TATA STEEL

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IIM Metallurgy Materials Engineering

Presents

International Conference on

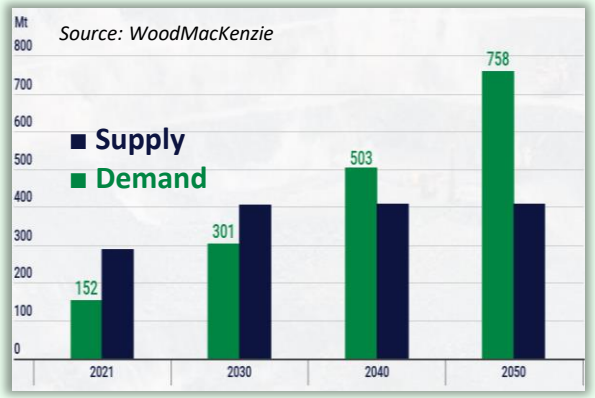
GREEN & SUSTAINABLE IRON MAKING

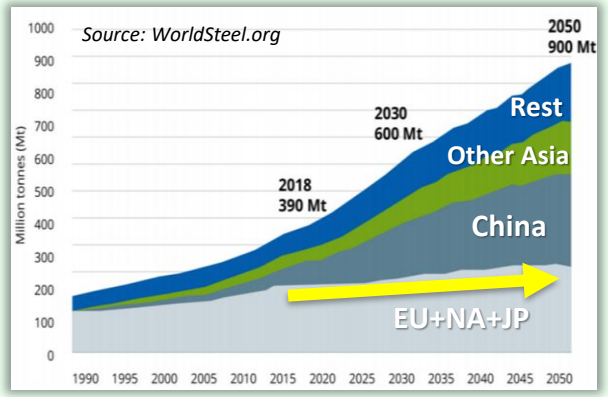
January 17 – 18, 2024

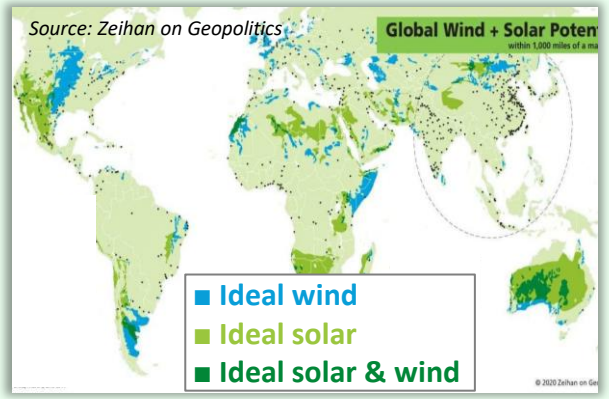
Title of Paper: Future of green ironmaking using BF/BOF route

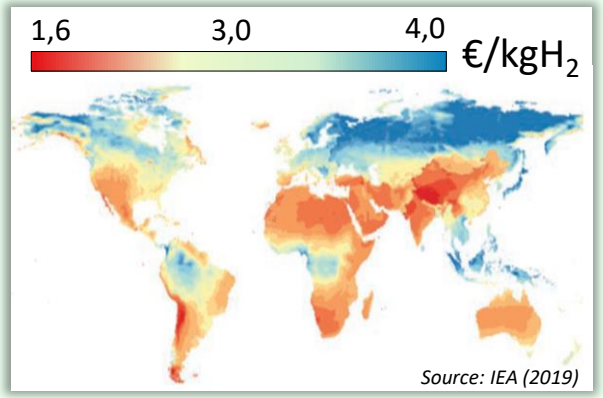
Presented By: Peter Kinzel

Future feedstock challenges of green steel





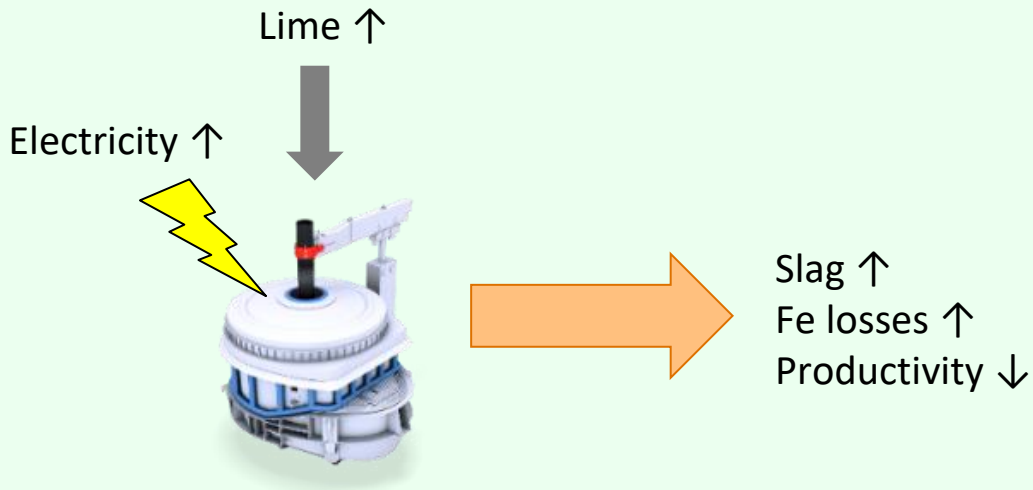




DR pellet availability	End-of-life scrap availability	Green electricity availability	Hydrogen availability
• Limited availability • Growing demand • High premium	• Limited availability • Growth in demand • Contaminated scrap (Cu)	• Unequal availibility of sun, wind & free usable land • High cost & scope 2 emissions in some regions	• Unequal green hydrogen production cost • Immature supply chain • Small volumes, high costs
Need for **FLEXIBLE ORE SOLUTION**	Need for **PRIMARY STEELMAKING**	Need for **POWER AUTONOMY**	Need for **FLEXIBLE H2 USAGE**

Indian iron ore

"Indian hematite … can have higher percentage of alumina (Al2O3 **up to 7%**)…"
– Indian Bureau of Mines (ibm.gov.in)



Indian medium-low grade ores in EAF:

- Al2SO3 is an acid gangue! EAF Basicity B3 ~ 2 → higher lime requirement
- Increased slag rate → increased FeO losses
- Higher electric energy consumption
- Higher electrode erosion
- Increased tap to tap time → Lower productivity

Blast furnace is more suitable
for medium-low grade ores with high alumina

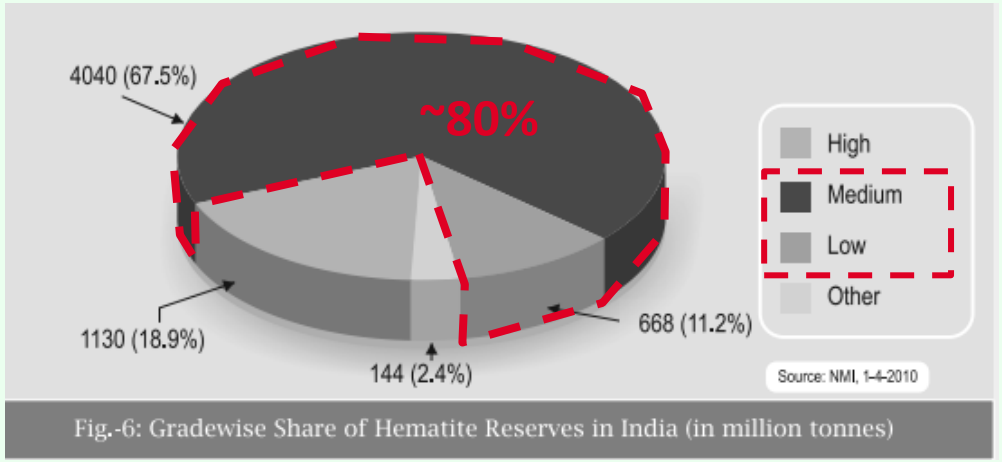


Fig.-6: Gradewise Share of Hematite Reserves in India (in million tonnes)

