

# FUTURE PRODUCTION ROUTES FOR A DECARBONIZATION OF THE STEEL INDUSTRY AND FUTURE UTILIZATION PATHS FOR THE BY-PRODUCTS GENERATED

OCTOBER  
29  
30  
31

voestalpine Stahl,  
Linz, Austria



## ESTEP 2024 Annual Event



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K1-MET  
voestalpine

30.10.2024



European Steel Technology Platform

*20 years together*



*meets*



# AGENDA

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- » Actual situation voestalpine Stahl GmbH
- » Research focus regarding decarbonisation
- » Process internal recycling of zinc rich dusts
- » Smelter and EAF slag utilisation

# voestalpine STAHL LINZ

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- » voestalpine Stahl GmbH is operating 3 BF and 3 BOF in Linz
- » A crude steel production up to 6,0 Mio. tons per year is possible. In 2023 the crude steel production was about 5,19 Mio. tons [Relining of BF-5]
- » The CO<sub>2</sub> emissions in 2023 were 1.670 kg/t (direct emissions) and about 2.400 kg/t (including scope 2 and 3) of crude steel
- » As part of the greentec steel initiative, an EAF furnace will be erected replacing one BF, due to that investment voestalpine will reduce direct CO<sub>2</sub> emissions by around 30% by 2029 compared to 2019

# voestalpine STAHL LINZ



# voestalpine greentec steel

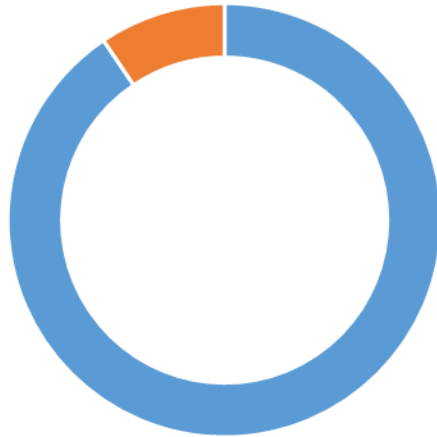
## RESEARCH PRIORITIES



- » voestalpine is conducting research on various **breakthrough technologies**
- » Focus on **Carbon Direct Avoidance (CDA) projects** (CO<sub>2</sub> avoidance):
  - » **HYFOR**: Pilot plant for the reduction of (ultra)-fine iron ore fines using hydrogen at voestalpine Stahl in Donawitz
  - » **SuSteel (Sustainable Steelmaking)**: CO<sub>2</sub> neutral production of crude steel using **hydrogen plasma** at voestalpine Stahl in Donawitz
  - » **H2FUTURE**: hydrogen PEM electrolyser pilot facility in Linz

# HOT METAL VS. DRI PRODUCTION 2023

Hot metal vs DRI production 2023 [%]

