

# Forging the Future: Innovations in Sustainable Steelmaking



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# Got a little Metallurgist in you?

Exploring Pressing Questions

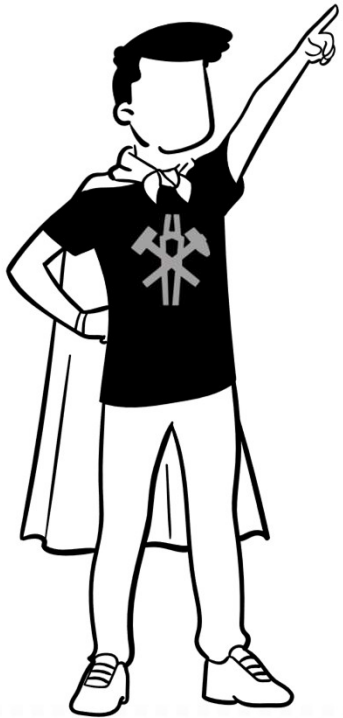
WIVAP&G  
Energy Model Region

SuSteel follow-up 



metallurgical competence center

## What is Green Steel?

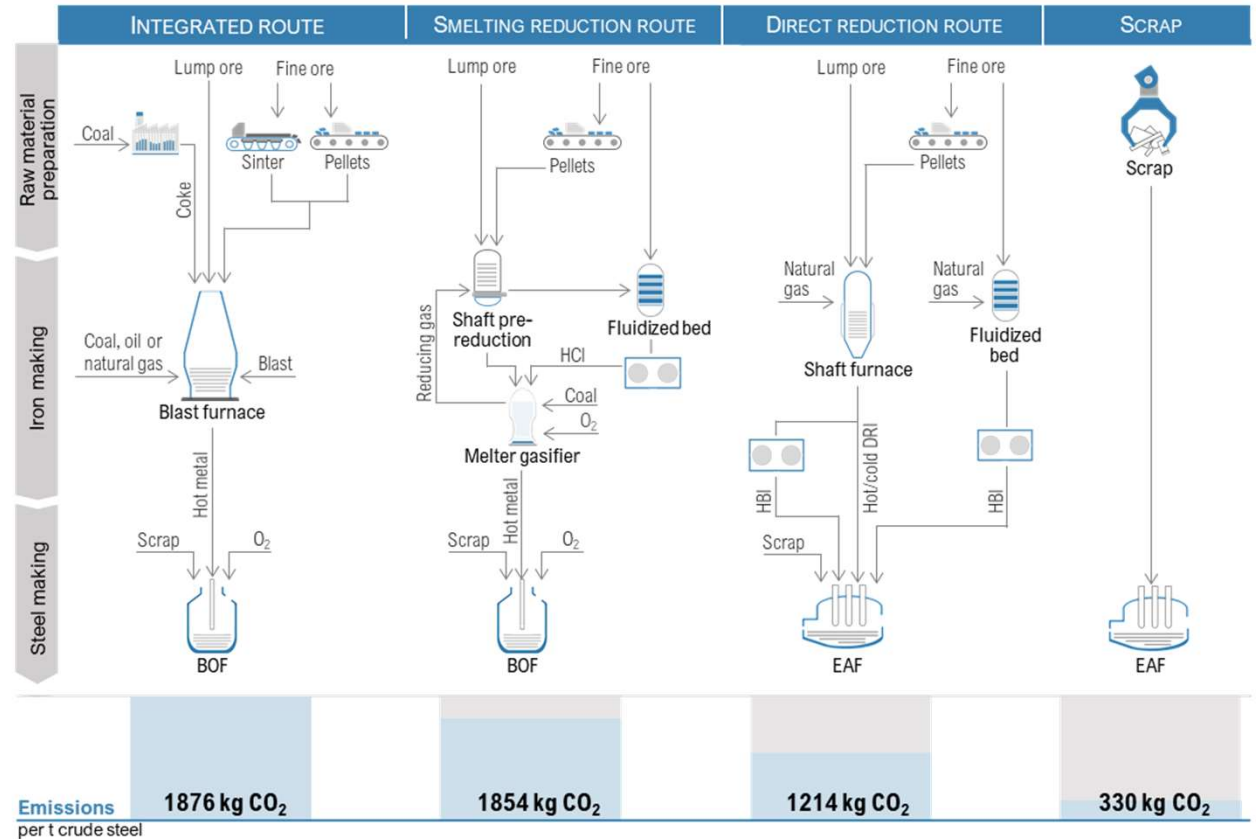


# What is Green Steel?

## Current Steel Production

### CO<sub>2</sub> mitigation potential

- Scrap recycling has lowest CO<sub>2</sub> emissions (-83% in comparison to the blast furnace – basic oxygen furnace route)
- Problem: scrap quality – quantity, availability
- Fossil energy has to be replaced by hydrogen and electricity from renewables



Reference: Stahlinstitut VDEh

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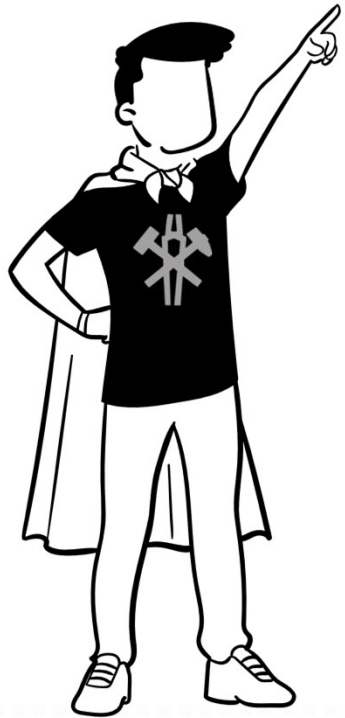
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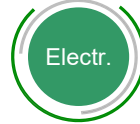
metallurgical competence center

## How do we reduce emissions?



# How do we reduce Emissions?

## Mitigation Strategies

		CIRCULAR ECONOMY		CARBON DIRECT AVOIDANCE	
Pathways / Groups		Enhancing the recycling of steel (e.g. scrap in BOF/EAF) and its by-products, Resource efficiency			
		SMART CARBON USAGE (+CCS)			