- Indian Bureau of Mines (ibm.gov.in)

Decarbonisation pathways for ore based steel making (Scope 1+2)

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+ biomass

DRI-EAF route

High grade pellets

+ CCUS or biomass

DRI-OBF route

Low grade pellets

+ CCUS or biomass

EASyMelt route

Electrically assisted syngas smelter

Flexible ore input

Hot Syngas

Hot H2 Syngas

Transform

Reduce

Today

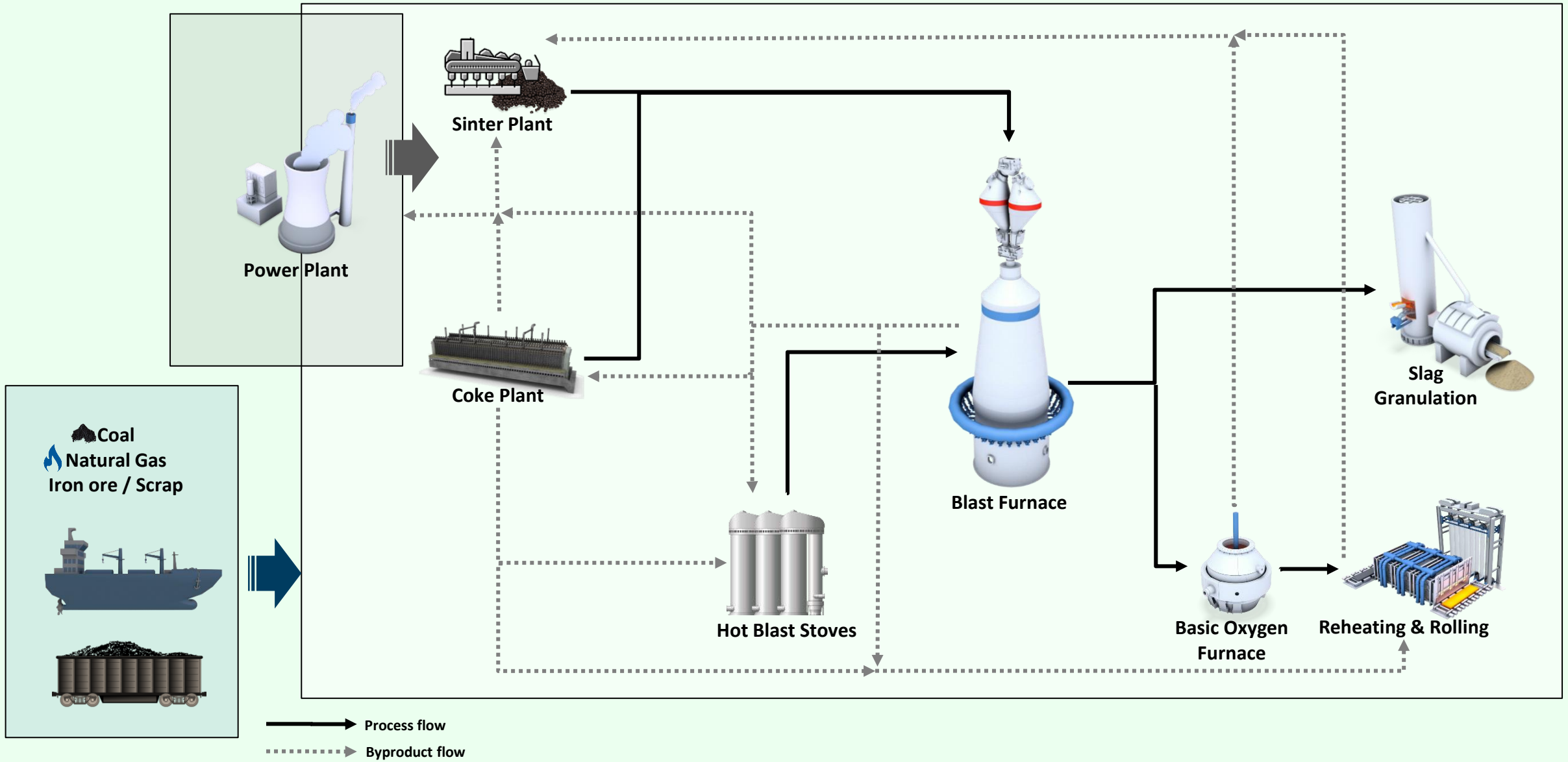
Blue BF route

Flexible ore input

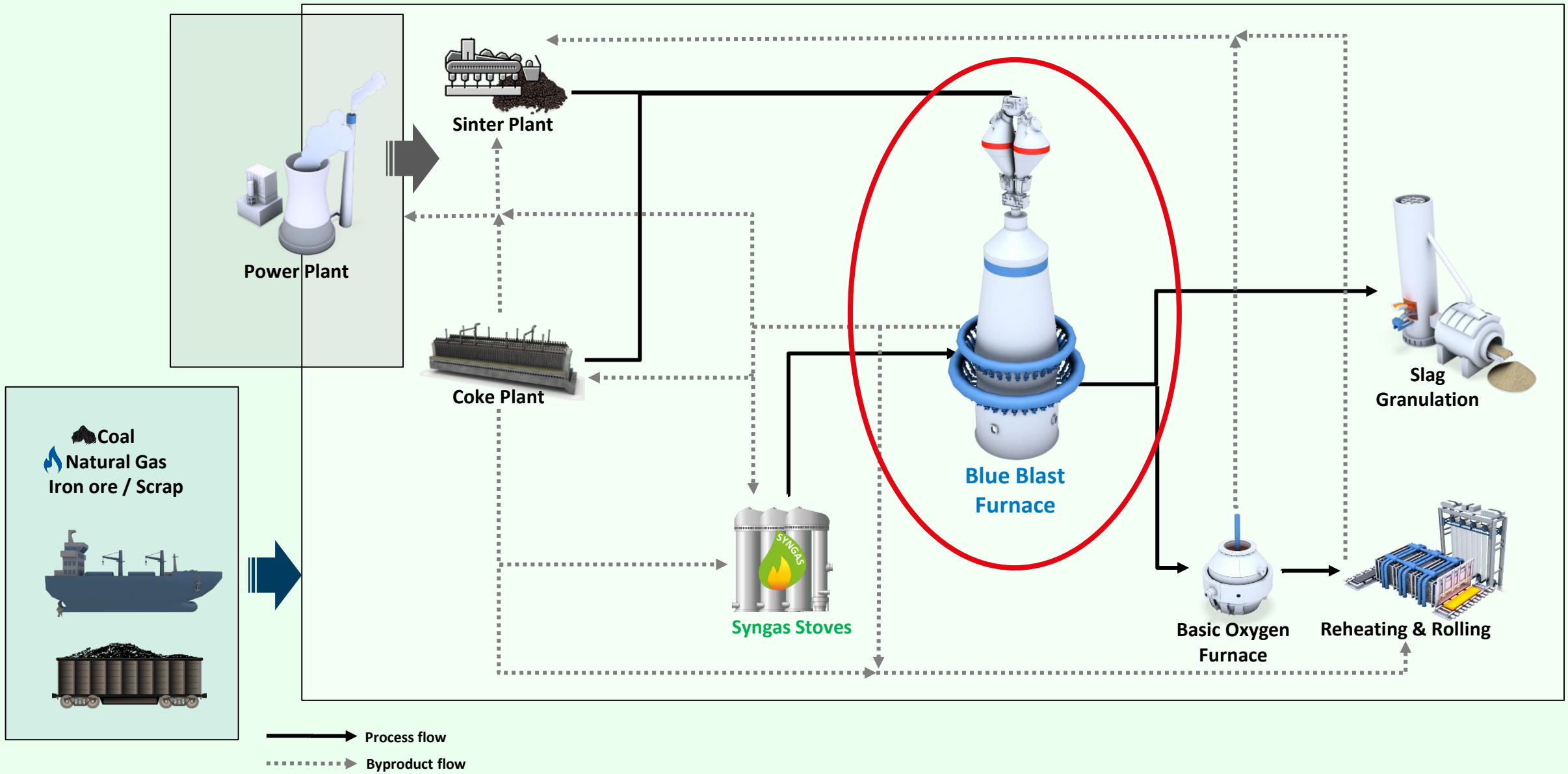
100% **75%** **50%** **25%** **Net-zero**

