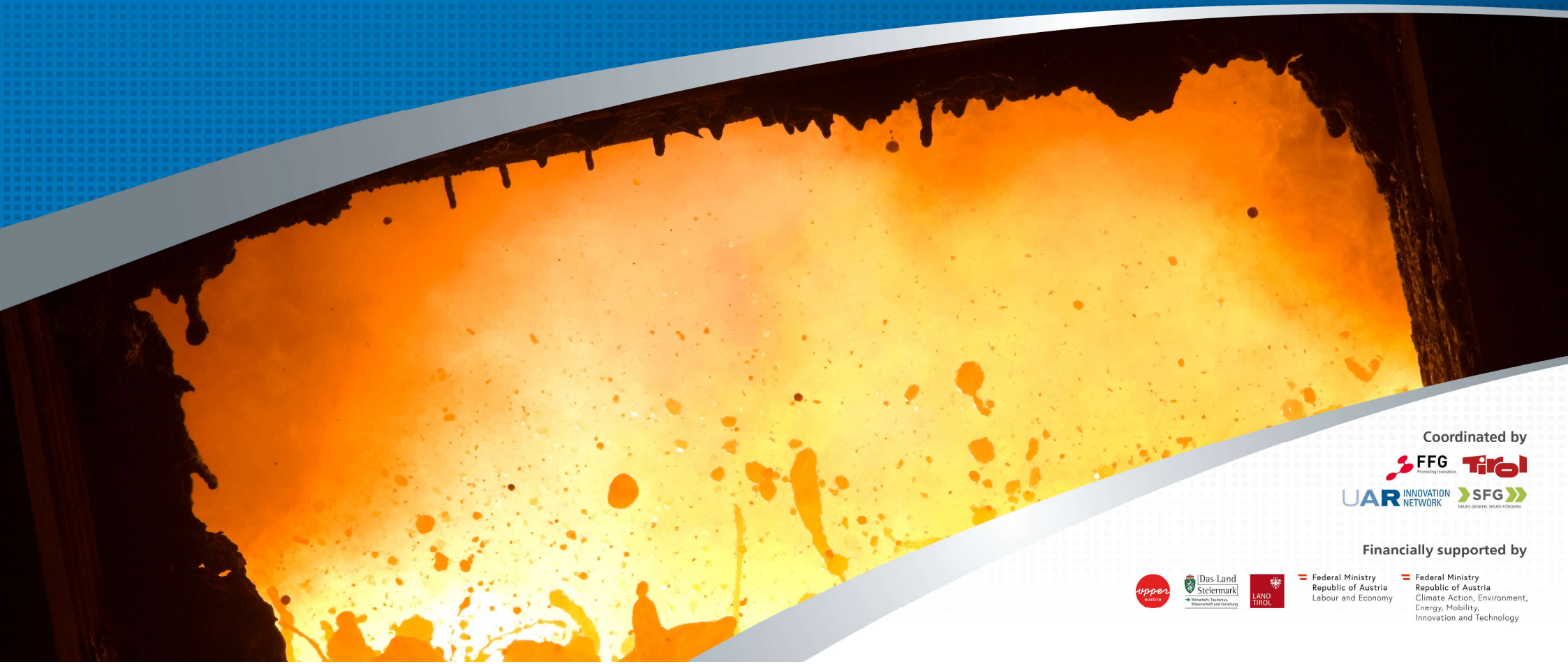
Climate Neutral Steelmaking

Linz, November 27th, 2023

Michael Zarl

metallurgical competence center



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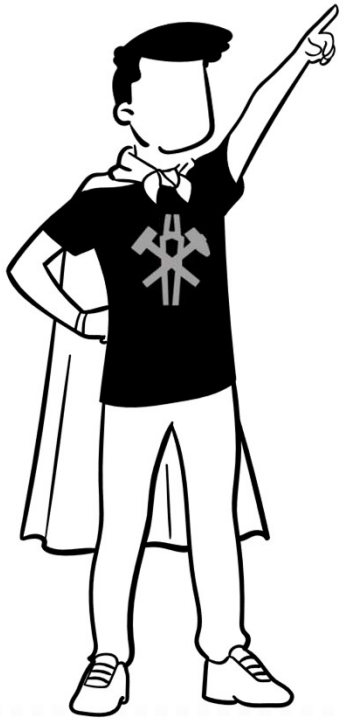
Mitigation Strategies

