TACOS: Towards a zero CO_2 sintering

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TACOS

Towards A zero CO_2 Sintering

847322

Speaker : Hubert FOUARGE

- Timing : 49 months duration, [June 2019, → June 2023]
- Consortium :
  - CRM (Coordinator)
  - AM Maizières
  - Tata Steel Ijmuiden
  - CSM (RINA)
  - AM Belgium (Gent plant)

Funded by the European Union

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ESTEP workshop –SecCarb4Steel – 29th of November 2024

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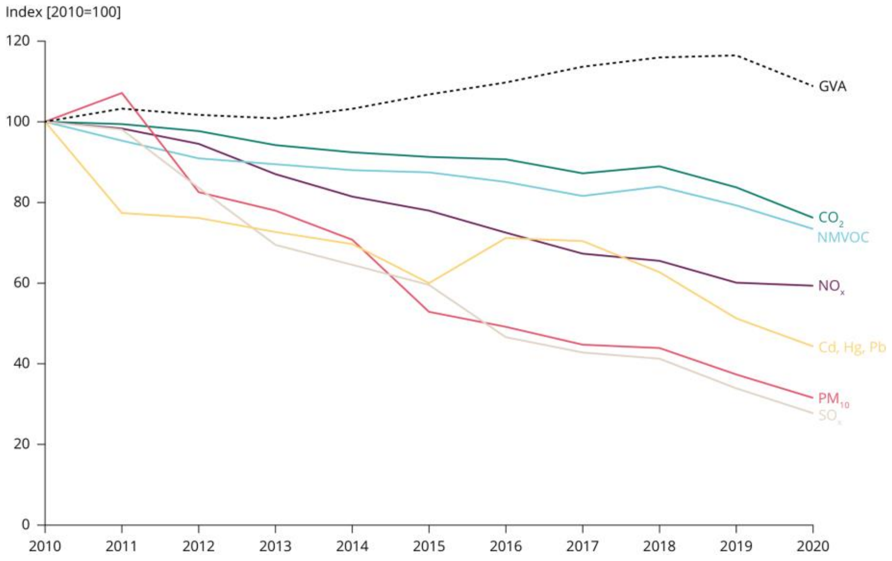
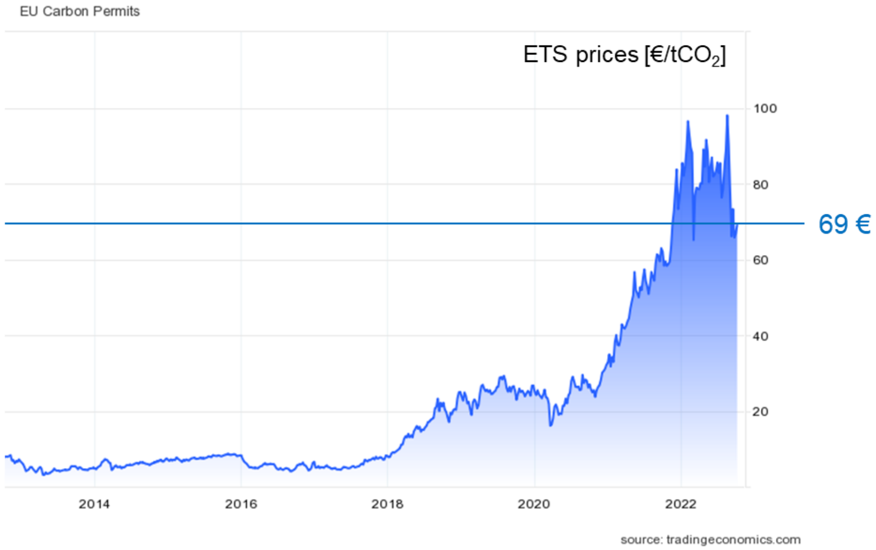
Context

- Growing environmental constraints



- Increasing CO_2 prices



➔ need for technological solutions to reduce emissions from the steelmaking industry

Figure sources: https://www.eea.europa.eu/ims/industrial-pollutant-releases-to-air
https://tradingeconomics.com/commodity/carbon