SCOPE 1+2 EMISSIONS

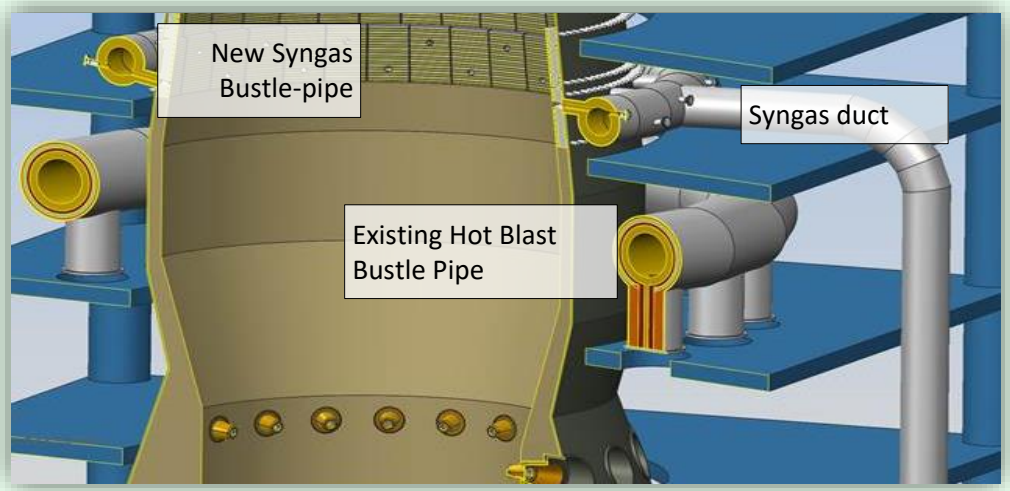
Current steel plant configuration



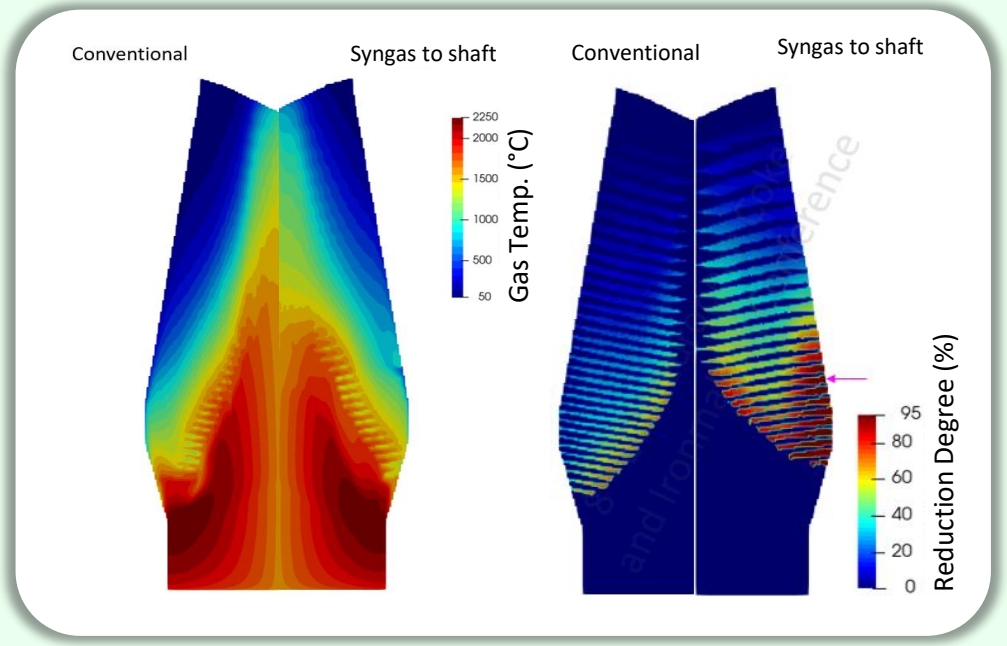
First decarbonisation step



Shaft injection

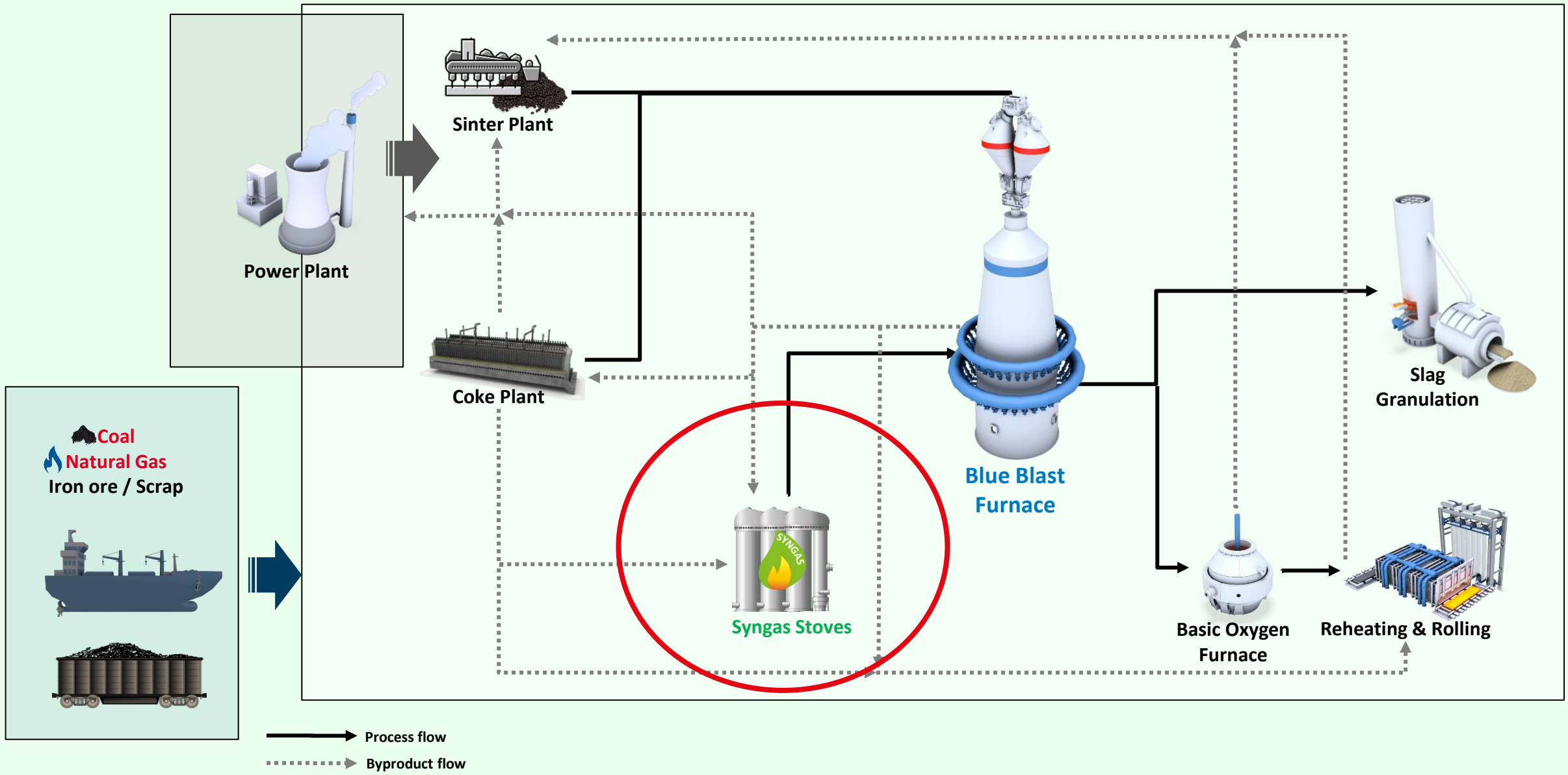


- ✓ **Thermal energy input** for endothermic reactions & heating
  - → increased topgas temperature
  - → more HBI/scrap charging possible
  - → more auxiliary fuel (H2,CH4,COG,…) with O_2 at tuyere possible