Overview of CO_2 mitigation pathways

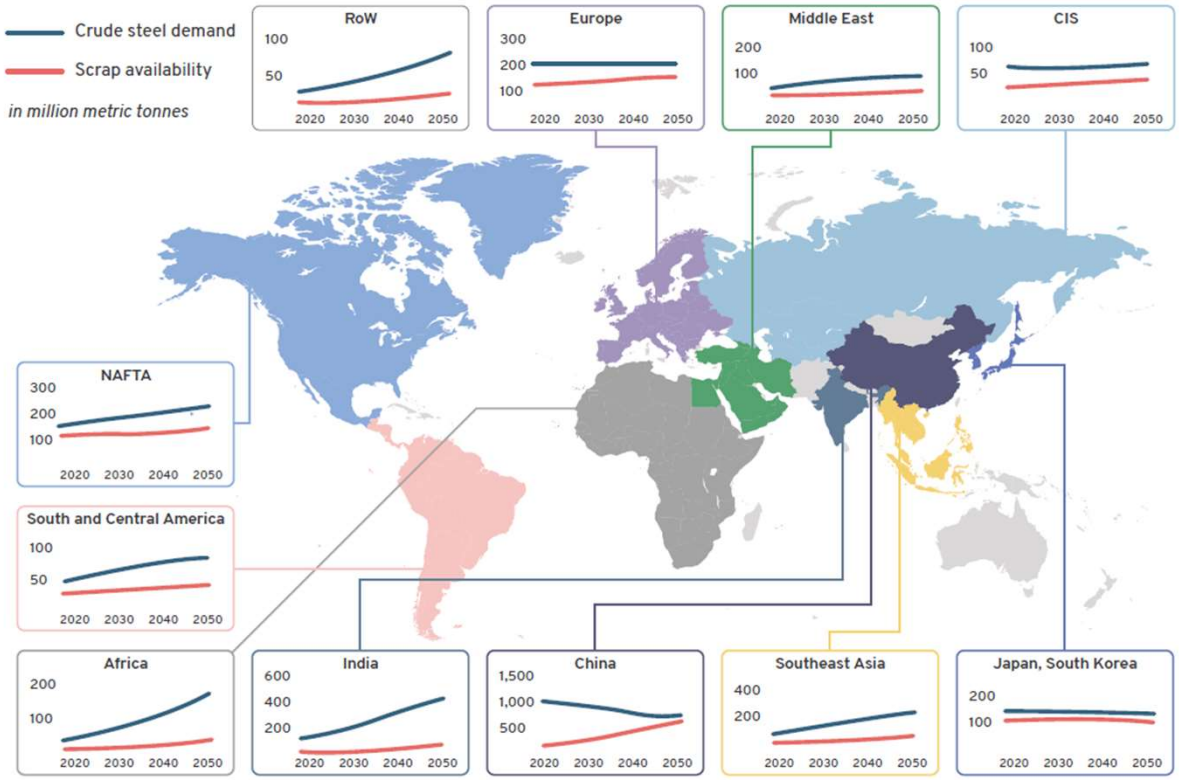
Pathways / Groups	Description	Initiatives
Circular Economy	Enhancing the recycling of steel (e.g. scrap in BOF/EAF) and its by-products, Resource efficiency	
Smart Carbon Usage (+CCS)		
Process Integration with reduced use of carbon (+CCS)	Integration of process steps and internal use of process gases	HIsarna, TGR-BF-Plasma (IGAR), PEM, STEPWISE,
Carbon Valorisation / Carbon Capture and Usage (+CCS)	Using CO/CO_2 from steel mill as raw material (chem. conversion of CO/CO_2)	Steelanol, Carbon2Chem, FReSMe, Everest, Carbon2Value
Carbon Direct Avoidance		
Hydrogen-based metallurgy	Use of renewable electricity in basic steel-making e.g. production of H_2 to replace carbon	HYBRIT, H2Steel (H2Future, **SuSteel**, Hybrid Steel Making), tkH_2Steel, GrInHy, SALCOS, Hydrogen Hamburg, SIDERWIN
Electricity-based metallurgy		

Why don‘t we use only scrap-based processes?



Technology development OBM

Global trend for scrap availability



https://missionpossiblepartnership.org/

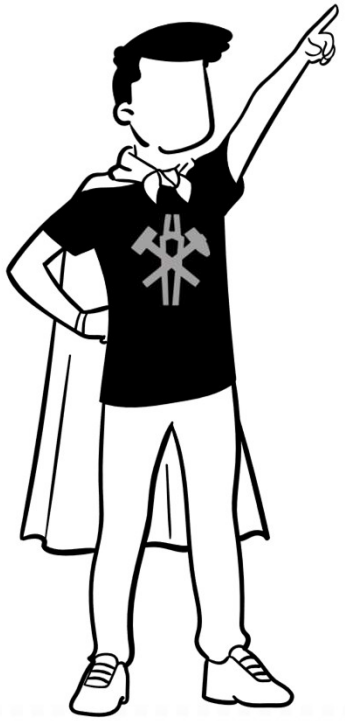
- Crude steel demand will be 30 % higher in 2050 than it is today
- Much of this growth will be in emerging economies with declining demand in China, Europe, Japan, and South Korea
- Contribution of scrap in the total steel charge will likely grow to 40 % in 2050 from 30 % than today
- Process technologies for OBM (ore based metallics) will have an important role in future CO_2 neutral steelmaking

Got a little Metallurgist in you?

Exploring Pressing Questions

WIVA P&G Energy Model Region
SuSteel follow-up
K1 MET metallurgical competence center