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Project Overview

In order to allow steelmakers to comply with ever stringent environmental constraints, this project evaluates Alternative heat solutions bringing significant decrease of CO_2:

- Alternative solid fuels with or without pre-treatment;
- Process modifications :
  - Combustible gases for injection at strand surface (combined with WGR);
  - Waste gas recirculation;
  - High temperature fumes produced in an external combustion chamber = VeLoSint process

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Alternative solid fuels

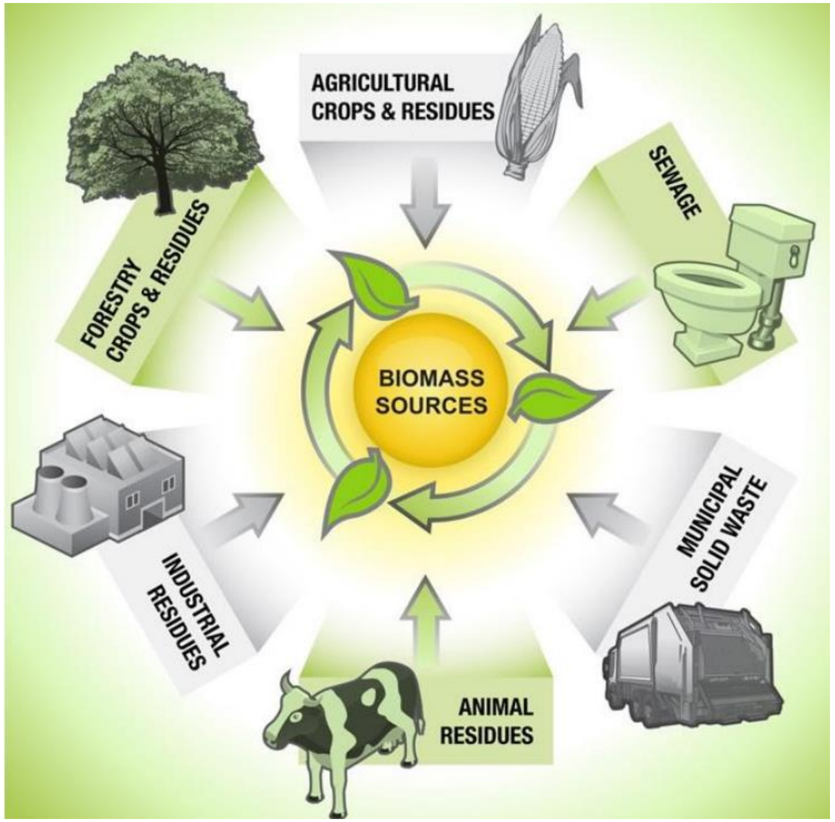
ASF =

- Waste valorisation
- Biofuels = CO_2 capture from the atmosphere

Wide range of ASF characterized :

- ✓ Residues from gasification of wood chips
- ✓ Char from thermal pyrolysis of husk (grain)
- ✓ Torrefied biomass
- ✓ Material from hydrothermal conversion of biomass
- ✓ Coffee grounds
- ✓ Residue from instant coffee production
- ✓ Eucalyptus wood (pyrolyzed wood chips)
- ✓ Various streams of urban waste

