



Steel: from main to co-product in a circular economy

OCTOBER 29
30
31

voestalpine Stahl,
Linz, Austria



ESTEP 2024
Annual Event



Harmen Oterdoom

Steef Steeneken

October 30th, 2024



European Steel Technology Platform

20 years together



meets



voestalpine

ONE STEP AHEAD.



Butter Bridge

Staff : 5 persons

- >100 years experience in steel, Fe-alloys, Zn/Al, electric smelting, energy, trade

FeNi furnaces, open bath smelting, DC/AC furnaces, blast furnaces

Now consultancy:

- mining,
- OEMs,
- steel,
- sub suppliers,
- cement industry.



H2, DRI & scrap shortage



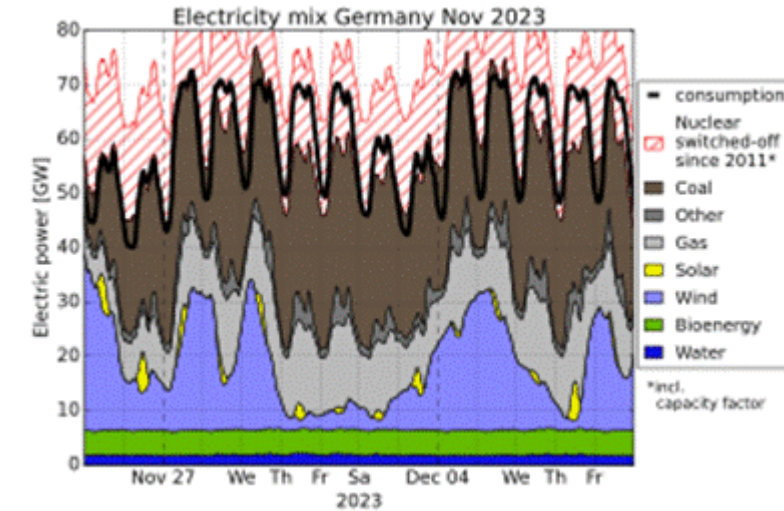
H2, DRI & scrap



No BF-ore smelting development

Challenges

- BF to EAF
 - Cement slag loss
 - EAF slag gain
- Energy supply (sources, seasonal)
 - TSIJ 725 MW BF gas
 - Coke Oven Gas recycling
 - Solar & wind energy
- Grid stability (instability, harmonics)
 - EAF / H2 / solar / wind
- Organic waste usage
 - Biomass
 - Urban waste
- EU resilience
 - Economic
 - Strategic



From: Making Green steel

From: Making Green steel

To: Steel as Circularity Enabler

During a Societal Change

→ Is Europe overly focused on H2 to make production of steel green?

Hydrogen reality: not going too well...

MMSteel 2024 / 4:	Lhyfe: € 6 – 7 / kg H ₂
McKinsey 2024 / 5:	in FT: US\$ 3 → US\$ 5 /kg H ₂
MMSteel 2024 / 10:	Lhyfe: >€ 8 / kg H ₂ „The Hype is over“
ESTEP 2024 / 10:	„We need more hydrogen“

‘Hype’ meets reality as Canada’s plans to export hydrogen to Germany stall

IRENE GALEA >
INCLUDES CLARIFICATION
BERLIN

Shell scraps plans for hydrogen project on Norway’s west coast due to lack of demand

OSLO
REUTERS

Offshore hydrogen pilot 'no longer an efficient use of our resources': Vattenfall

Financial Times, may 2024

Lex in depth: how the hydrogen hype fizzled out

Norway's Equinor scraps plans to export blue hydrogen to Germany

By Reuters

Thyssen-Krupp

Stahl-Krise gefährdet Wasserstoff-Pläne – Netzbetreiber warnt

Arcelor Mittal, may 2024

'Green hydrogen is too expensive to use in our EU steel mills, even though we've secured billions in subsidies'

“Munce [HyCap] agreed. In Europe, he said, more co-operation between industry and government was needed to create more investor certainty. “We certainly have come out of this hype cycle.””

Processing technology: what to do?

Technology	TRL	EU change	Global change	Global roll out	Challenges (€/kWh)
Scrap – EAF	9	Very high	Small	Off the shelf	Scrap
H2-DRI – EAF	8 – 9	Very high	Small	„Off the shelf“	DR-ore, process, H2
H2-DRI – Smelter	7 – 8	Very high	Very high	3 – 10 years	Capex, opex, process, H2
H2-DRI – DC fce	6 – 8	Very high	Very high	5 – 10 years	Capex, opex, process , H2
Molten Oxide	Low			10 – if ever	Capex, opex, scale
Electrowinning	Low			10 – if ever	Capex, opex, scale
H2-plasma + ore	Low			10 – if ever	Capex, opex, process , scale, H2
Pimp BF*	7 – 9	Medium	High	Now – 5 years	Tech