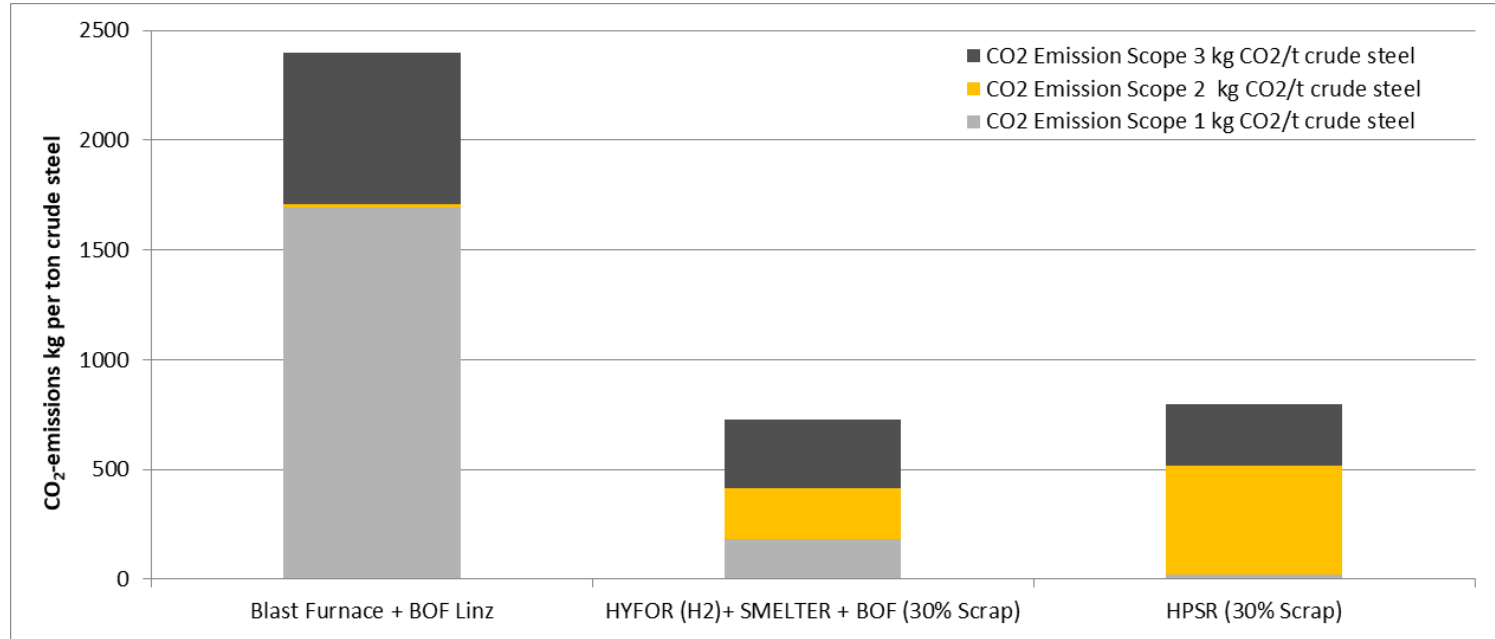


■ Hot metal ■ DRI

- » In 2023 about 135.5 Mio. tons of DRI were produced
- » The hot metal production ~ 1.3 bn tons hot metal were produced in 2023
- » Only **9.4%** of the iron ores are reduced with direct reduction

# REDUCTION PROCESSES

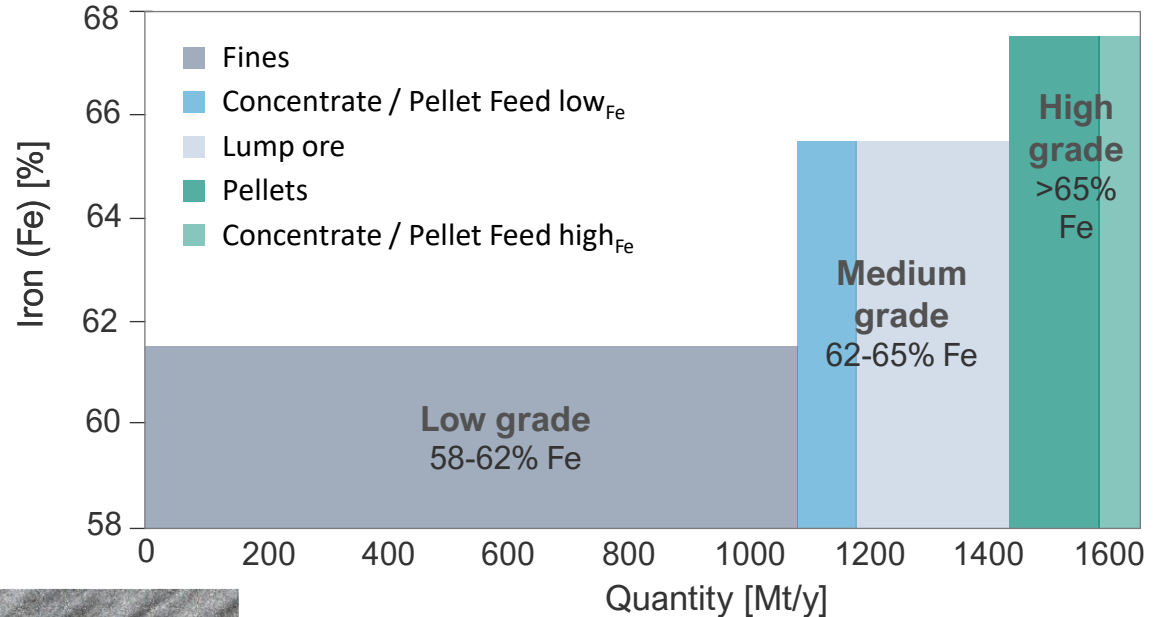
## COMPARISON OF CO<sub>2</sub> EMISSIONS