- ✓ **Reducing gas input** → less coke consumed for iron ore reduction
- ✓ Pushing bosh gas towards furnace centre → **reduced wall-channeling**



» -32% CO_2 **COG, H_2, pellet, HBI/scrap**

First decarbonisation step



Dry reforming

Dry reforming

$CO_2 + CH_4 \rightarrow$ "Syngas" $2\,CO + 2\,H_2$

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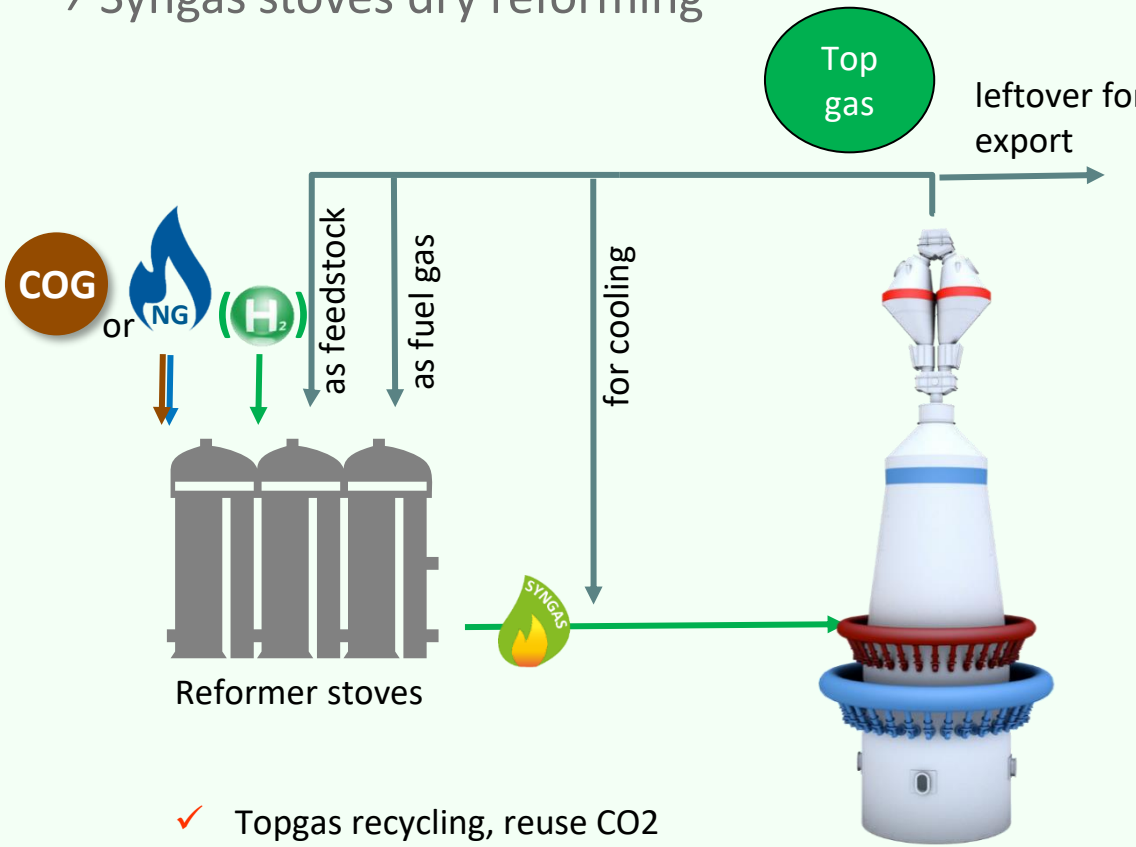
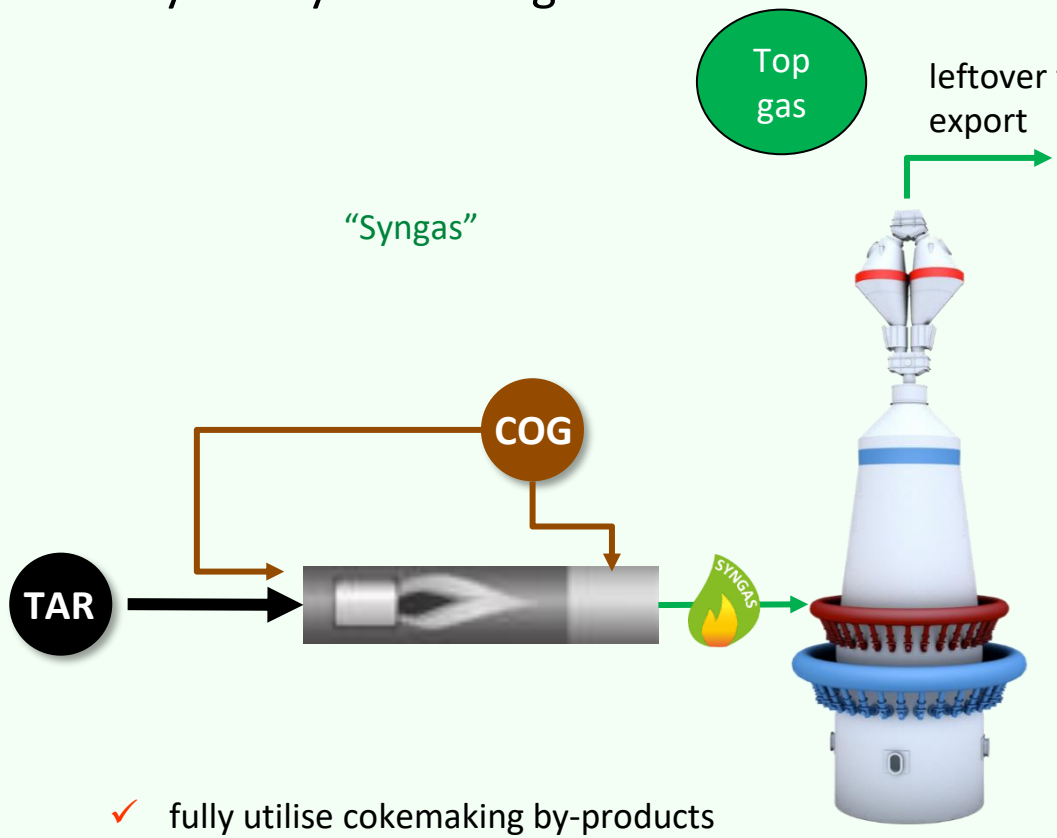
Patent pending