Description		<p>Process Integration with reduced use of carbon (+CCS)</p>  <p>Integration of process steps and internal use of process gases</p>	<p>Carbon Valorisation / Carbon Capture and Usage (+CCS)</p>  <p>Using CO/CO<sub>2</sub> from steel mill as raw material (chem. conversion of CO/CO<sub>2</sub>)</p>	<p>Hydrogen-based metallurgy</p>  <p>Use of renewable electricity in basic steel-making e.g. production of H<sub>2</sub> to replace carbon</p>	<p>Electricity-based metallurgy</p>  <p>Use of renewable electricity in basic steel-making e.g. production of H<sub>2</sub> to replace carbon</p>
	Initiatives	Hlsarna, TGR-BF-Plasma (IGAR), PEM, STEPWISE,	Steelanol, Carbon2Chem, FReSMe, Everest, Carbon2Value	HYBRIT, H2Steel (H2Future, <b>SuSteel</b> , Hybrid Steel Making), tkH <sub>2</sub> Steel, GrInHy, SALCOS, Hydrogen Hamburg, SIDERWIN	

Reference: Eurofer low carbon Road-Map

# Got a little Metallurgist in you?

Exploring Pressing Questions

## So, what would a perfect process look like?



# Forging the path towards a sustainable future

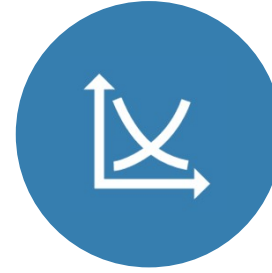
Let's characterize the perfect green steel process!



Carbon is baked into the current process. The mitigation of emissions necessary



Changing the steel industry means increasing the demand for green energy and hydrogen.



The competitiveness of green steel products depends on multiple factors.



The quality of seaborne ores decreases steadily.