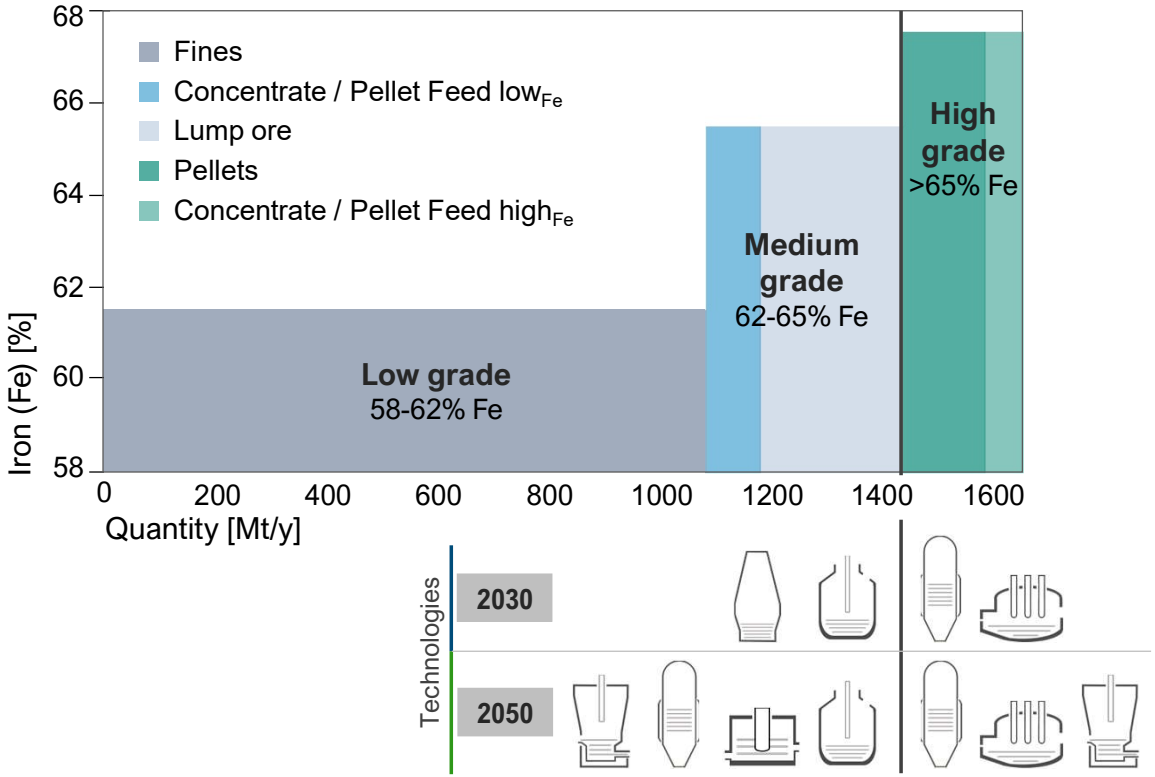
Why don‘t we only use ~~scrap based~~ high grade ore processes?



Technology development OBM

Iron ore qualities

- 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



Got a little Metallurgist in you?

Exploring Pressing Questions

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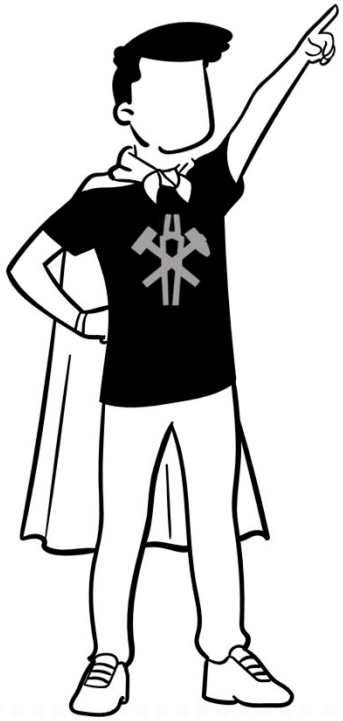
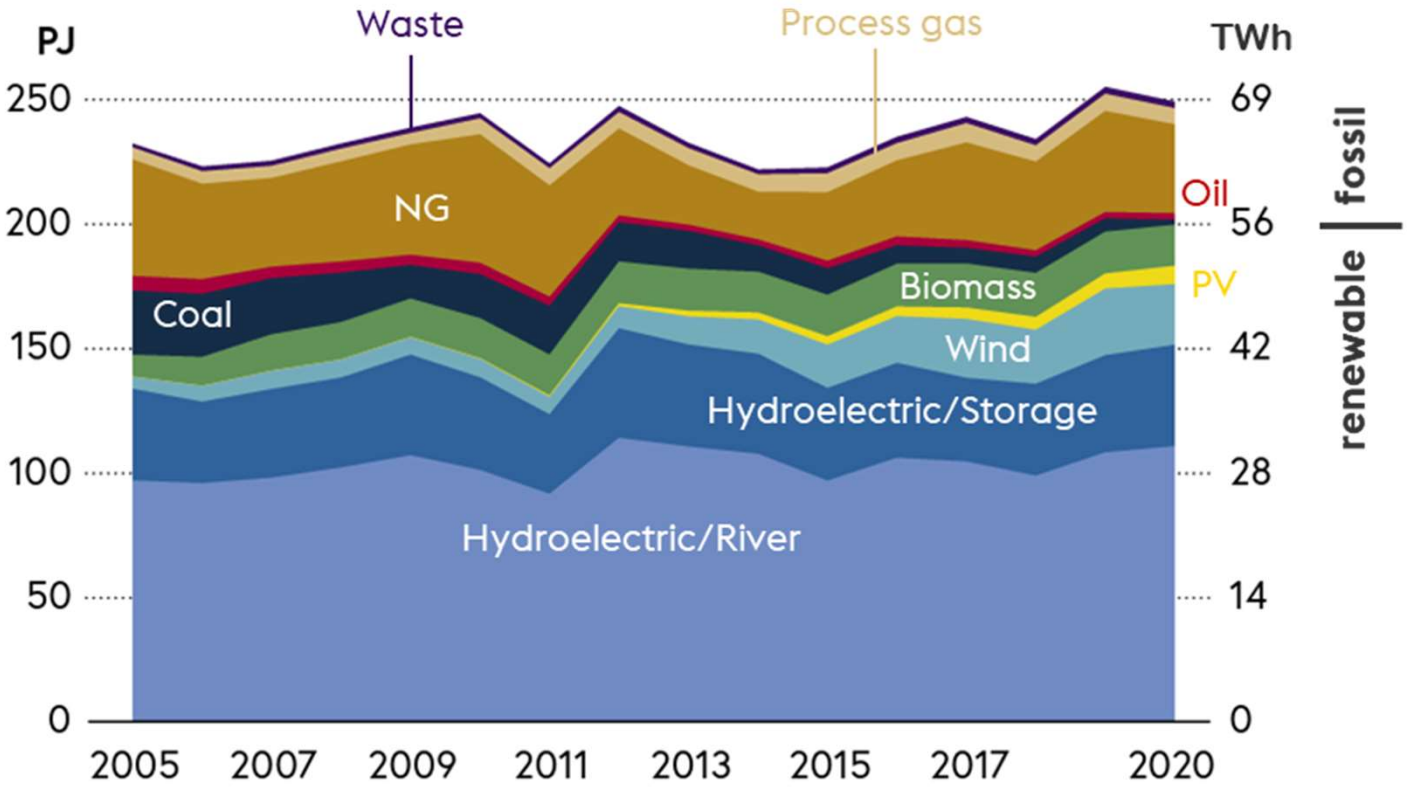
Why don‘t we just use ~~scrap based~~ ~~high grade ore~~ hydrogen based DR-processes?