› Syngas stoves dry reforming



- ✓ Topgas recycling, reuse CO2
- ✓ Possibility for H2 heating

› Oxytar dry reforming



- ✓ fully utilise cokemaking by-products
- ✓ keep topgas for downstream processes

Future steel plant configuration

Electricity

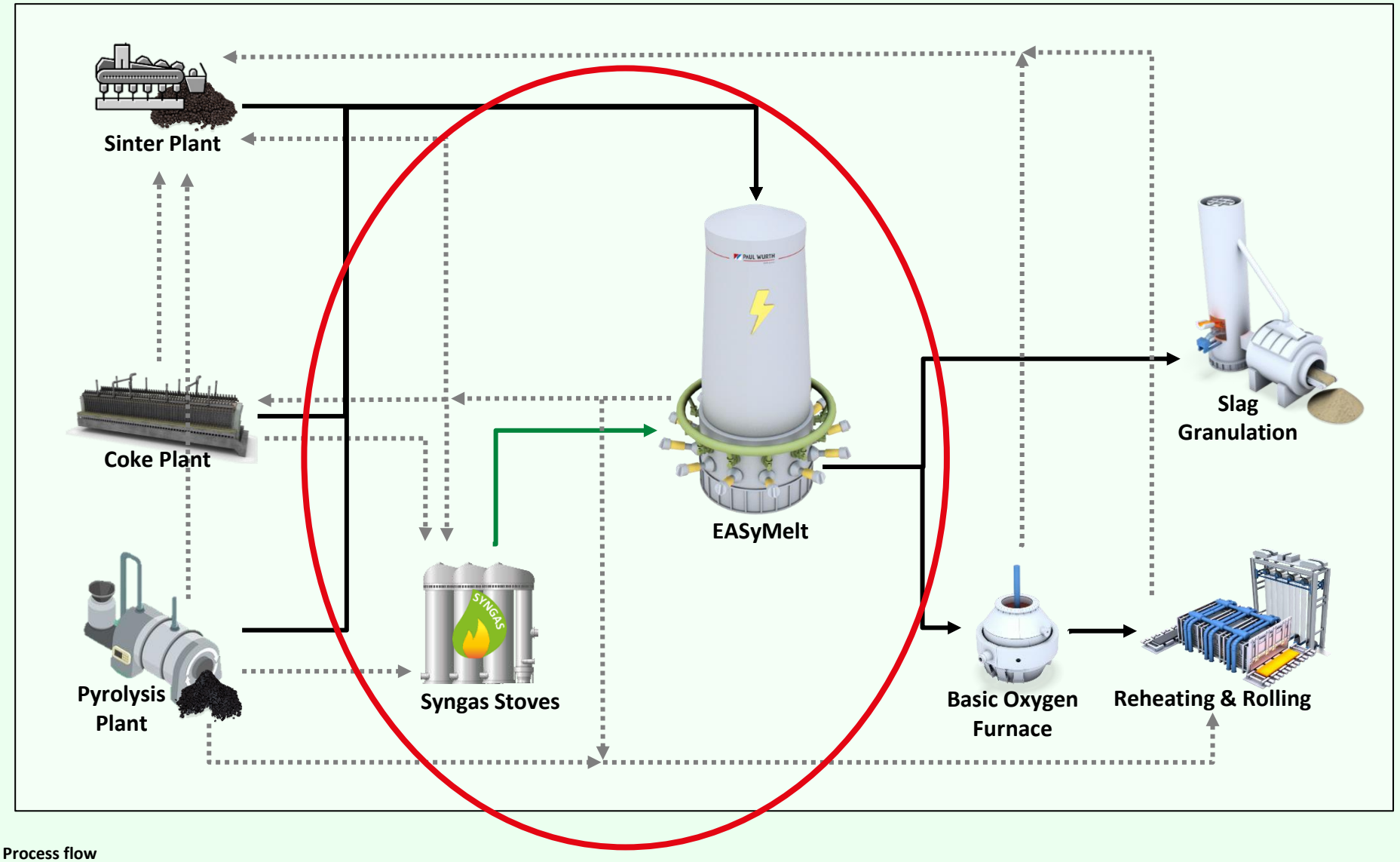
Hydrogen

Biomass

Coal

Natural Gas

Iron ore / Scrap

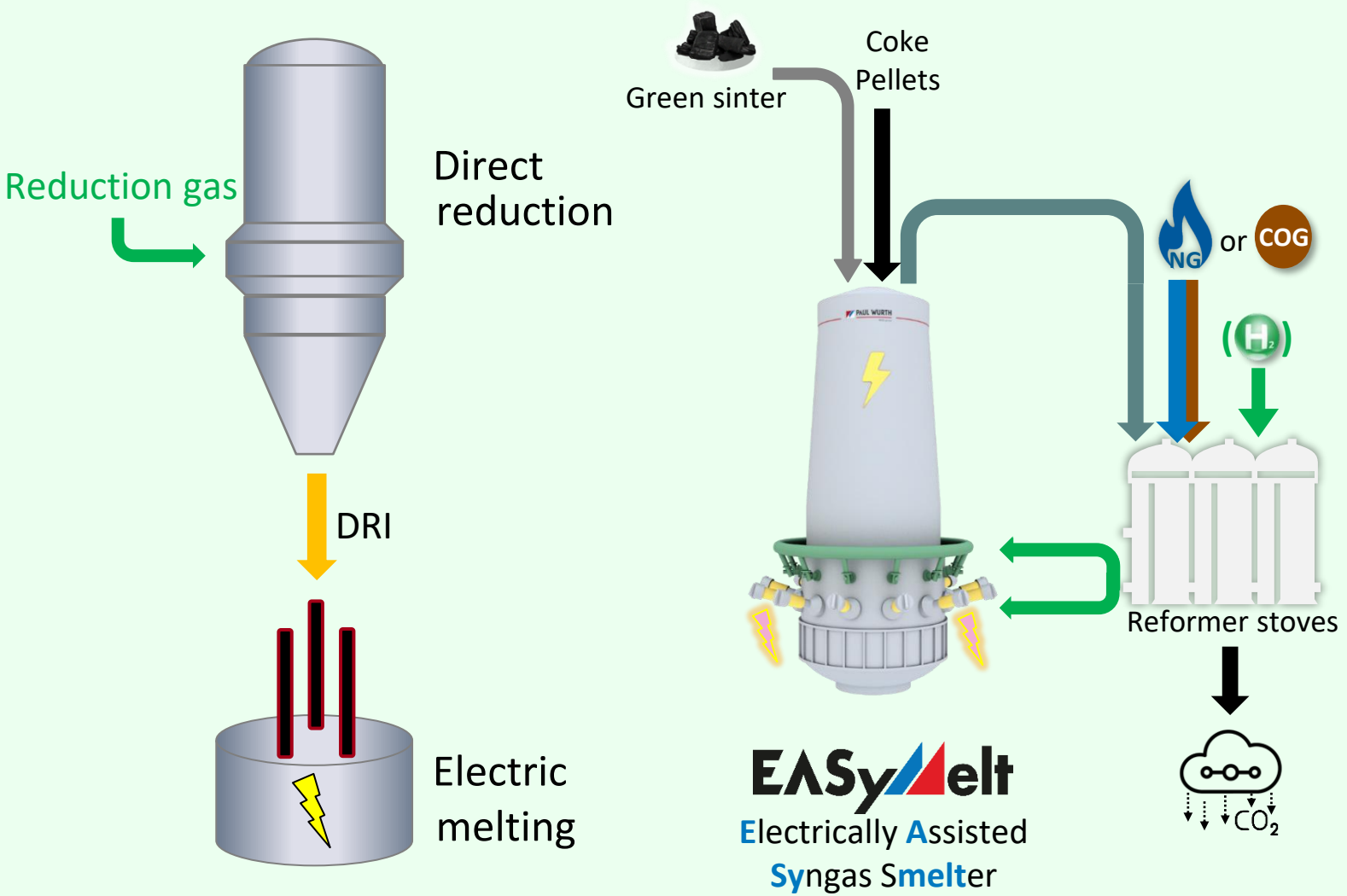


Process flow

Byproduct flow

Patent pending

Novel DR-Smelter for net-zero CO_2



EASyMelt™ features

- **Net-zero carbon**