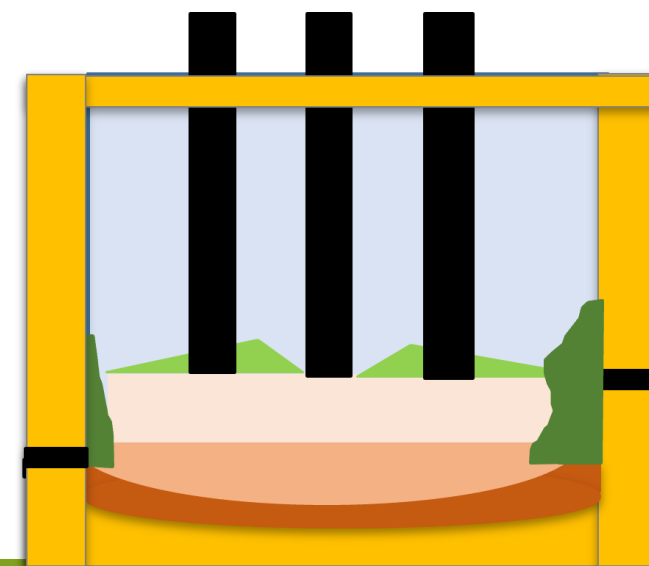
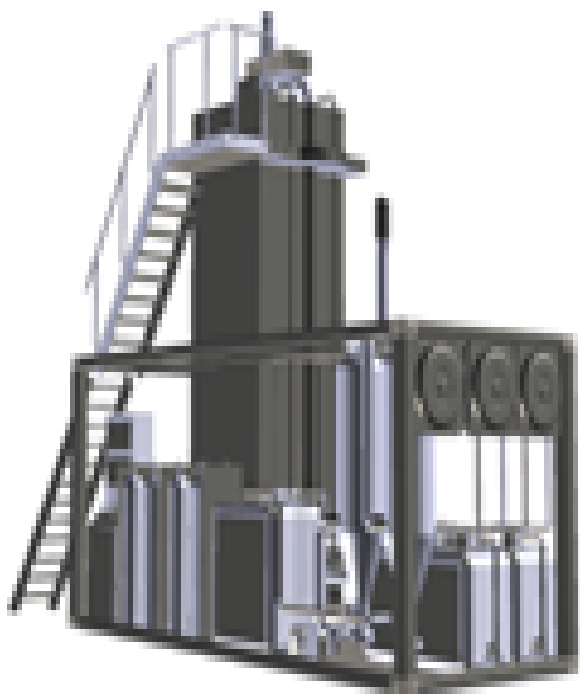
*Pimping the BF includes a.o. DRI charging, COG, H2 & syngas injection, plasma torch, biocoke, etc.

Steel CAN become pivotal in

(bio)waste processing

cement production

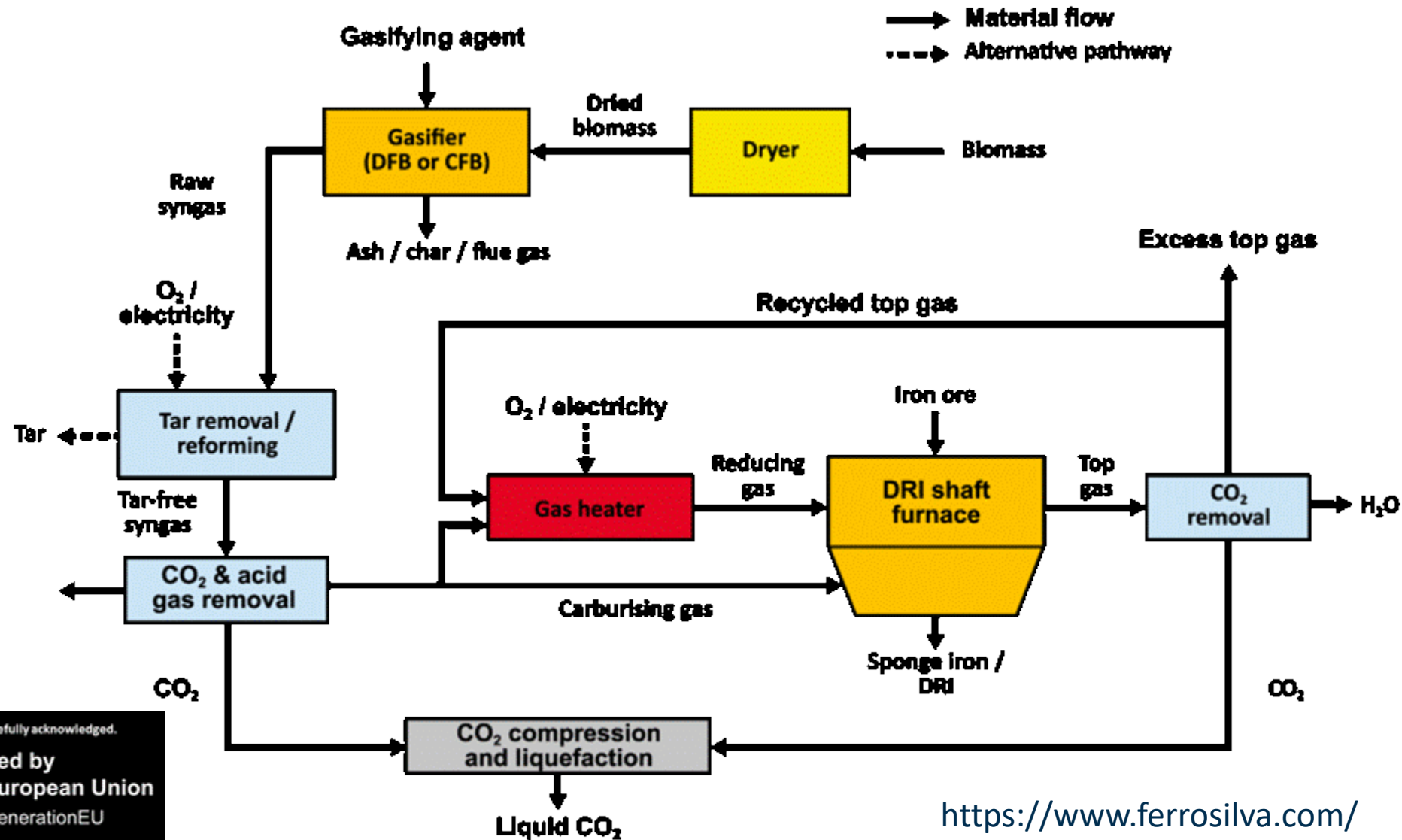
grid stabilization



Biomass gas

50 kt/y DRI

0,18 TWh biomass (0,2%)