HPSR...Hydrogen Plasma Smelting Reduction

# WHY DO WE THINK ABOUT ALTERNATIVES TO FIXED BED REDUCTION AND EAF OPERATION?

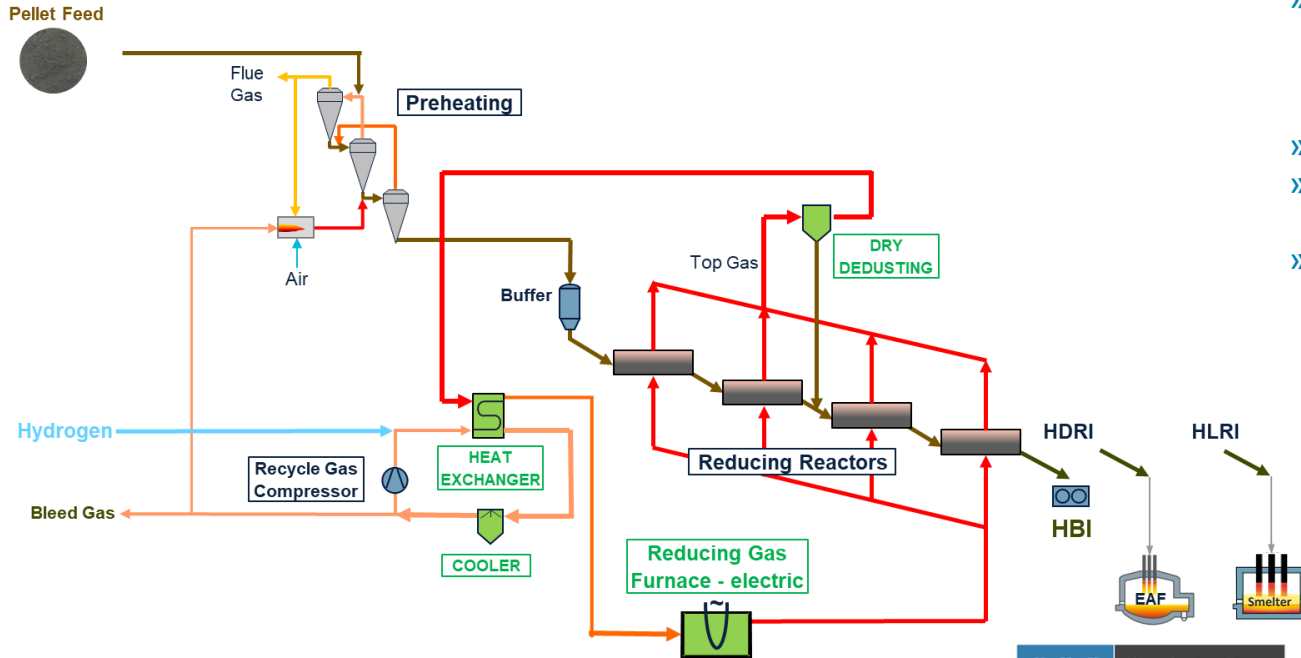
- » Global iron ore market is dominated by low and medium grade iron ores
- » High grade sea born iron ores are available in limited quantities
- » 75% of all beneficiated iron ores are fines