- **Lowest OPEX**
- **Lowest CAPEX**
  - Integrated into existing steel plant
  - Stepwise **low risk** approach
- **Energy & ore flexibility**
- **Waste recycling in sinter possible**
- **High production rate & quality**

EASyMelt - Electrically Assisted Syngas sMelter

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Key changes

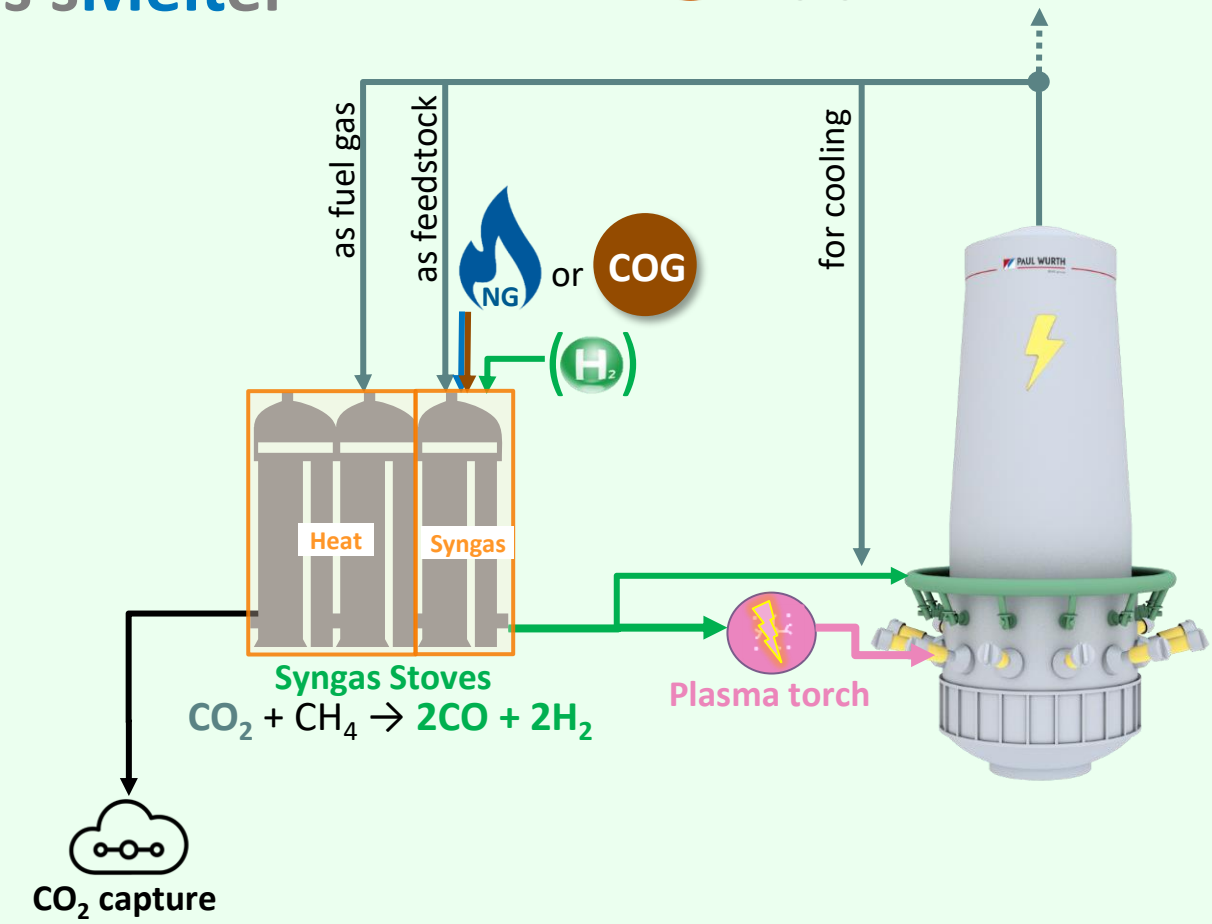
a) No blast, little consumption of cold oxygen
No PCI, nor auxiliary fuel injection

b) Instead: Externally generated syngas (H_2+CO)