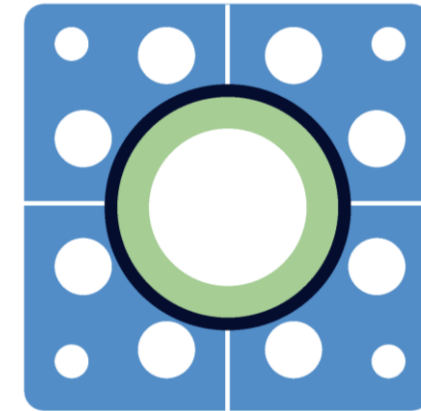
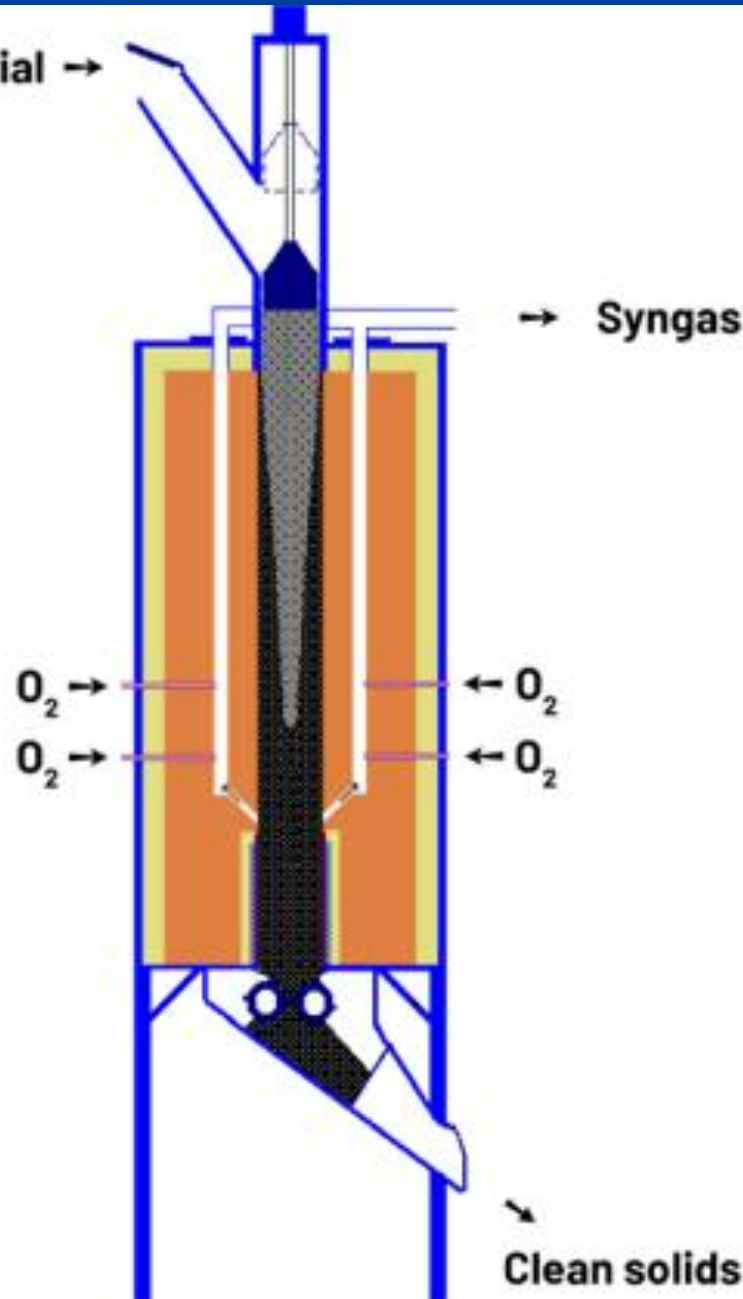
<https://www.ferrosilva.com/>

Feed material →



DOPS - Netherlands

- Moving bed
- Feed
 - Woodpellets ✓
 - B/C wood ✓
 - Plastics – **in progress**
 - Mixed waste
- Coking @ 1000°C
- Gas cracking/no tar
- Autotherm
- Designphase Pilot/Demo