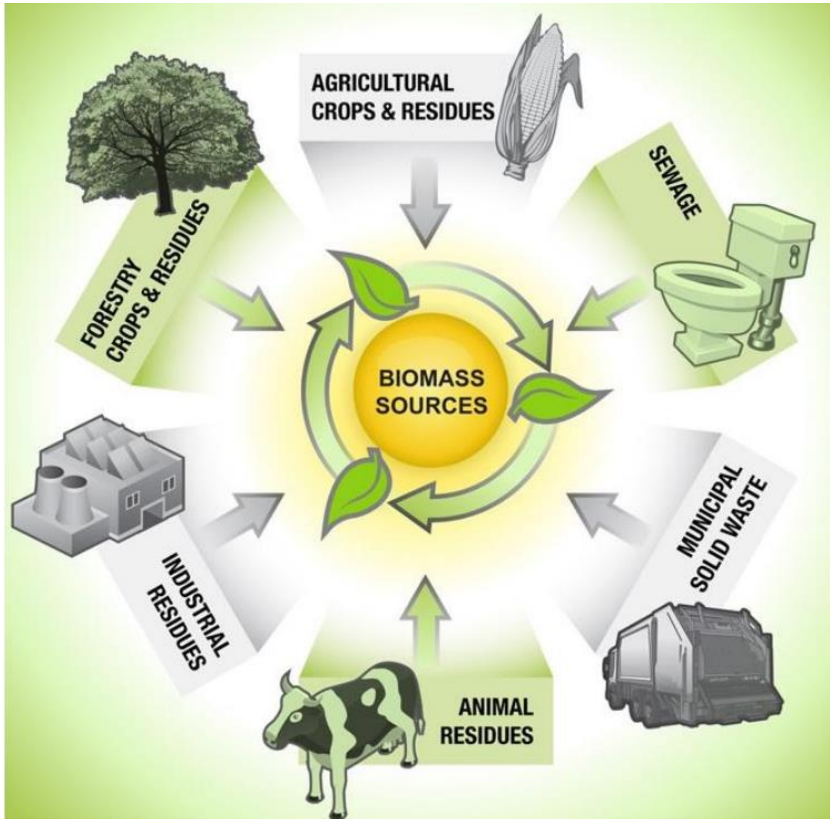
Special focus on thermal treatments to reduce volatile matter content



Alternative solid fuels

Lab characterizations ⇔ main limiting factors :

- Ignition temperature
  - ↔ homogeneous flame front
- Reactivity
  - ↔ flame front propagation speed
- Ash content
  - ↔ undesired residues that will remain in the sinter
- Volatile matter content
  - ↔carbon's valorization efficiency
  - ↔ pollutant emissions
  - ↔Fire risks in dedusting equipment



Alternative solid fuels

Sinter pot trials with

- Hydrochars
  - Fines
  - Pellets
  - Torrefied pellets
- Pyrolized biomass
- Raw needle shaped B-wood
- Pyrolized Eucalyptus flakes

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Alternative solid fuels

Pot trials - Main conclusions :

- Overall fuel consumption increased [kg_{SF} /T_{sinter}]

    ↔ Low %C in ASF

- Pyrolized Eucalyptus flakes ➔ Up to 60% fossil fuel reduction :
    - 30% fixed carbon content increase
    - 15% loading density decrease
    - 17% productivity increase
    - No sinter quality degradation

    - CO_2 : 50% decrease
    - NOx : 75% decrease
    - VOC's : 15 x more Total Organic Carbon emissions
    - SO_X : No increase but no continuous tendency

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Alternative solid fuels

Industrial trial at AMG : 3 days

- Traditional sintering (no WGR)
- ASF: pyrolized olive pits for availability reasons (100 tons)
  - At the time of the trial, there was no industrial pyrolysis solution for such volumes.
- Solid fuel blend : 10% (mass) biofuel +90% fossil fuel
  - Consumption adapted to keep quality constant
- Preliminary pot trial: 7% less CO_2 emissions, cst productivity

- Industrial trial results
  - Productivity: constant
  - CO_2 emissions: 7% reduction
  - Pollutants emissions:

NOx :	25 % decrease
SOx :	30% increase
Dioxins :	60% decrease
VOCs :	100% increase

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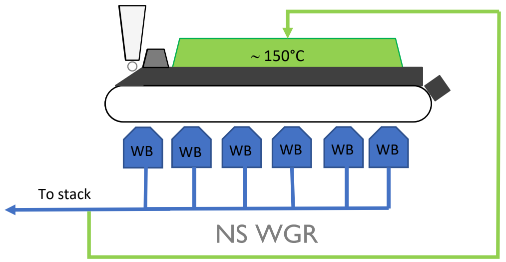
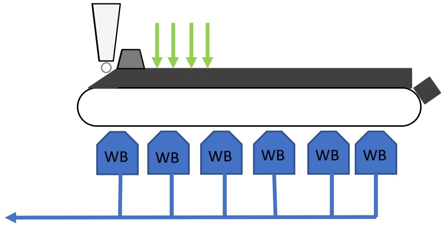
Process modifications