Replacement of fossil energy

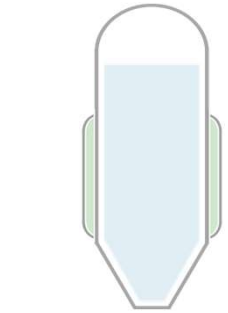
Electricity demand for climate neutral steelmaking

Electric energy production in Austria



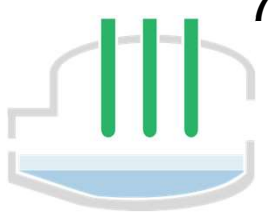
https://www.bmk.gv.at/themen/energie/publikationen/

Electric energy demand for 6,0 Mt steel/a



18 TWh_{el}
H_2 DRI

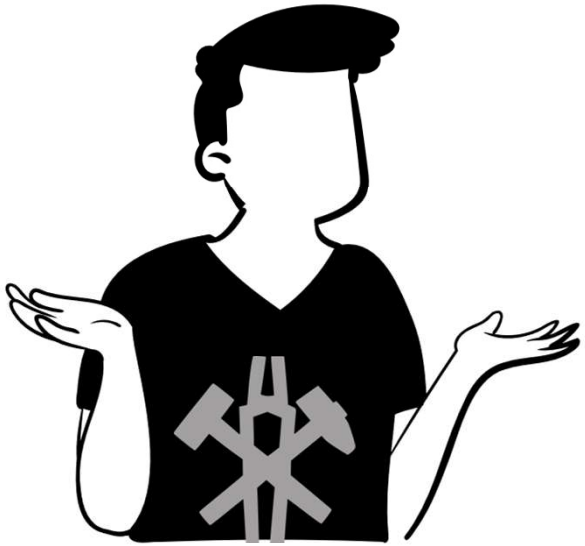
DRI/Scrap
75/25



2,5 TWh_{el}
75/25

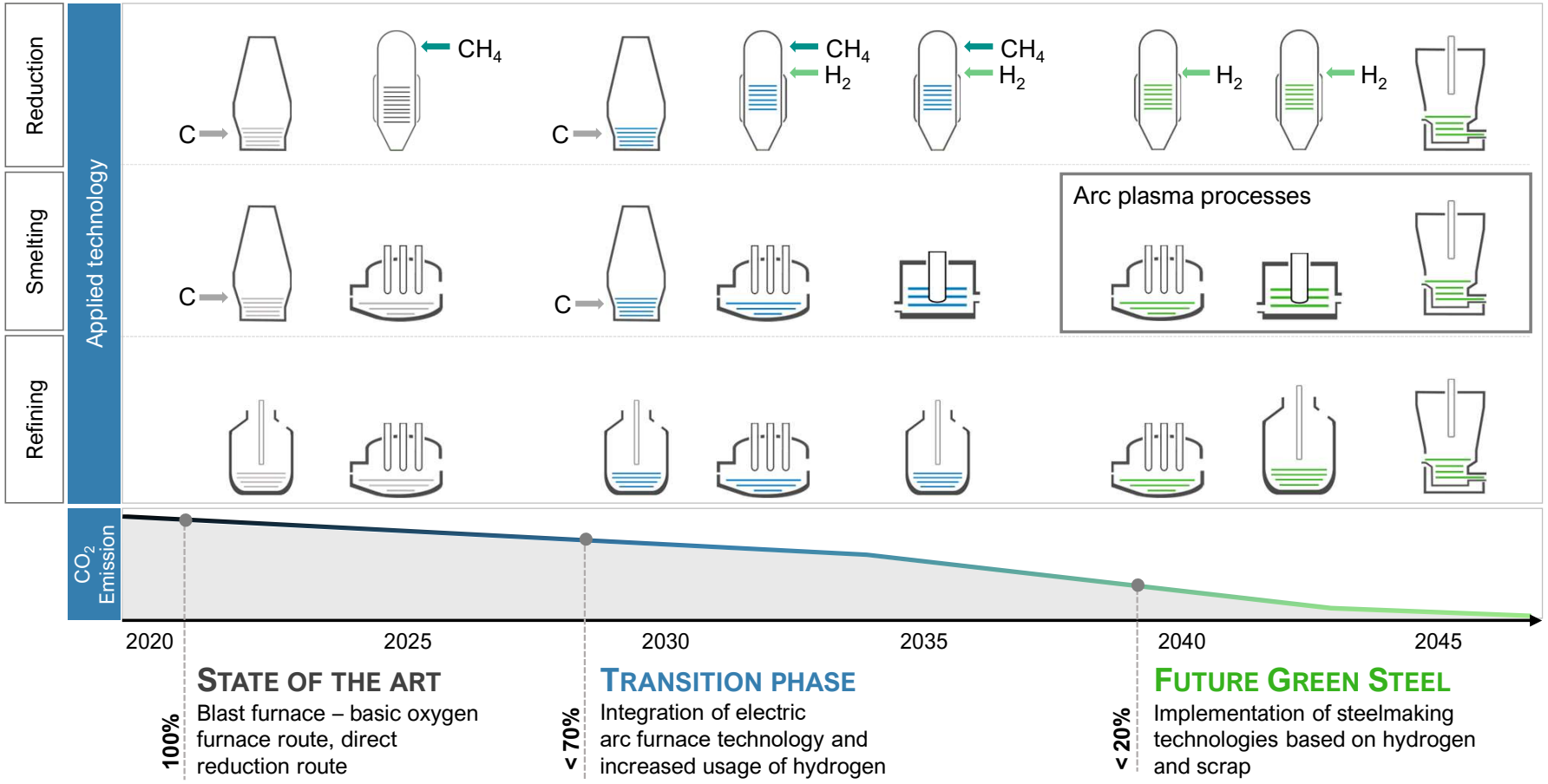
7,5 TWh_{el}
Downstream processes

So what to do?



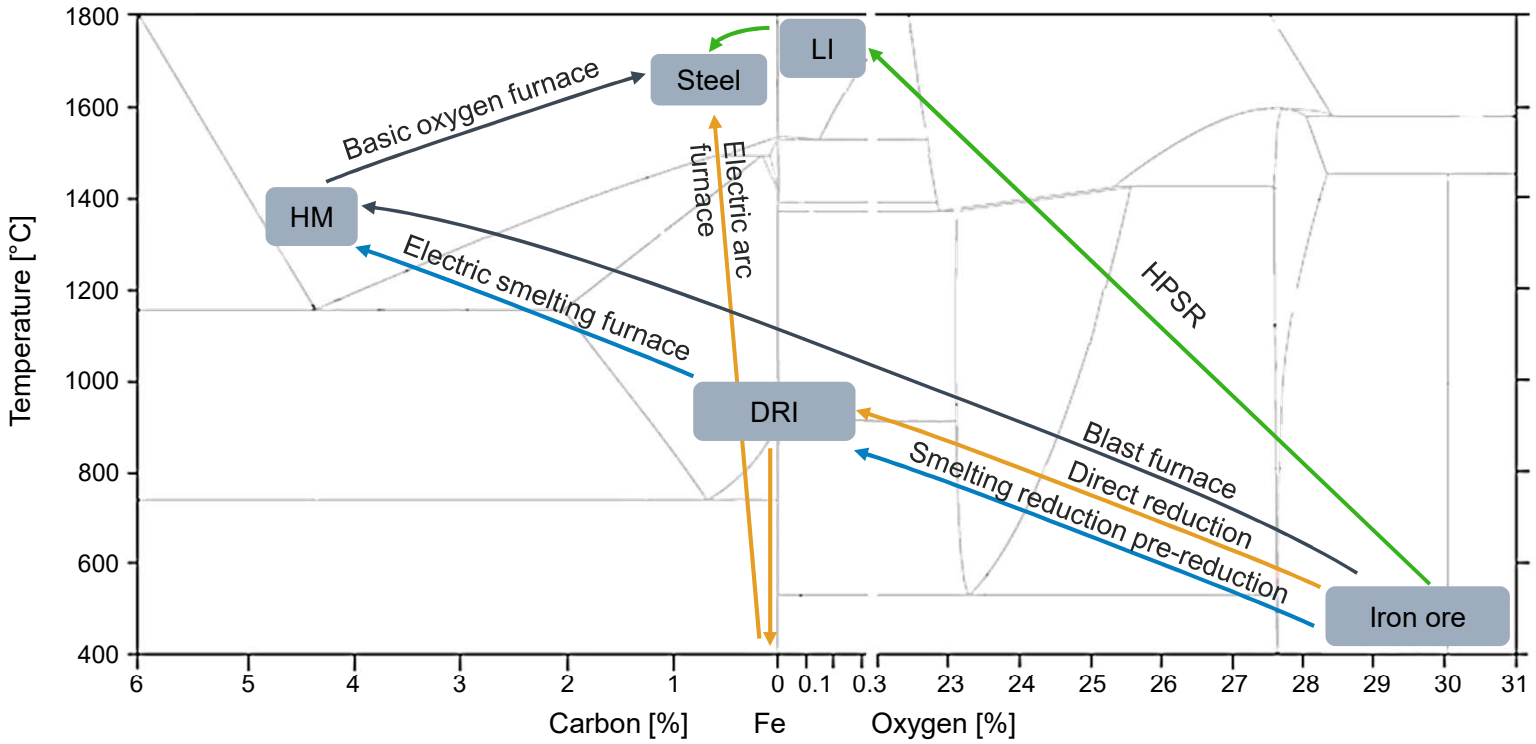
How is steel going to be produced?