DOPS – DCItm reactor

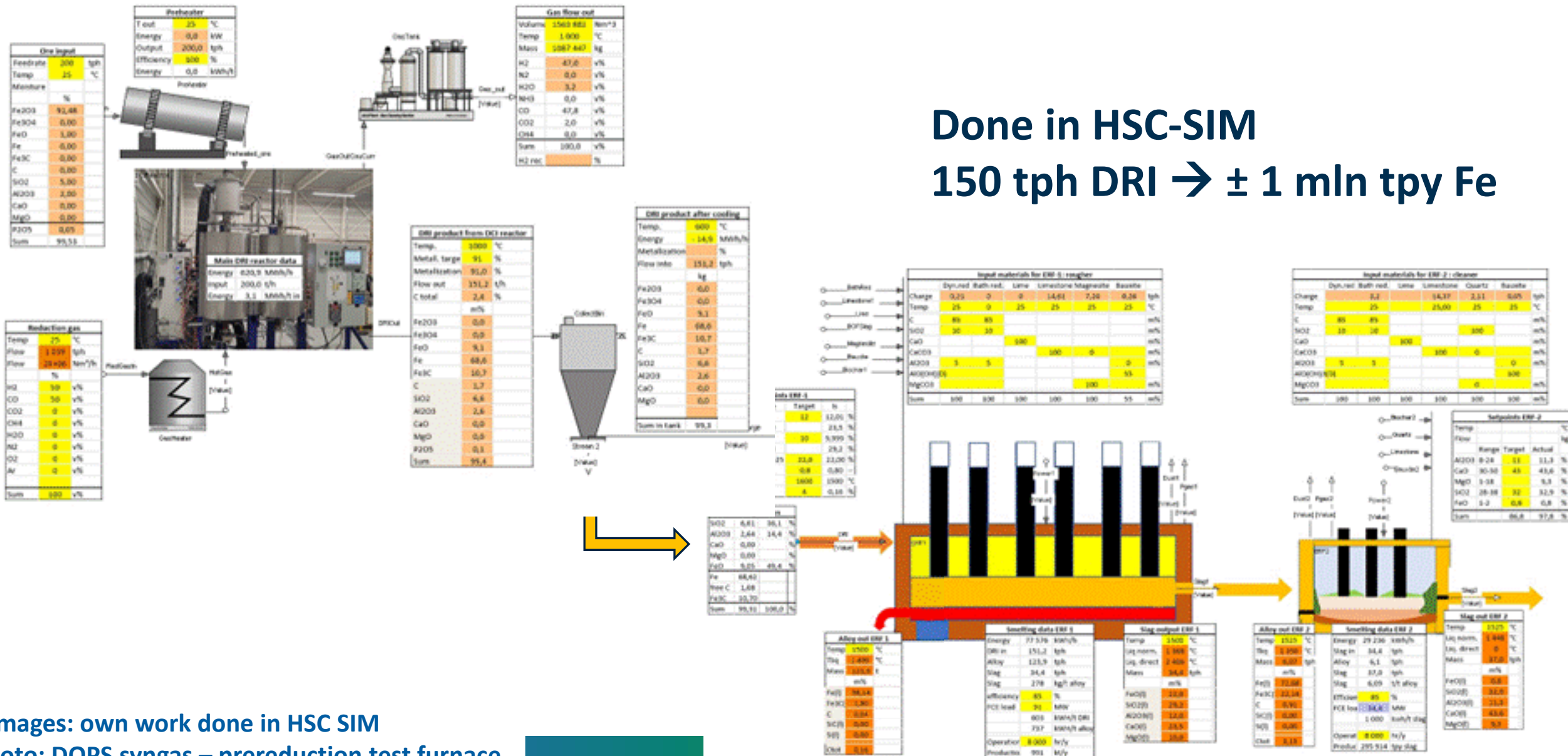
[DOPS RT - Direct Carbon Immobilization](#)

BTE group - ASCEM

- High quality binder from:
 - Slag
 - Fly ash
 - Other waste
- FEL 1-2 study ready
- Demo scale in progress



DRI – HM/Steel - Lime - Clinkerslag



Images: own work done in HSC SIM

Foto: DOPS syngas – prereduction test furnace

Integrated biomass – DRI – steel – slag test

Biomass/urban mass → syngas/coke/coal in smelting

- DRI by biomass-syngas, Netherlands
- Self-made biocoke for steel production
- First biomass green steel in Holland !!??



Power grid balancing

- Costs Billions in Germany
- May get worse
- Smelter = virtual battery
- Money maker!??

Energiewende

Engpässe im Stromnetz kosteten 2023 knapp 3,1 Milliarden Euro

ENERGY STORAGE

German Firm Turns Aluminum Smelter Into a 'Virtual Battery'

Trimet tests technology to create 1.12 gigawatt-hours of flexible capacity.

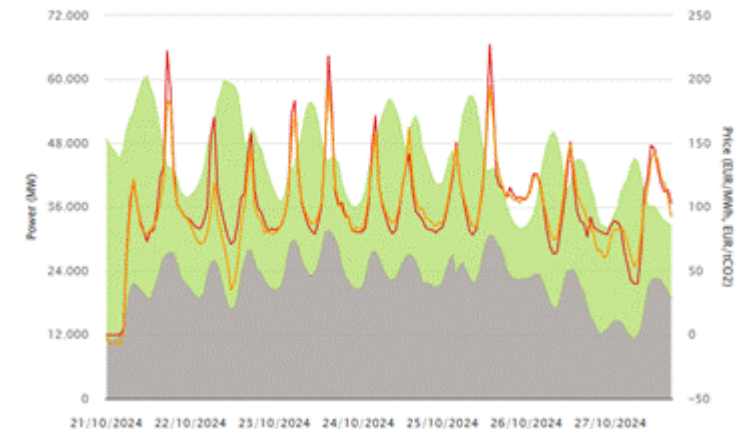
JASON DEIGN | MARCH 24, 2017

KANTHAL

ENVISIONING A FUTURE
WHERE POWER-
BALANCING FURNACES
ARE THE NEW NORM



Electricity production and spot prices in Germany in week 43 2024



Power grid balancing

- Costs Billions in Germany
- May get worse
- Smelter = virtual battery
- Money maker!??
- 1 Smelter ~ 1Mtpy ~ 100 MW
- 10 Mtpy ~ 1000 MW
- 40% instant load reduction / 2 hours
- 800 MWh flexible peak-shaving power