c) Top gas is recycled with the help of NG and/or COG

d) Syngas injection at lower shaft & tuyere

e) Tuyere syngas superheated to ≈2000°C by plasma



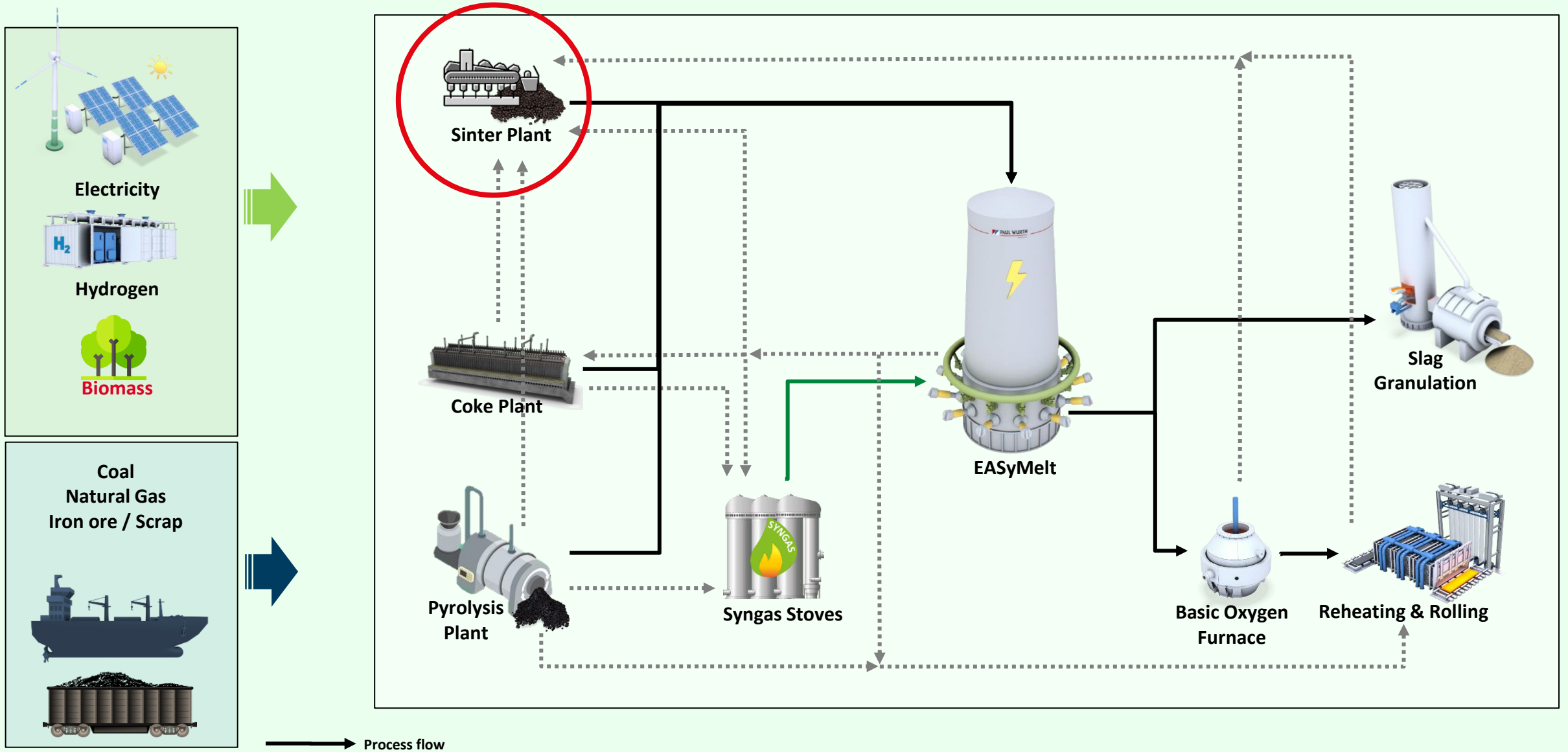
» -43% CO_2 NG

» -61% CO_2 NG + H_2

✓ **Climate-neutral by carbon capture**

→ Target coke rate of 180-100 $\frac{kg}{t_{Hot\ metal}}$

Future steel plant configuration



Sinter plant

Maintain unique advantages :

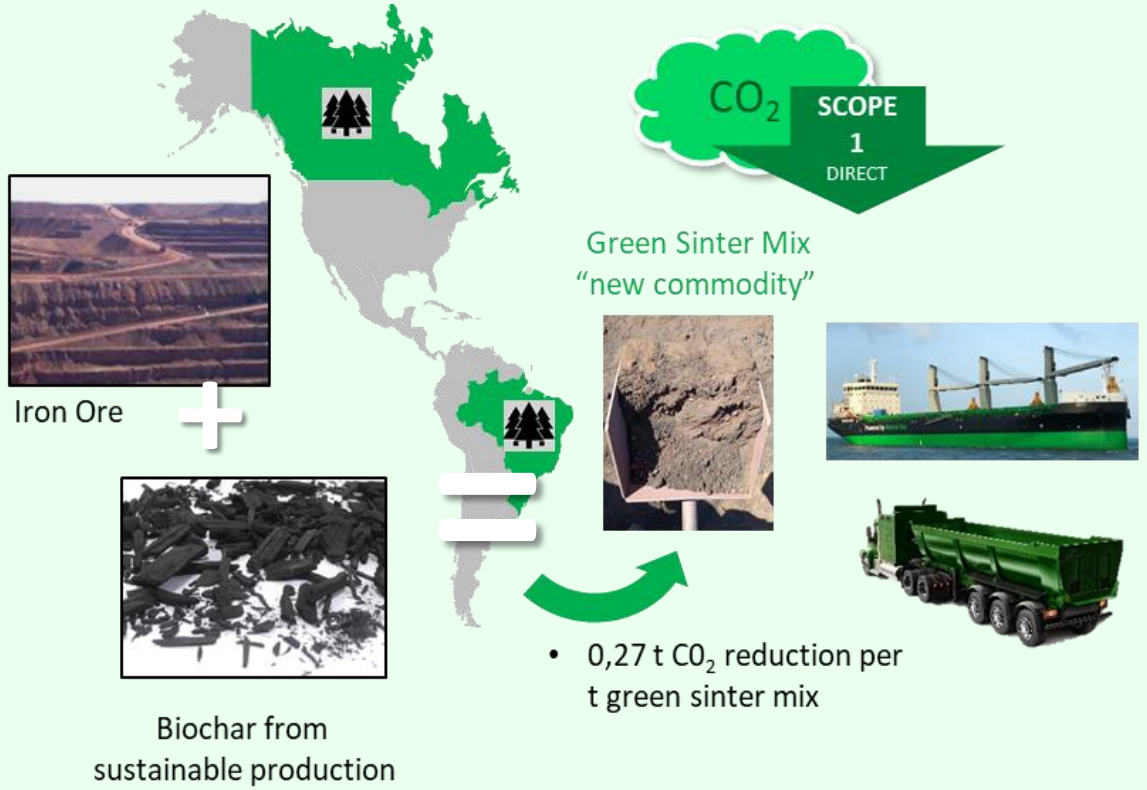
› flexible utilisation of low cost iron ore grades
(no vulnerability to high pellet premium prices)

› integration of steel plant by-products

Decarbonize with biomass:

› **Integrated** pyrolysis plant co-located with a steel plant can provide **biochar** and also **bio-fuelgas**

› **Distributed** pyrolysis plant co-located with an iron ore mine can provide biomass & ore together as **green sinter feed mixture**