Transition process towards green steel



Steelmaking process routes

From iron ore to crude steel



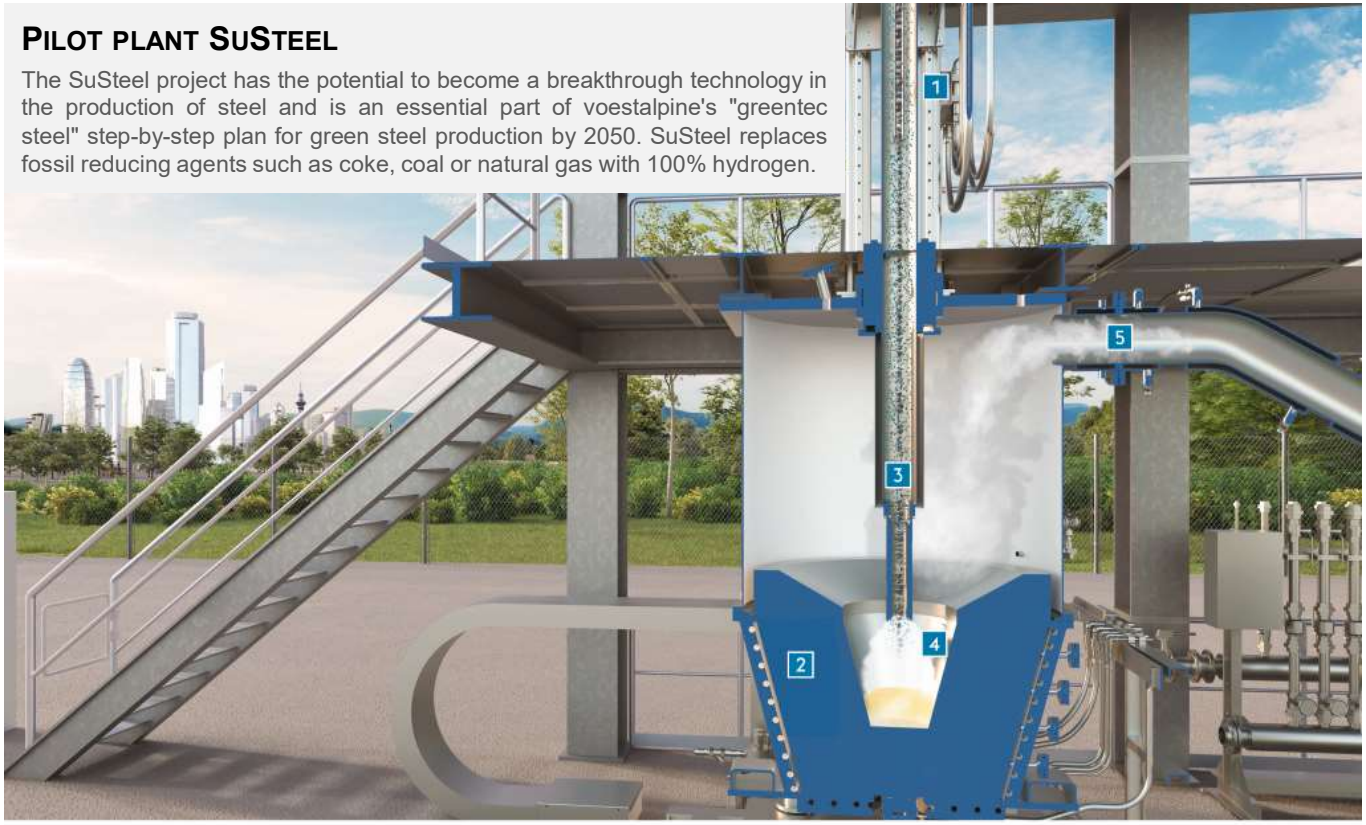
DRI … direct reduced iron
HM … hot metal (pig iron)
LI … liquid iron (steel-like liquid product)
HPSR … hydrogen plasma smelting reduction

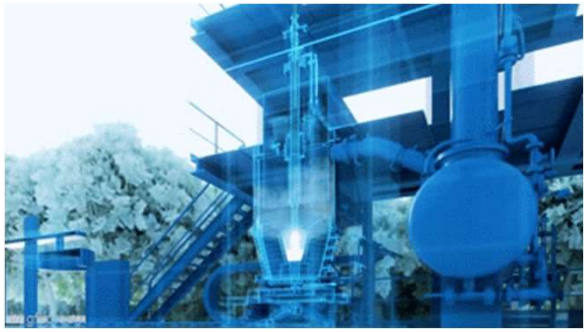
Process development SuSteel

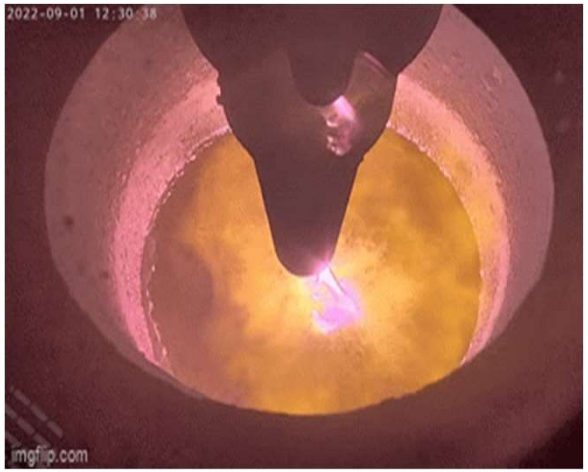
HPSR process in detail

PILOT PLANT SUSTEEL

The SuSteel project has the potential to become a breakthrough technology in the production of steel and is an essential part of voestalpine's "greentec steel" step-by-step plan for green steel production by 2050. SuSteel replaces fossil reducing agents such as coke, coal or natural gas with 100% hydrogen.