Energiewende

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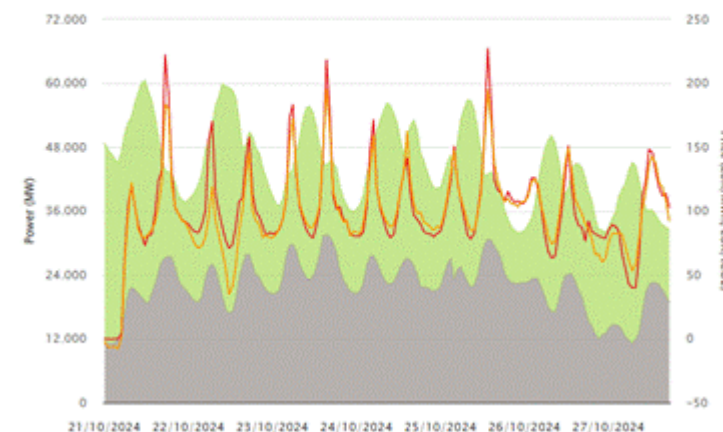
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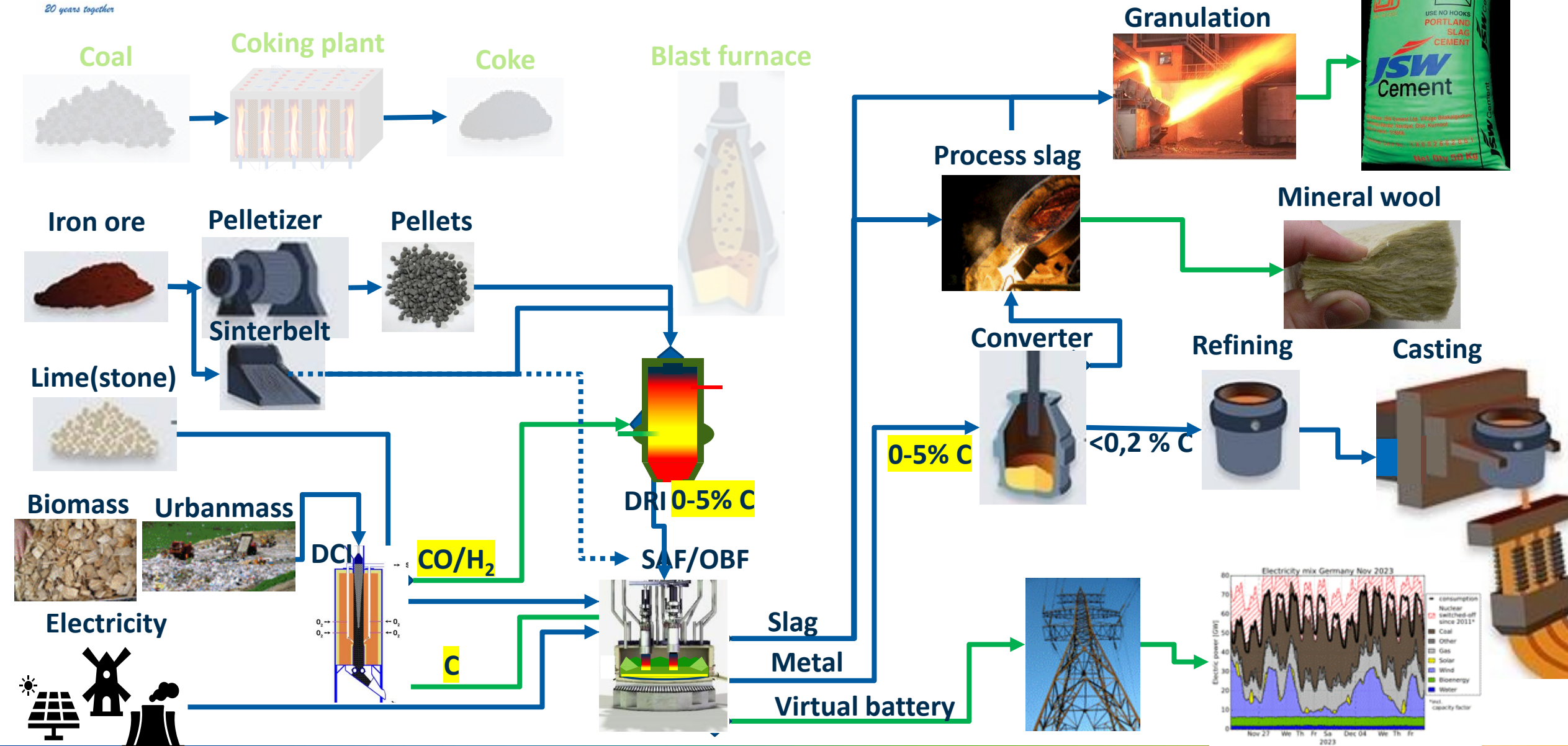


KANTHAL

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Possible future green steel mill



Concluding

EU path to replace blast furnaces with EAFs:

will not solve global CO₂ emissions from steel

may not lead to economically viable steel production in EU

Parallel pathways for:

Slow Innovative $\leftrightarrow$ Fast Large Scale

H₂, electrons $\leftrightarrow$ bio/urban mass

For global impact & business opportunity:

Develop BF-grade ore tech: BF pimping & AC/DC smelters

For EU re-orientation:

Create more investor certainty $\rightarrow$ ensure mid-term reliable & affordable energy

Support non-researchinstitute startups more!