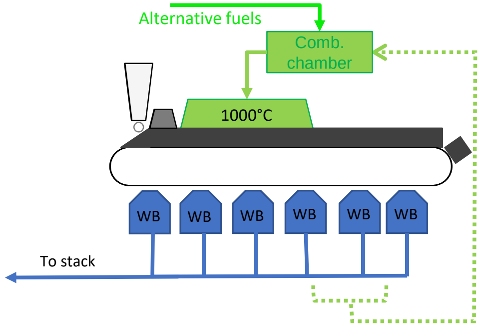
Industrial measuring campaign, modelling work and pot trials :



- Waste gas recirculation (WGR) → optimization of process parameters
  - ✓ 0 – 15% solid fuel saving



- **Fuel Gas injection** :
  - Valorization of biofuel-based gases possible
  - ✓ Case study = BF gaz injection : 10 % solid fuel saving



- **Hot fumes injection – VeLoSint process**
  - External combustion chamber => possible valorization of waste, biofuel, …
  - ✓ 35 % solid fuel saving with limited productivity drop (14%)
  - → **up to 31 % CO_2 reduction** depending on the alternative fuel used in the CC

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Fuel gas injection at strand surface

Objective = re-equilibrate process needs by injection of combustible gas at process beginning

→ additional heat input and flame front widening

Background : SuperSINTER technique "Secondary-fuel Injection Technology for Energy Reduction" with natural gas

TACOS case study : BF gas valorisation

↔ Available gas on site today

- Injection of BFG mixed with air above the sinter surface
  - 18% BFG: 17.1% O_2 / 4.1% CO_2 / 5.1% CO / 0.09% CH_4

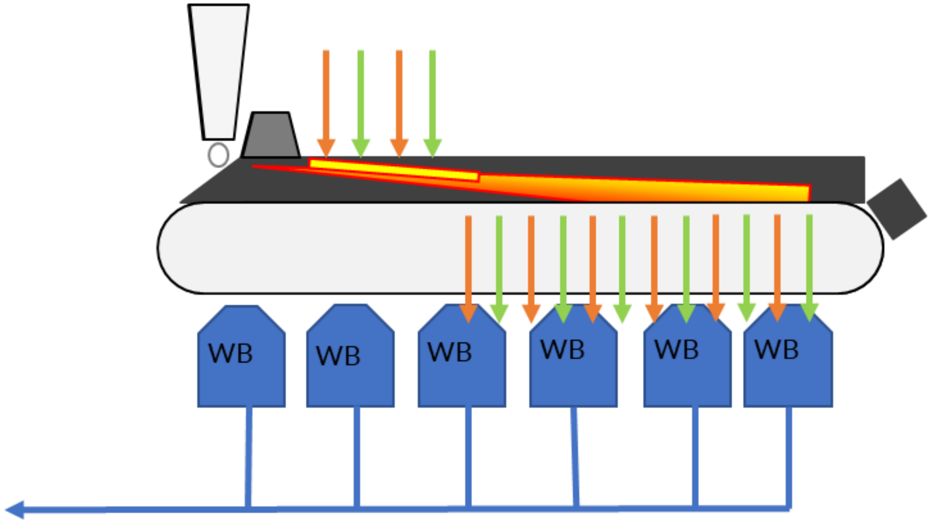
    Remark : No H_2 available at pilot station → replaced by CO

→ 10% solid fuel saving

→ Replacement rate ≈ 1 ($MJ_{fuel\ gas}/MJ_{SF}$)

→ Productivity drop (7%)

→ ~ C^{st} quality + RDI improved



Solid fuel saving	REF	6%	8%	10% *
BFG in input gas [%]	0	12.3	18	18
Injection length [%]	0	21	20	24
Productivity [t/m².day]	28.1	26.7	25.1	26.1
ISO T [%>6,3 mm]	72.6	74.1	73.9	71.4
Reducibility [%]	62,1	62,9	-	62,6
RDI [%<3,15 mm]	26,6	23,4	-	23