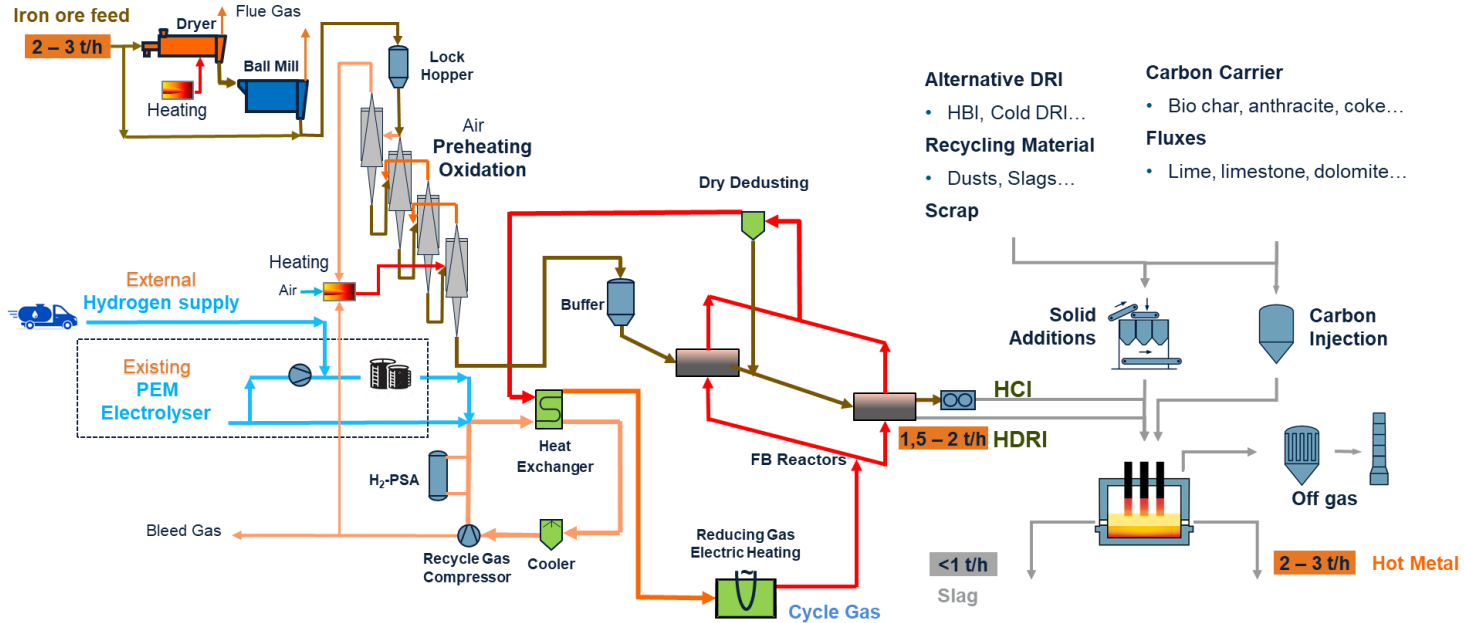
# HYFOR PROCESS

## H<sub>2</sub>-BASED FLUIDISED BED REDUCTION OF FINE ORE

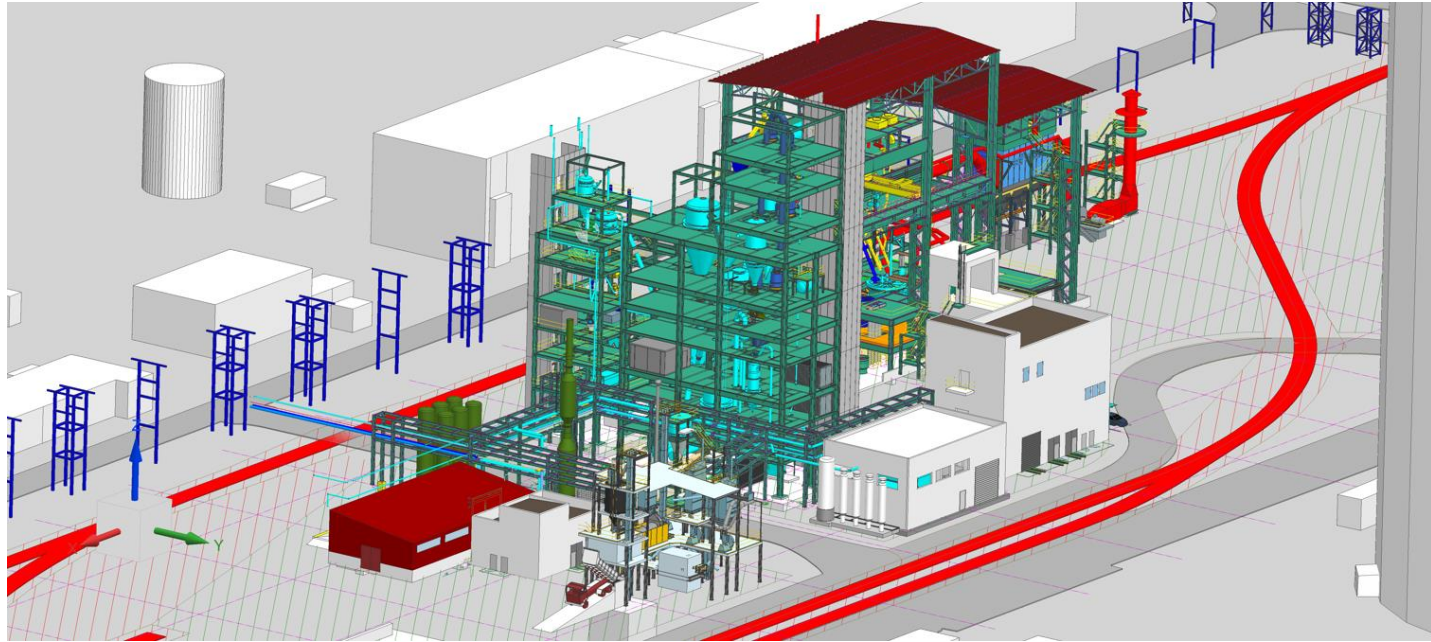


- » Cross current fluidised bed reduction process
- » Reduction temperature appr. 700°C
- » Feed material: Pellet feed
- » Product: (DRI) HBI metallisation > 90%
- » Reducing agent: Hydrogen (steam reforming or electrolysis)