1 **HYDROGEN AND IRON ORE SUPPLY**
Hydrogen and iron ore are fed to the plant.

2 **ELECTRIC ARC FURNACE**
The DC electric arc furnace is the heart of the plant. The reactions take place in the transferred arc.

3 **ELECTRODE**
Iron ore and hydrogen enter the reaction zone of the arc via a hollow electrode.

4 **REACTION ZONE**
Hydrogen is ionised into plasma and the iron ore is melted and reduced in one step. Crude steel is produced.

5 **END PRODUCT: WATER VAPOUR**
At the end of the process, only water vapour escapes. CO_2 emissions are fully avoided.

Hydrogen plasma smelting reduction pilot

Process developement Sustainable Steel (SuSteel)

- Fundamental research project for direct steelmaking from iron oxides with H_2 plasma smelting reduction (HPSR)
- Verify of process concept with batch operation in a DC electric arc furnace (EAF) with 250 kVA
- Upscaling of the technology from 100 g to 50 kg tapping weight
- Creating design parameters for an increased reactor size and continuous operation
- Demo plant for this breakthrough technology is located at voestalpine Donawitz site

SuSteel pilot plant

Process development SuSteel

Commissioning of the pilot plant

CHRONOLOGICAL DEVELOPMENT IN PICTURES

MILESTONES

Plant
Plant erected

Trials
Stable trials

Production
First pure iron produced

Charging
Charging higher loads

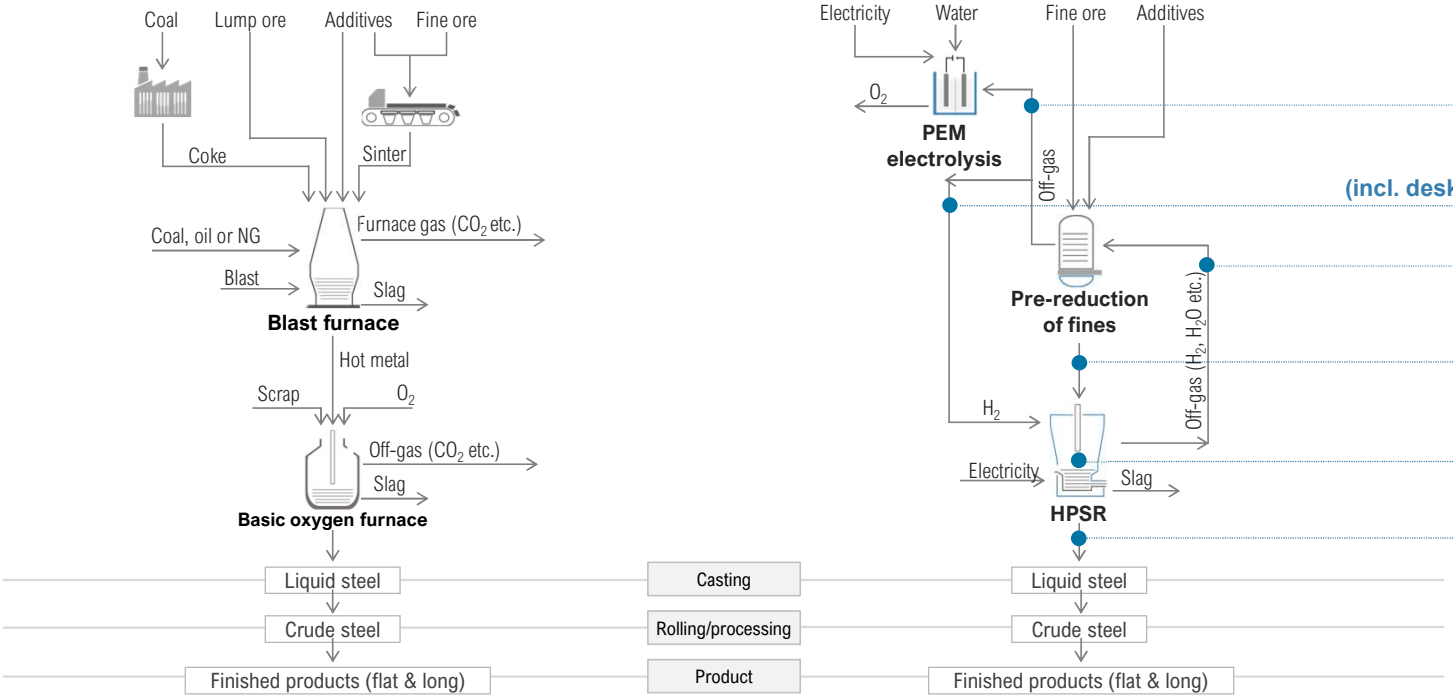
Production
First blocks

Process development SuSteel

Technological tasks for upscaling

INTEGRATED ROUTE (STATE OF THE ART)