See steel as an enabler with a very different business model approach

Carrot & stick to encourage more cooperation



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FOR GREEN STEEL

3rd INTERNATIONAL CONFERENCE

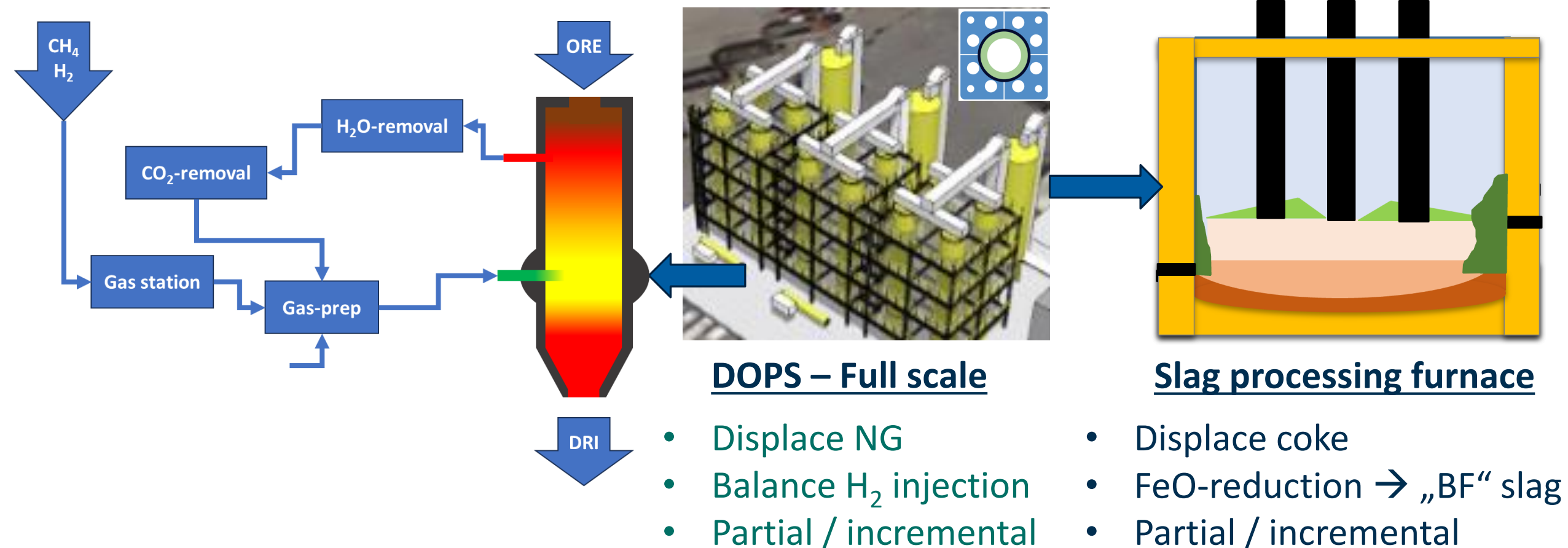
meets

A CIRCULAR ECONOMY DRIVEN
BY THE EUROPEAN STEEL





→ And use the coke!