* return fines not recirculated

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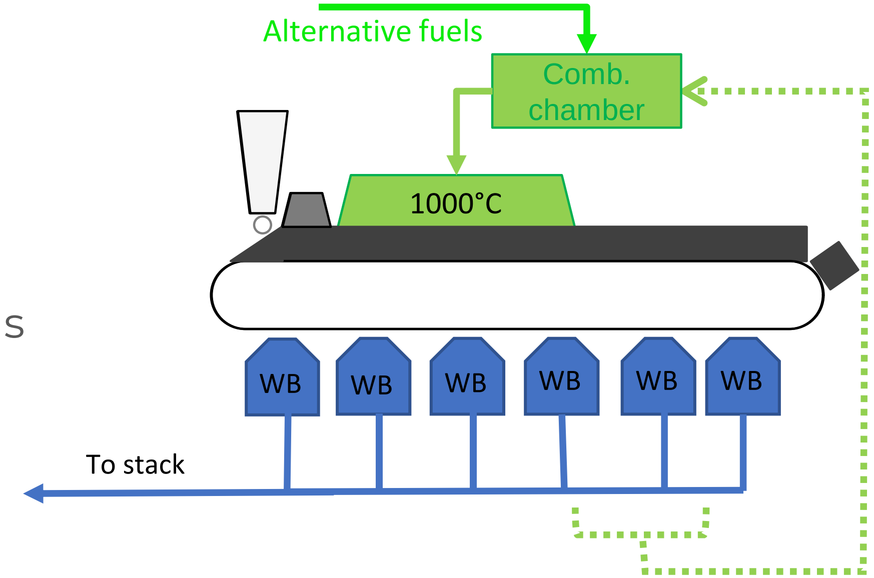
High T° fumes from external combustion chamber

VeLoSint process (Very Low CO2 Sintering) :

Objectives :

- drastically reduce CO_2 and other pollutants emissions
- flexibility regarding alternative fuels supply
  - Biomass
  - Process gases
  - Plastic, wastes
  - Electricity (plasma torch)
  - Etc.



Tools :

- Modelling : CRM's mathematical model of the sintering process
- Pot trials – gas preparation line with :
  - Gas mixture is prepared then (electrically) heated and injected onto the pot

CRM's sintering pilot station
Gas preparation line with
heating up to 1050°C

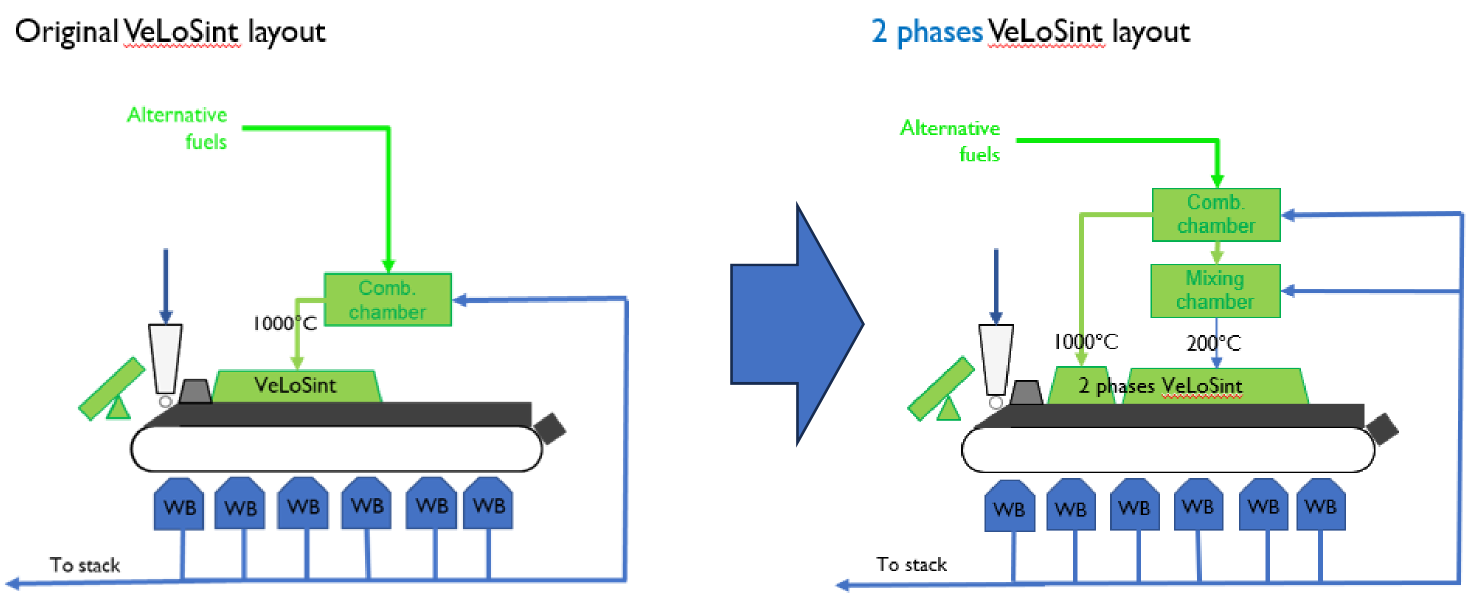
High T° fumes from external combustion chamber