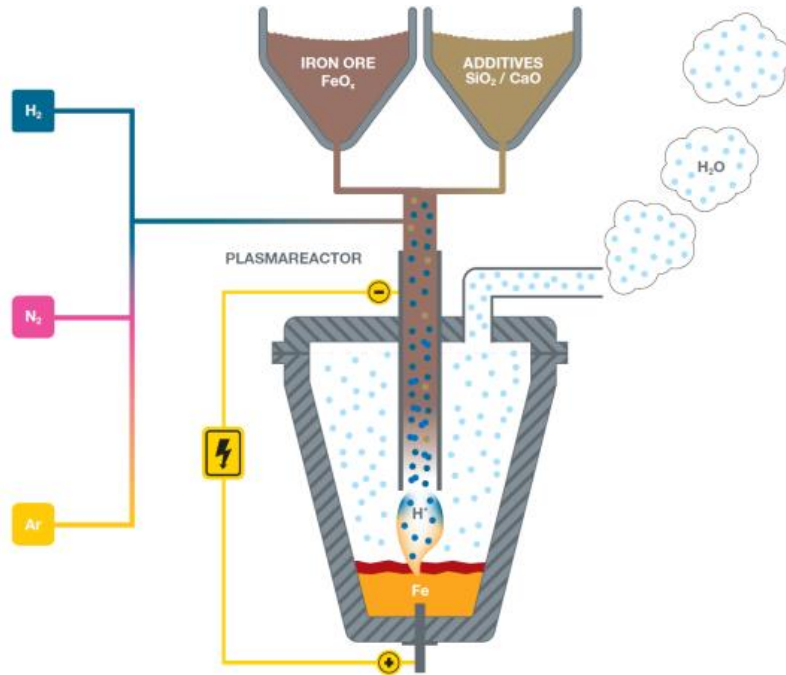
# NEXT STEP ENGINEERING Hy4Smelt PLANT



# DECISION REGARDING PROJECT REALISATION END OF 2024 – ERECTION 2025 – 2026?



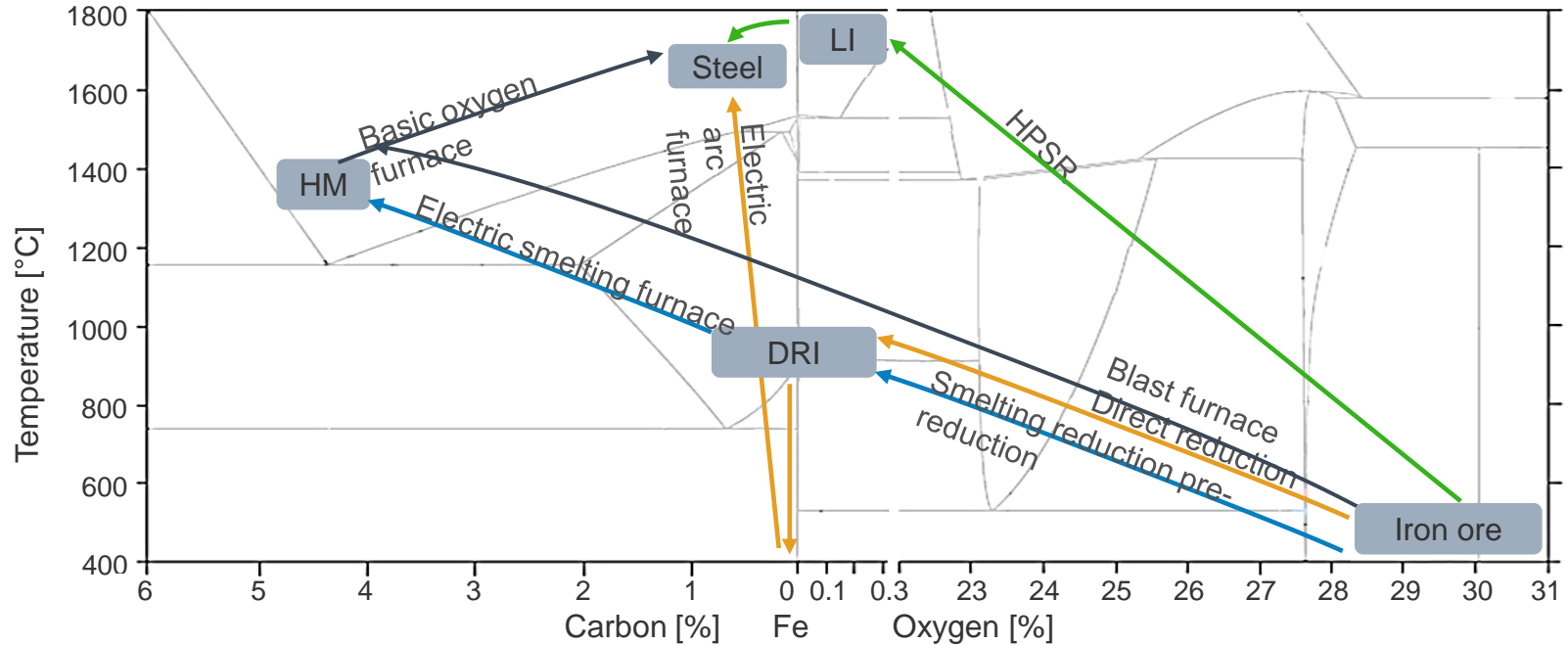
# HPSR PROCESS



- » Demo plant at the voestalpine Stahl Donawitz site in Leoben
- » Production rates of up to 250kg/h – batch operation
- » Usage of sinter and/ or pellet feed
- » One process step from iron ore to crude steel

# HPSR PROCESS

## FROM IRON ORE TO LIQUID IRON IN ONE STEP



# HPSR PROCESS

## DEMO PLANT voestalpine STAHL DONAWITZ



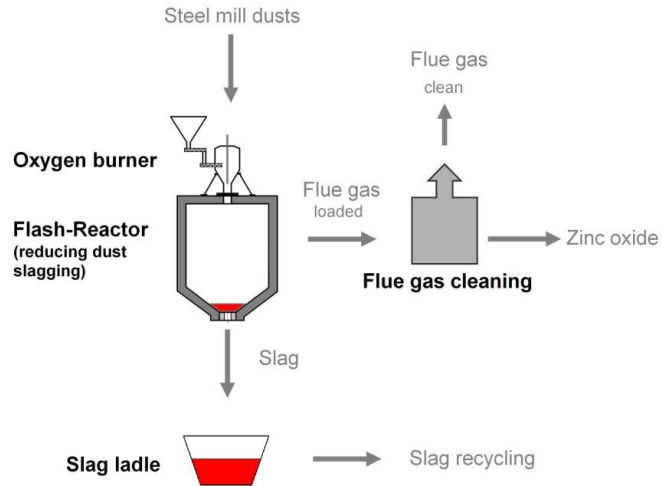
# RECYCLING STRATEGIES

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- » At the moment most by products (iron rich dusts, mill scale, own/production scrap) can be reduced process internally
  - » Especially zinc rich dusts are an unsolved recycling problem
  - » Due to the planned replacement of the blast furnace, the slag from a future Smelter will have to be recycled
  - » The recycling of EAF slag is also in focus of research activities

# RecoDust PROCESS

## AS PART OF THE ReMFra PROJECT



### Process principle

- » Selective evaporation
- » Reducing atmosphere is provided by a natural gas/oxygen burner with an air ratio below 1
- » Substitution of natural gas with hydrogen possible

