup>

6. Tata Steel has been operating its pilot plant on HIsarna technology for a decade in its IJmuiden plant. HIsarna technology is a low carbon technology that uses inferior quality iron ore, eliminates the usage of coke and also uses steel slag in its process, hence making it a sustainable technology for the future. In the last couple of years, Tata Steel along with a large global steel company has been jointly running trials in the IJmuiden Pilot Plant. The Board today reviewed the progress of the trials, reviewed the scalability opportunities of the technology and have given the approval to commence engineering work and to commence regulatory approval process to set up a demonstration plant around 1MTPA capacity in Jamshedpur. Tata Steel owns the global intellectual property rights of the HIsarna process technology, and this is one of the key focus areas in the new technology space for the Company.

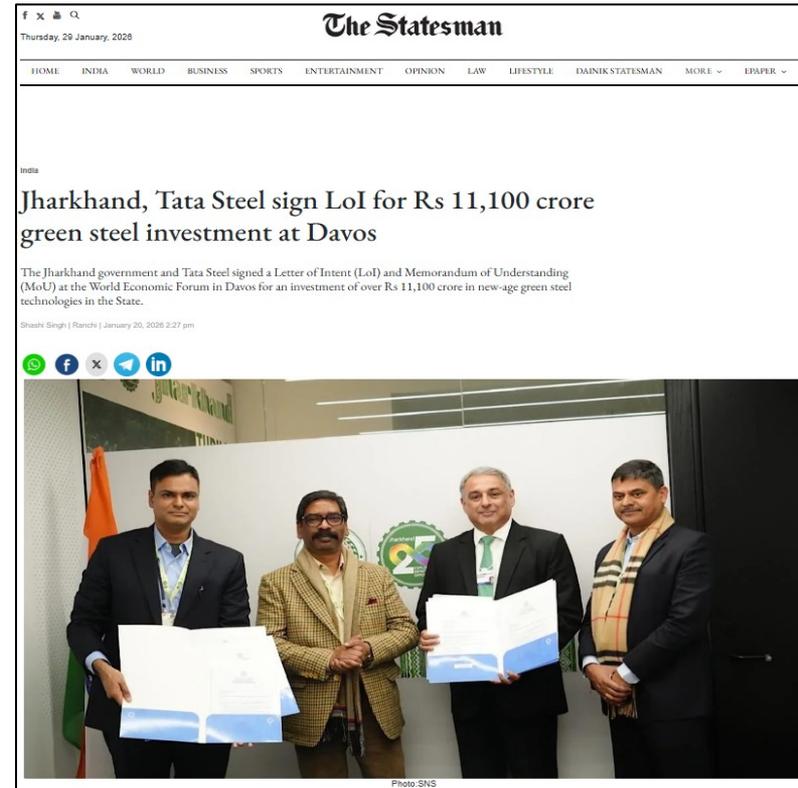
- At the 2026 World Economic Forum:
  - Jharkhand, Tata Steel sign Lol for Rs 11,100 crore green steel investment at Davos<sup>[9]</sup>
  - “...the proposed investment includes the deployment of advanced ironmaking technologies such as HISARNA and EASyMelt...”

[6] [Tata Steel Board affirms the long-term strategy for growth in India](#), Tata Steel, retrieved 12 December 2025

[7] "WATCH: Tata Steel Investor Call Pt1" (video). youtube.com. [Tata Steel](#). 11 December 2025.

[8] "WATCH: Tata Steel Investor Call Pt2" (video). youtube.com. [Tata Steel](#). 11 December 2025.

[9] [Jharkhand, Tata Steel sign Lol for Rs 11,100 crore green steel investment at Davos - The Statesman](#)



# Conclusions

- Hlsarna is a breakthrough technology offering significant environmental and economic benefits. Hlsarna will be an enabler for a sustainable global steel industry:
  - It allows a reduction of CO<sub>2</sub> emissions
  - It can be fossil free and with virtually zero stack emissions
  - In combination with CCUS it could be carbon negative
  - It enables building a circular economy
- Hlsarna offers flexibility:
  - Use of low-grade ores
  - Wide range of coal qualities
  - Use recycled slag as a flux replacement
- Hlsarna technology is ready for scale-up
  - Engineering for first industrial scale facility in Jamshedpur has started

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Contract DEI1160014

## 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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**Do you have any questions?**

**Tata Steel**

Hlsarna

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