Early pot trials result :

- lowering O2% increases sintering level at low solid fuel input

Modelling results (50% coverage by VL hood and -30% SF) :

- Lower O2 => slower combustion => Better synchronization of heat transfer and combustion => higher T°
- => Layout optimization then confirmation at pot trial



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High T° fumes from external combustion chamber

Pot trials results :

- 2-phase VeLoSint layout
- With 35% SF reduction
- Increased burnt lime content (2→ 4,5%)

➢ 13.6% productivity loss
➢ slightly improving reducibility and reduction strength
➢ At the expense of some cold mechanical strength

Combined with ASF, it allowed to reach

➢ 0% fossil fuel in mix
➢ 18% productivity gain
➢ Lower SOx and Nox emissions

	Ref.	VeLoSint	VeLoSint+ 100% biofuel
SF consumption [kg.t_s^{-1}]	56.1	38.9	72.7
SF reduction [%]	-	30	-22
Hood coverage [%]	-	24 + 54	41+52
Hot gas T [°C]		1000 + 200	1000 + 200
O_2 content in gas [%]		8	8
Productivity gain [%ref.]	-	-13.6	+18
ISO-T [%>6.3 mm]	74.5	65.2	72.7
RDI [%<3.15 mm]	26.6	25.3	-
RI [%]	62.1	66.0	-
Emission /T sinter			
Sox reduction	-	-7%	75%
Nox reduction	-	28%	89%
VOC increase	-	46%	828%

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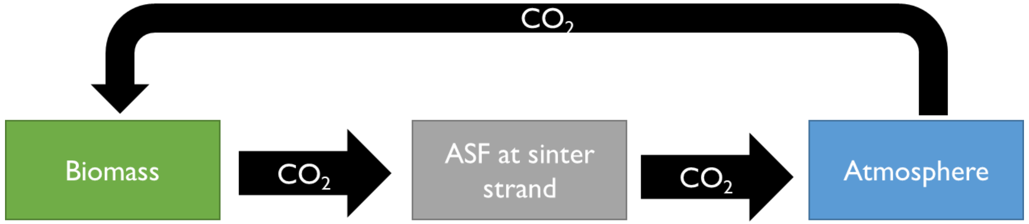
Conclusion & perspectives



Conclusion

- Some ASF are suitable for the sintering process itself, thus allowing for CO2 emission mitigation without negative impact on productivity and quality. But :
  - They can lead to increases in other pollutants
  - The economic viability of their use at the industrial scale remains to be proven since ASF would need to be about as cheap as traditional solid fuel, which was not the case at the time of the project.
- Specific layouts (VeLoSint, fuel gas injection) make it possible to valorize a wide range of alternative, renewable heat sources as well as various byproducts;

Perspectives

TRANSinter

- In the frame of the RFCS-funded project 101112600 'TRANSinter', the following solutions will (among others) be studied and beneficiate from the learnings of TACOS:
  - Replacement of fossil solid fuel by ASF produced by thermochemical treatment of low-value waste
  - A new waste gas recycling layout called Zero Emission Sintering, which allows for carbon capture at the sinter strand
    - The combination of both solutions could lead to negative CO2 emissions at the sinter strand

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