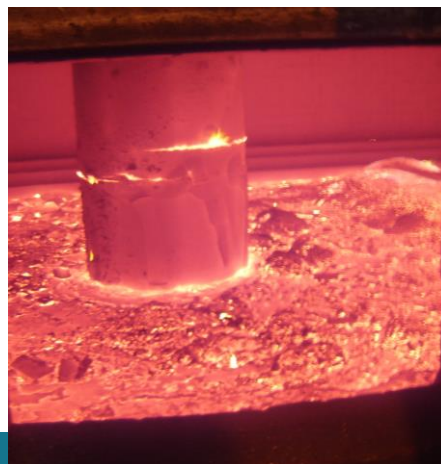
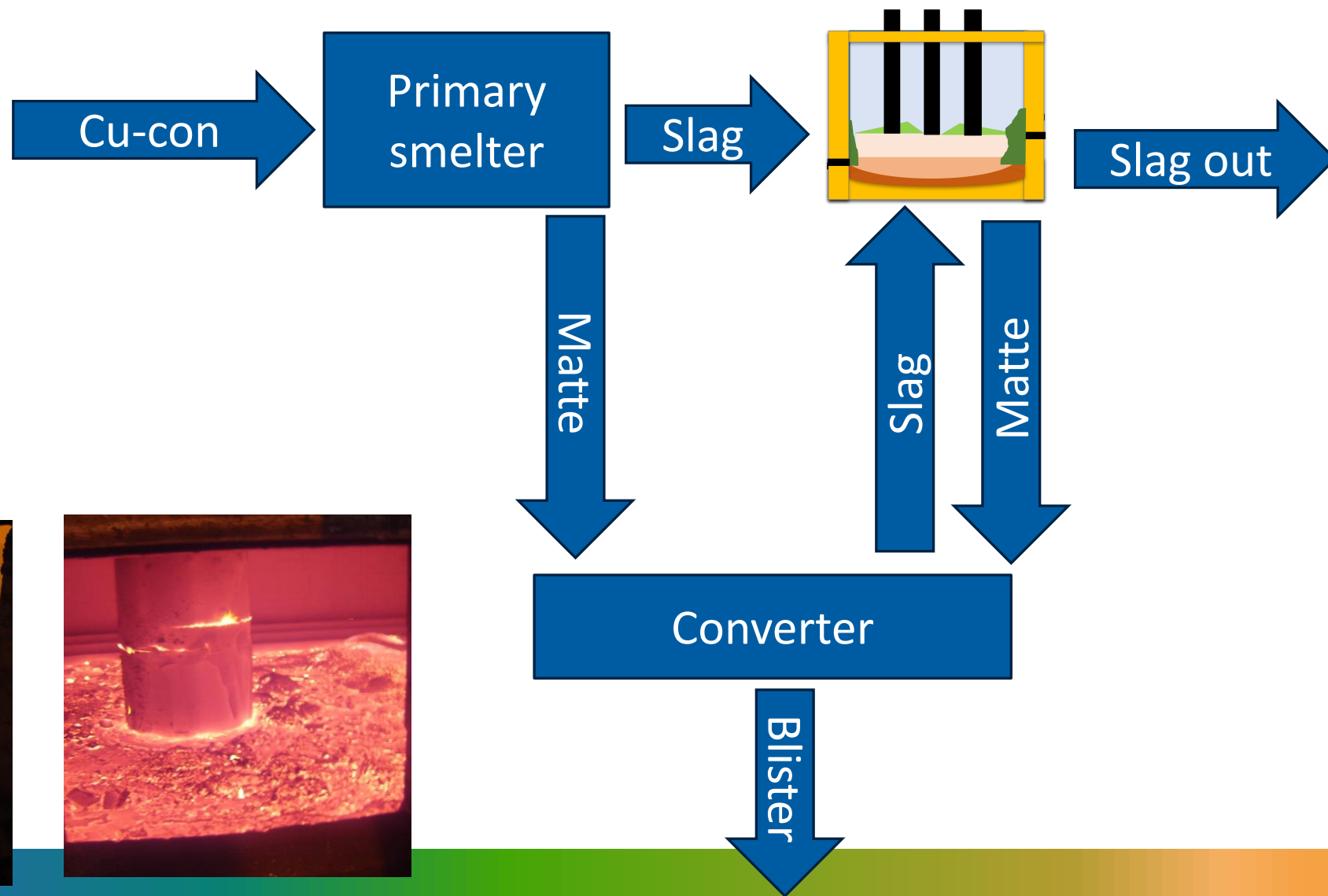