**A low-carbon process that is**

**energy efficient and has a high utilization rate of hydrogen,**

**also keeps operating and capital costs low**

**and can work with low-grade ores**

# Got a little Metallurgist in you?

Exploring Pressing Questions

## Why is low-grade iron ore important?





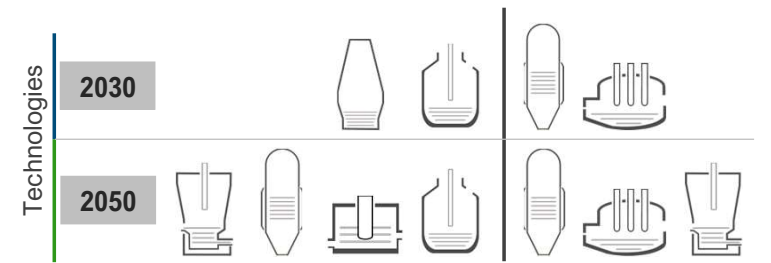
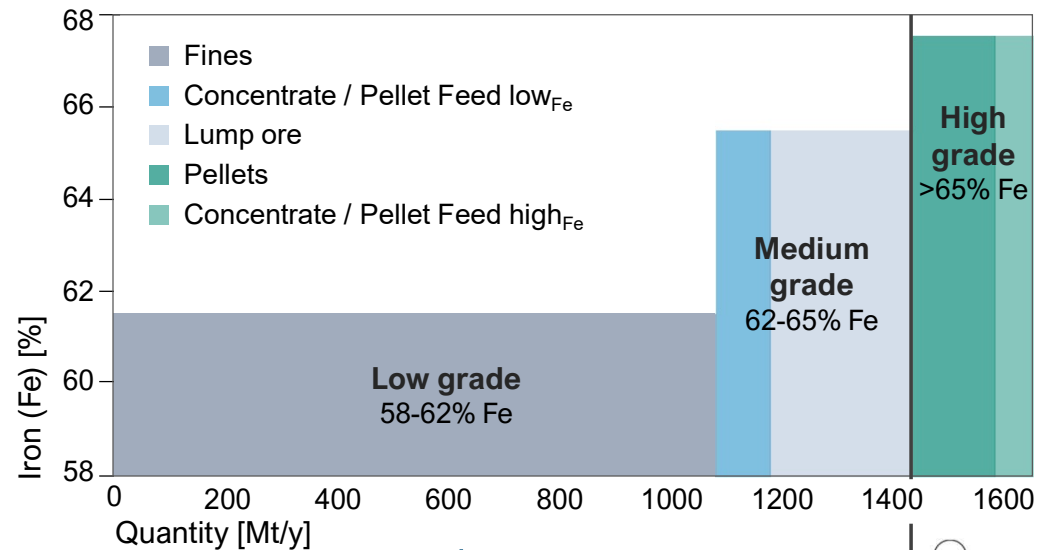
# Iron ore qualities

Why is the ore quality of such importance?