### Motivation

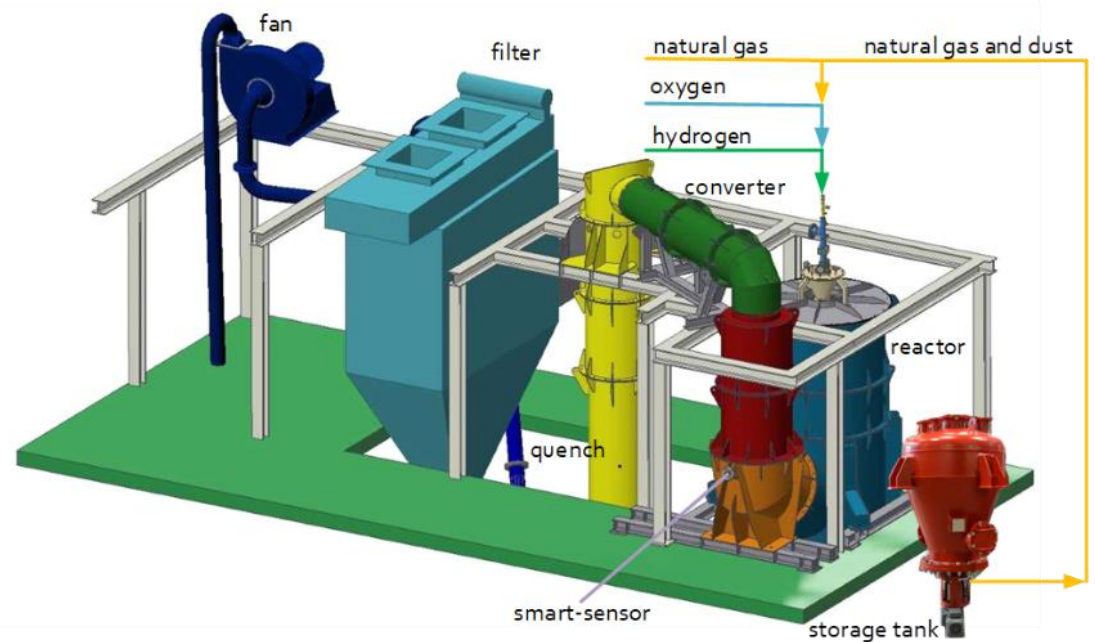
- » Recycling of residues from integrated steel plants (especially converter dust)
- » Reuse of iron and zinc
- » Save costs
  - » Landfill costs
  - » Processing costs
  - » External treatment
- » Resource conservation



# RecoDust PROCESS

## RecoDust pilot plant

- » At the Chair of Thermal Processing Technology, Montanuniversitaet Leoben
- » Dosing rate up to 250 kg/h
- » One batch up to 250 kg
- » Tapping discontinuously



# RecoDust PROCESS

## PRODUCTS & CHEMICAL ANALYSIS OF TWO TRIALS

- » RecoDust slag (RDS)
  - » Iron ore substitute
  - » Hard material, not leachable



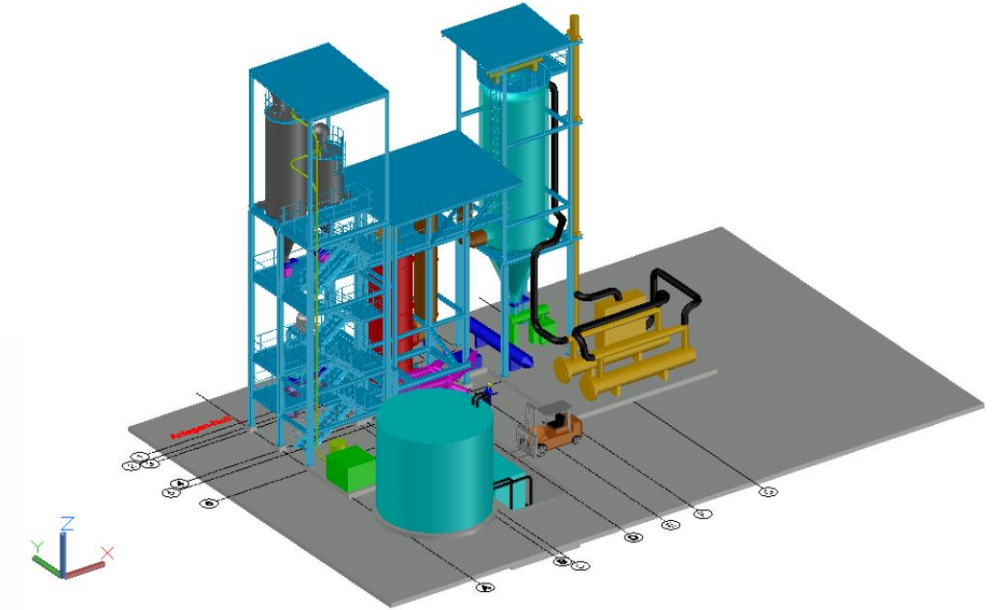
- » Crude Zinc Oxide (CZO)
  - » Secondary zinc resource
  - » Washing process to remove halides