EAF (BF) slag issue

Slag processing is not new

- Cu slag cleaning
- Cu recovery



EAF (BF) slag issue

Slag processing DRG

→ DR-grade ore / scrap

→ EAF slag to BF slag

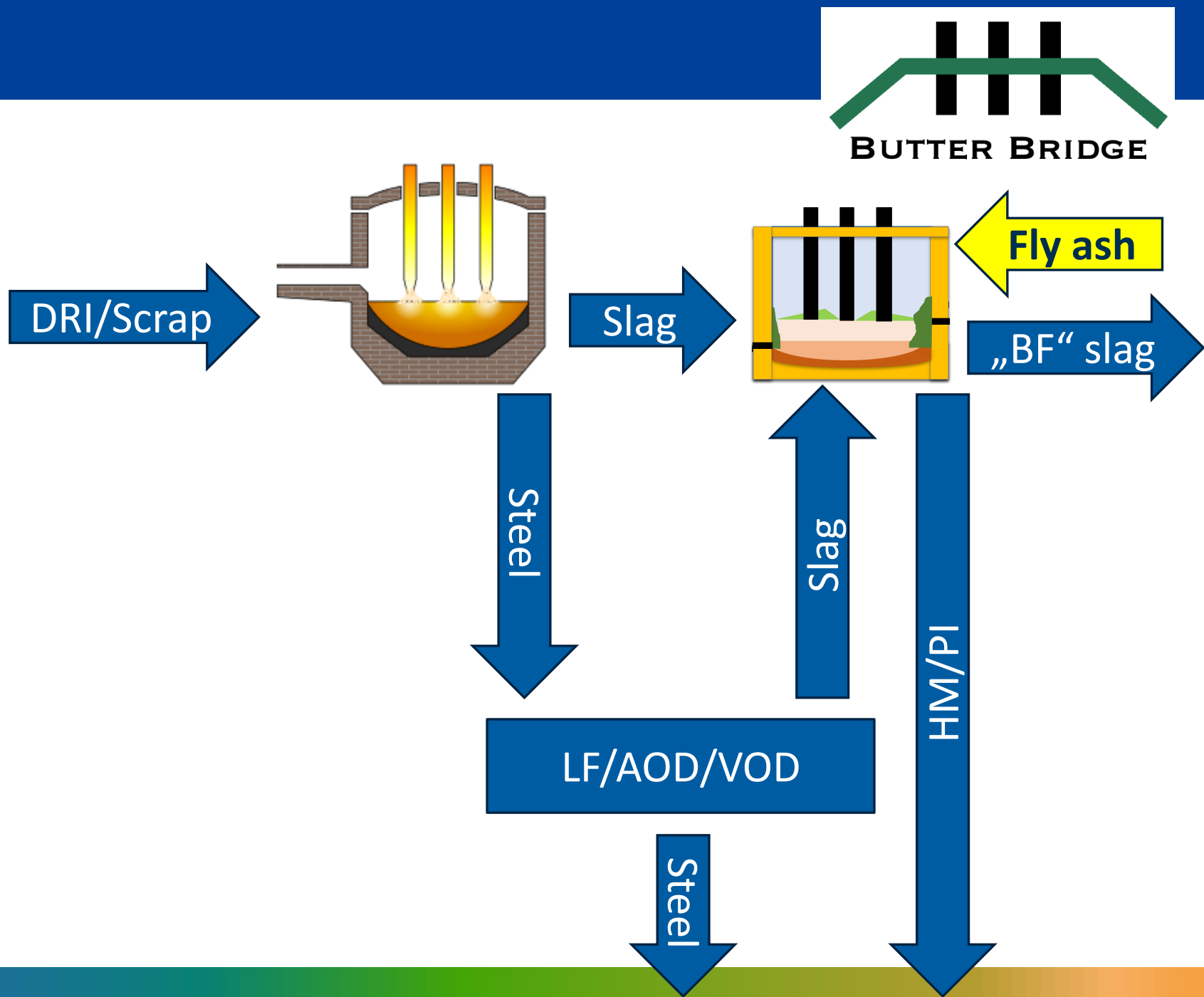
→ EAF slag cleaning

→ Fe-recovery

→ CaO recovery

→ Option 1: back into ESF

→ Option 2: dedicated smelter

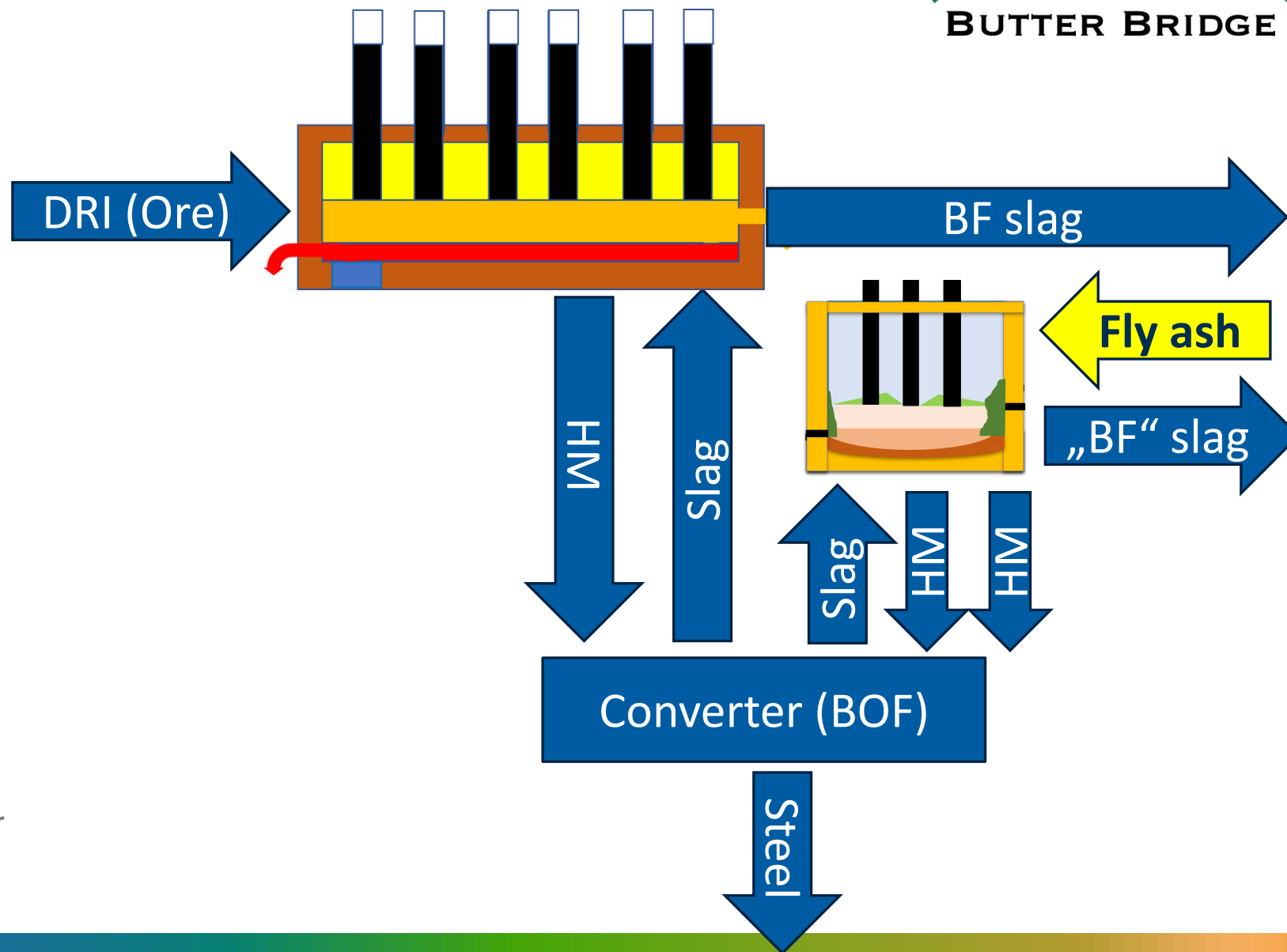




EAF (BF) slag issue

Slag processing BFG

- BF-grade ore
- DRI/BOF slag to BF slag
- BOF slag cleaning
 - Fe recovery
 - CaO recovery



- Option 1: back into DRI-smelter
- Option 2: dedicated smelter