The global iron ore market is dominated by low and medium-grade iron ores

High-grade seaborne iron ores are available in limited quantities

75% of all beneficiated iron ores are fines



Reference: RTM Report

# Got a little Metallurgist in you?

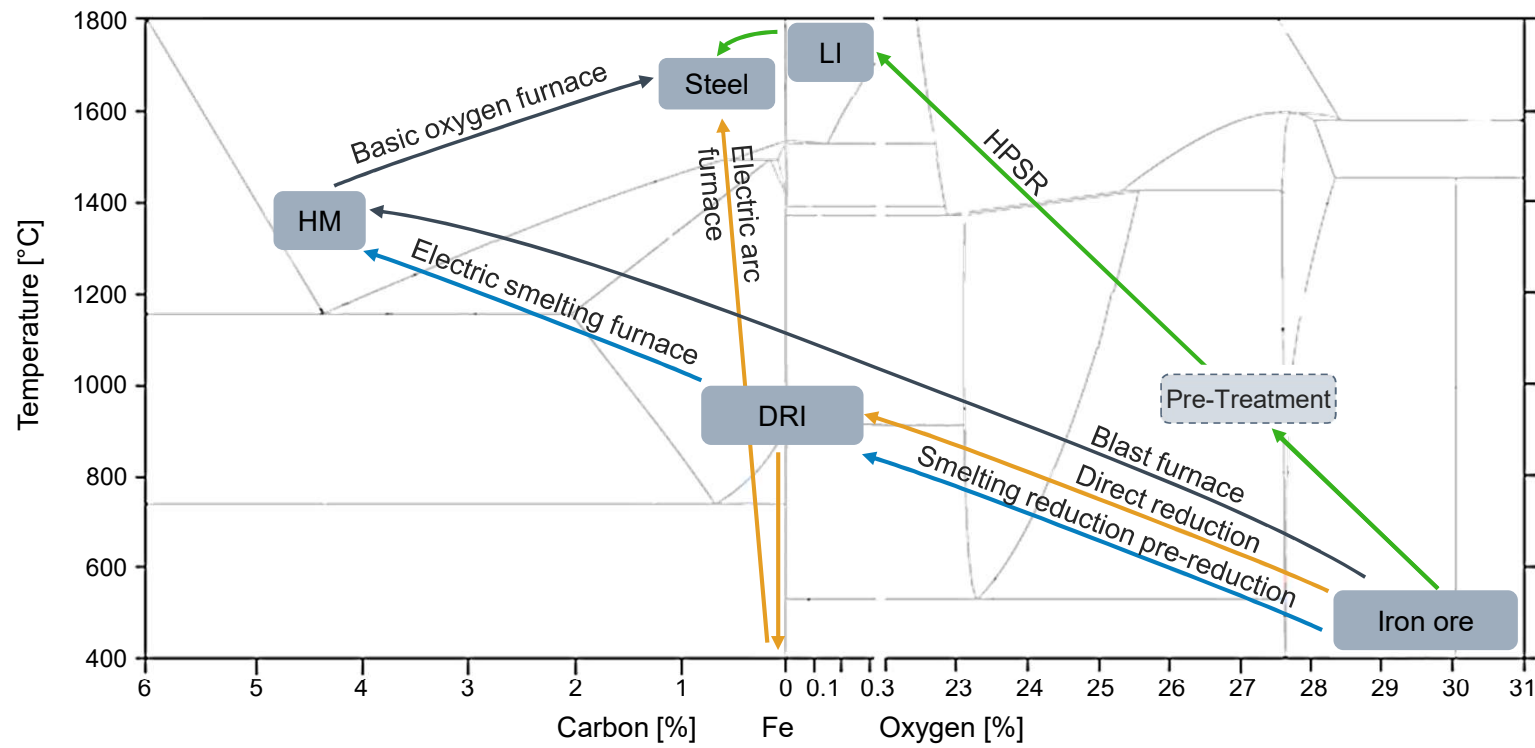
Exploring Pressing Questions

## How do we keep it simple and carbon free?



# Steel making process routes

One step ahead with one step to steel



DRI ... direct reduced iron  
HM ... hot metal (pig iron)

LI ... liquid iron (steel-like liquid product)  
HPSR ... hydrogen plasma smelting reduction

Reference: PhD Thesis J.F. Plaul

# Got a little Metallurgist in you?

Exploring Pressing Questions



## It seems we need to take a short look at this HPSR Process!

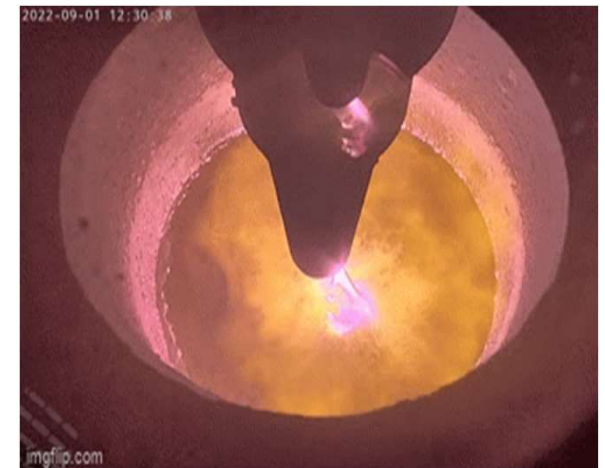
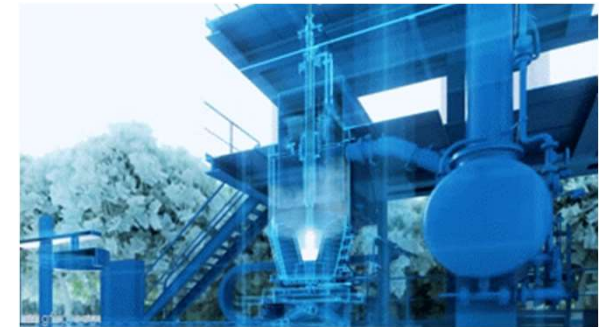
# The SuSteel Project