Feedstock	ZnO	Fe <sub>tot</sub>	CaO	MgO	Cl
100% BOFD	23.40	47.19	8.5	1.8	0.01
Trial	Zn	Fe <sub>tot</sub>	CaO	MgO	Cl
K15-7 RDS	0.22	52.39	10.66	2.17	0.001
K15-7 CZO	64.50	10.58	0.76	0.18	0.319
K15-8 RDS	0.216	48.20	9.93	2.07	0.001
K15-8 CZO	68.10	7.91	0.48	0.10	0.370

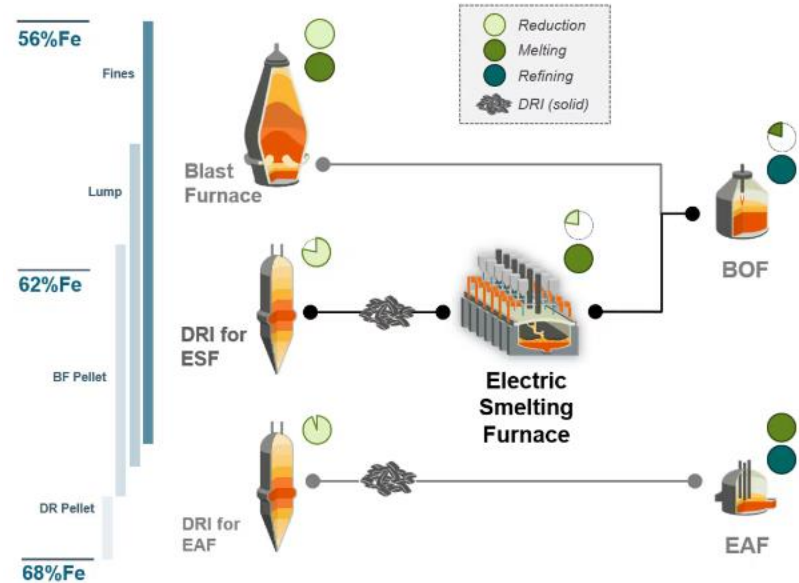
# RecoDust PROCESS – SCALE UP

- » Layout of an industrial scale plant with a dosing rate of 1 t/h
  - » 2 dust silos
  - » Hot gas filter for steam production
  - » Wet slag granulation of the RDS



# SLAG TREATMENT

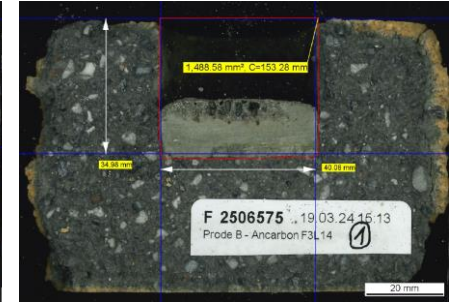
- » Due to the change of metallurgical processes also the by products will change
- » Smelter slag with a basicity of about 1.1 [-] is considered to be a substitute for BF slag as input material in the cement industry
- » Research projects are ongoing to produce Smelter slag in lab scale
- » EAF slag could be used in road construction
  - » EAF slag has excellent mechanical properties, making it a strong and durable material for road construction
  - » Limitations in heavy metal content have to be considered



Source: [Pathways to decarbonisation episode seven: the electric smelting furnace \(bhp.com\)](https://www.bhp.com)

# SLAG TREATMENT

- » Crucible test were done to find out the best suitable refractory material for Smelter operation
  - » 50/50 (fused) MgO and Al based refractory with carbon bond
- » Smelter tests will be done in a one ton DC furnace
- » Produced Smelter “slag” will be analysed if it is usable in cement industry



# OUTLOOK

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- » There are many research activities ongoing reducing the carbon footprint of the steel industry
- » Till now the BF/ BOF route is still state of the art to produce steel out of iron ores
- » Recycling will become an even more important topic due to the fact that for example a sinter plant won't be operated in a "future" steel shop
- » The transformation of the steel industry is ongoing but we are just at the beginning

# Thank you!

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ONE STEP AHEAD.