Integrated route consisting of raw material preparation, blast furnace (iron making) and basic oxygen furnace (steel making)



HYDROGEN PLASMA SMELTING REDUCTION

HPSR route consisting of green hydrogen supply, pre-reduction of fines and HPSR

SuS-F

Objectives

- Recycling of water
- Continuous supply of green hydrogen (incl. desktop study of integrated hydrogen production)
- Recycling & further use of off-gas
- Continuous feeding of ultra fine ore
- Automated and digitalized system
- Semi-continuous tapping of carbon lean steel
- Dissemination

Process development SuSteel

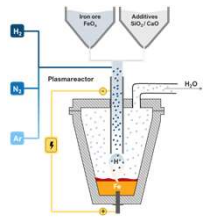
History and outlook to a continuous process

1998

First trials

Construction of a plasma smelting reactor in laboratory scale and first trials

2016 - 2019



SuSteel

Analysis of different concepts (plasma, feeding system, reactor geometry)

Construction of a demo plant at voestalpine

2019 - 2023

Operational optimization of hydrogen plasma smelting reduction

Selection of suitable materials

Slag management

Conceptual design of the electrolysis system

2019 - 2023

Fundamentals of hydrogen reduction

Process variations to achieve economic optimization

Optimization of raw material input

Concept for upscaling and continuous operation

2022 - 2025

Sustainable steelmaking follow-up

Development of a semi-continuous production process of carbon-lean steel in one step (200 kg/h)

Concept for hydrogen supply

2023 - 2027

Continuous HPSR process development

Process variations to achieve economic optimization

Parameter evaluation for continuous operation

Design of a pilot plant layout

2025 – 2027+

SuSteel pilot engineering

Basic engineering SuSteel pilot plant with >1t/h capacity

TRL 5

TRL 7

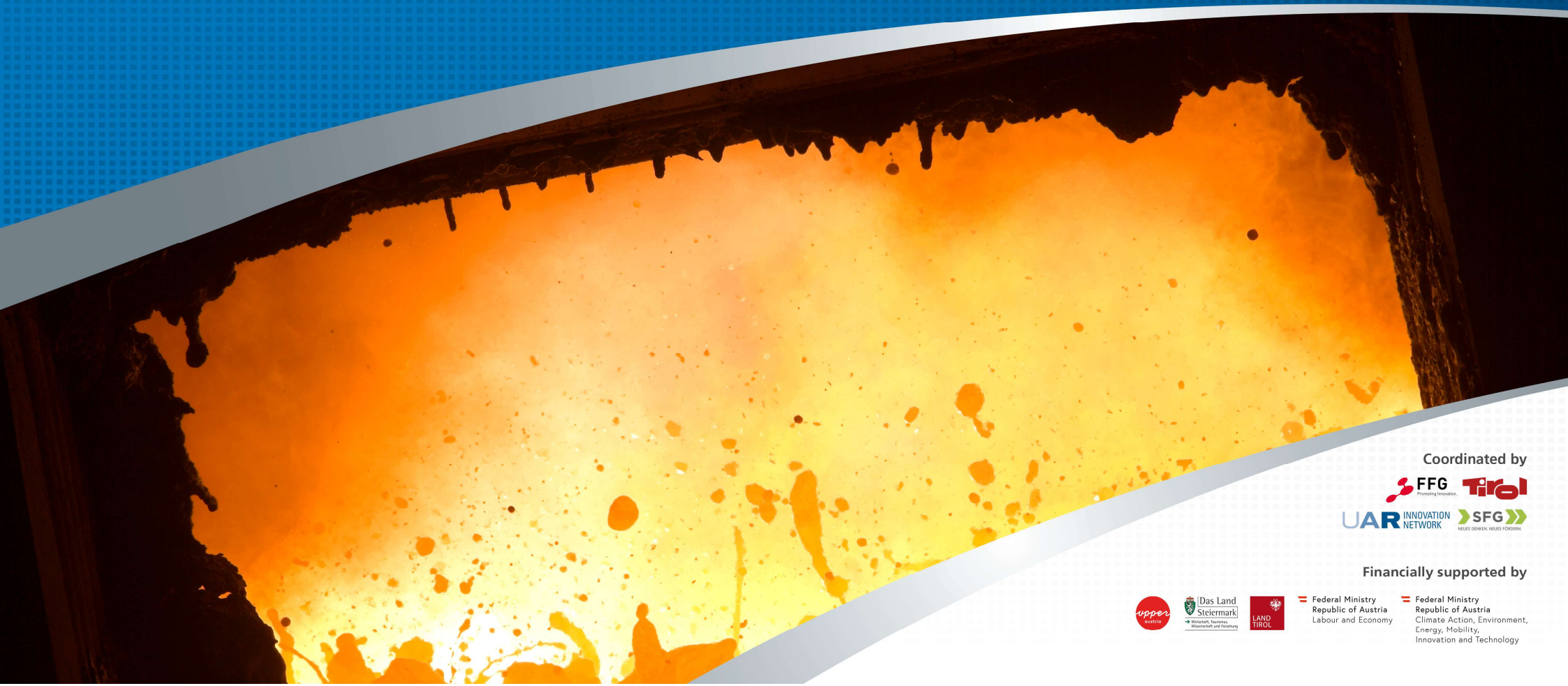
2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2023 | 2024 | 2025 | 2025+

Thank you! Questions?

Linz, November 27th, 2023

Michael Zarl

metallurgical competence center



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