## HPRS in a nutshell

Reference: voestalpine

### 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<sub>2</sub> emissions are fully avoided.

# Forging the path towards a sustainable future

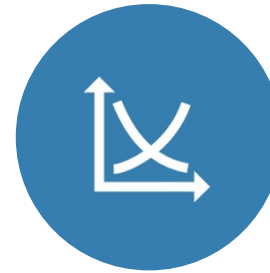
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# The HPSR Process

## Hydrogen Plasma Smelting Reduction



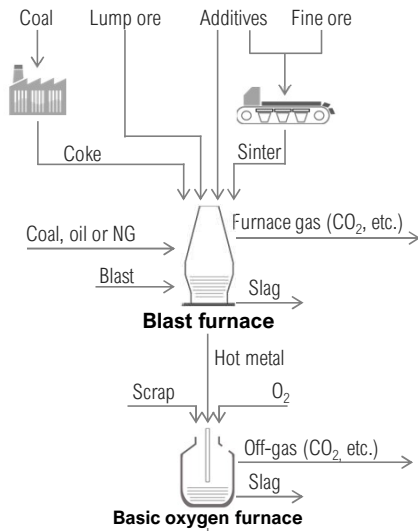
Reference: voestalpine

# Next steps for the Scale-up

What's the plan for now?

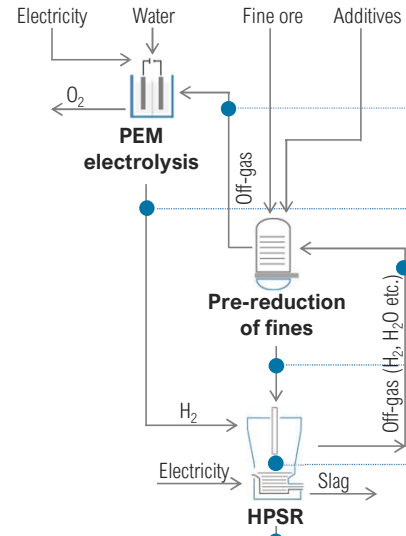
## INTEGRATED ROUTE (STATE OF THE ART)

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)

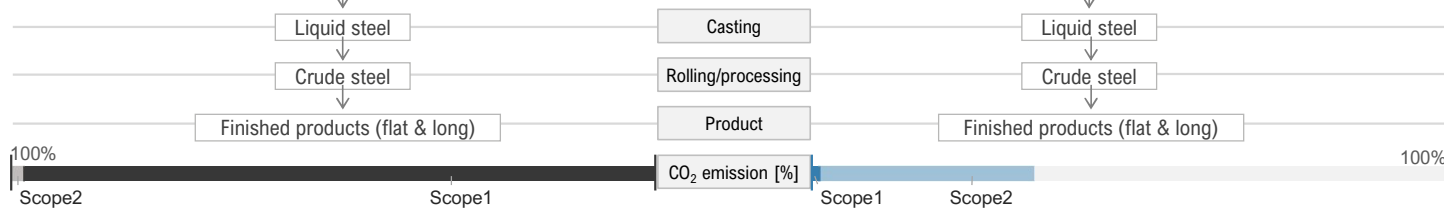
Recycling & further use of off-gas

Continuous feeding of ultra fine ore

Automated and digitalized system

Semi-continuous tapping of carbon lean steel

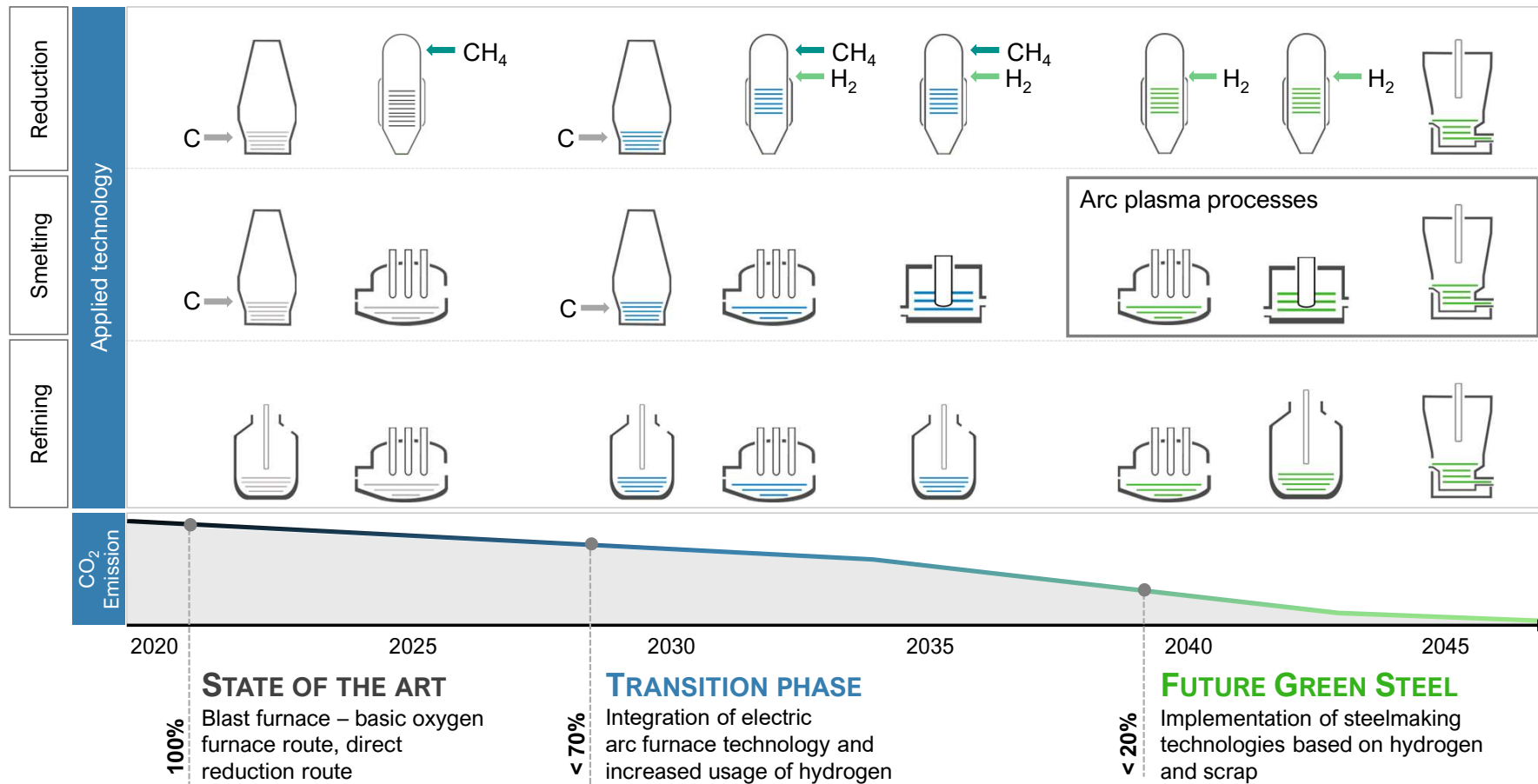
Dissemination





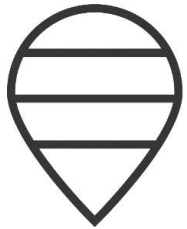
# How is steel going to be produced?

Transition process towards green steel

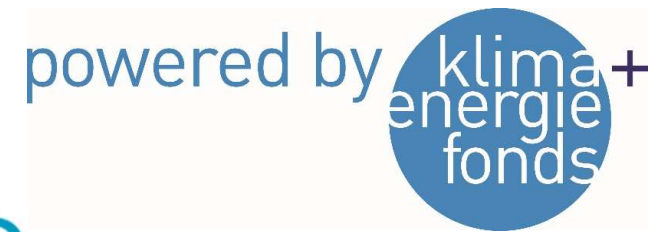


# Thank you for your kind attention!

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