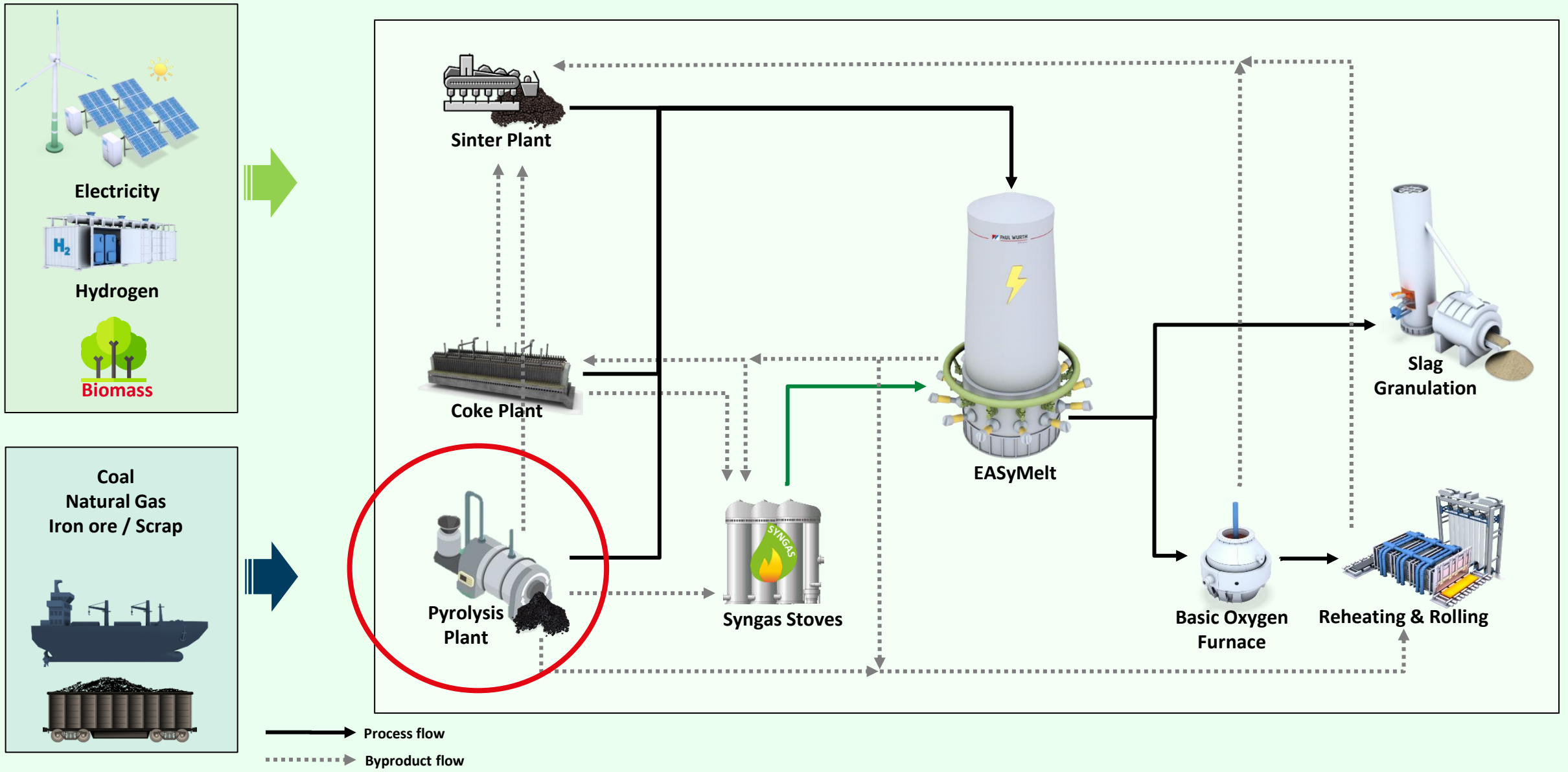
Reduced **TRANSPORT COST**

No "pure" charcoal import → *Reduced* **DUST EMISSION**

Reduced **INFLAMMATION RISK**

→ Green sinter feed mixture
= economical transport vehicle
& CO2 lean sinter feed material

Future steel plant configuration



Biomass Pyrolysis Plant

High added value application needed:

- **Sinter Plant**: energy & enabler for recycling and standard ore usage
- **EAF**: energy & enabler for nitrogen removal and slag foaming

→ *High C-fix requirement*

TorrCoal / Perpetual Next
Rotary drum technology
(small size feedstock)

Carboval
Shaft technology
(lumpy feedstock)

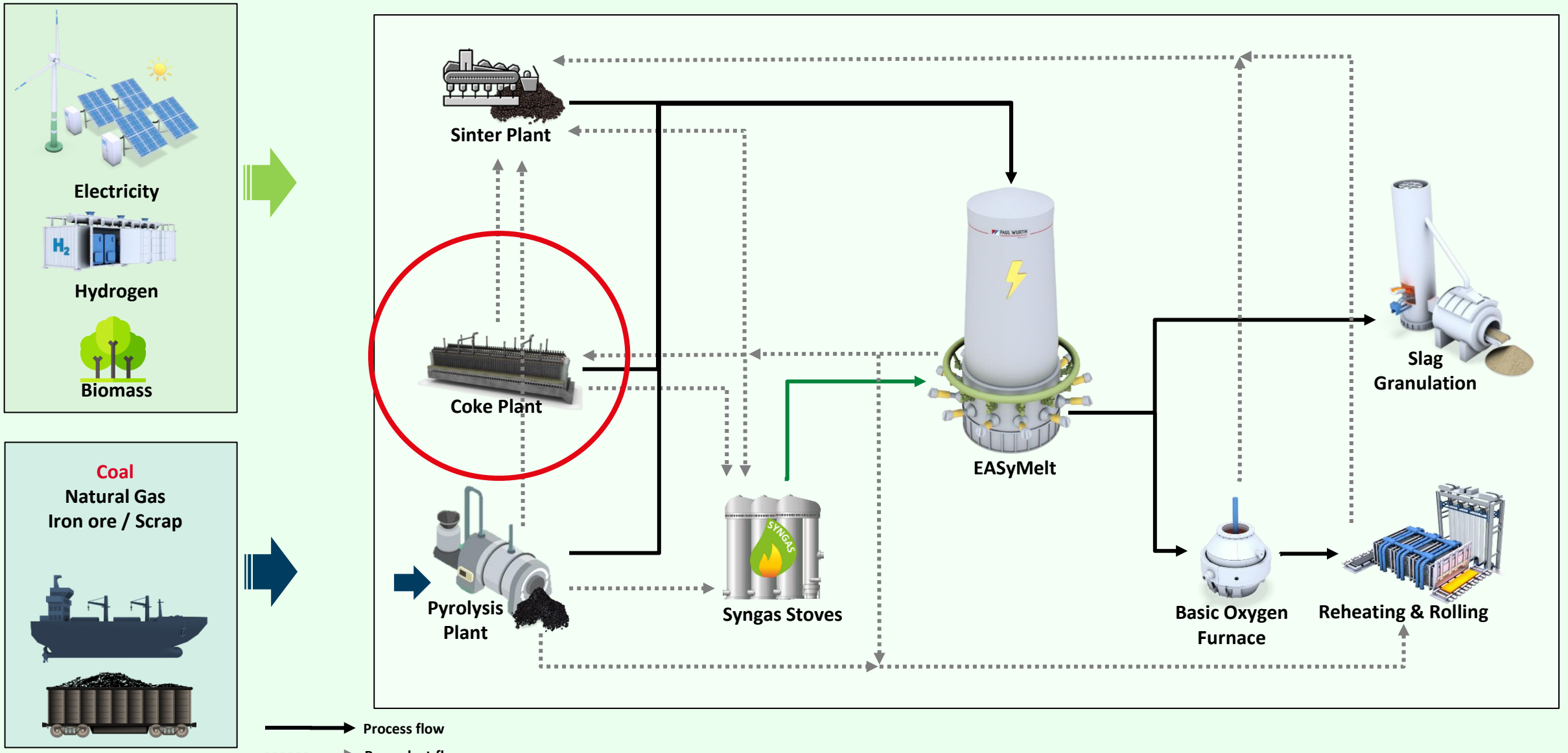
SMS solution: Integrate by-product energy into steel plant

- Reforming of permanent gas & condensables

  to produce a easily transportable bio-fuelgas, which is similar to BOF gas

Pilot installation
for by-products valorisation

Future steel plant configuration



Coke oven plant

Low coke rate BlueBF/EASyMelt:

› Reduced coke demand → reduced emissions at coke plant

Solutions for future:

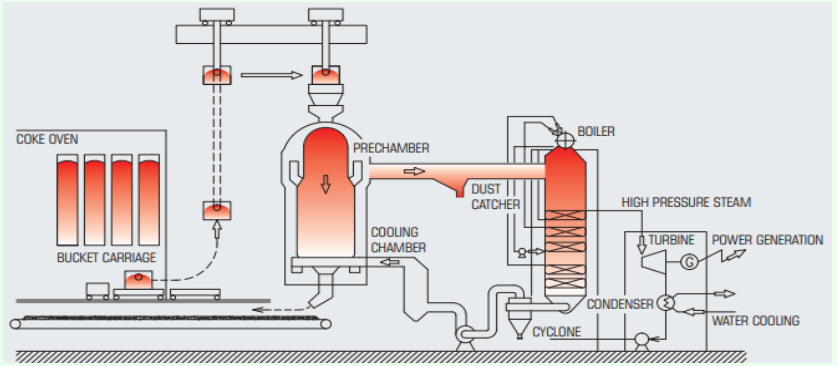
› **Coke dry quenching** → improved coke quality, reduced emissions, reduced coke plant visibility, water savings, heat recovery

› **Charging system improvements** → Smokeless controlled charging system, SOPRECO® system emission reductions

› **Doors and bracing system** → Emission free doors, door and frame cleaners

› **Controlled combustion** → Advanced combustion system, COKEXPERT™

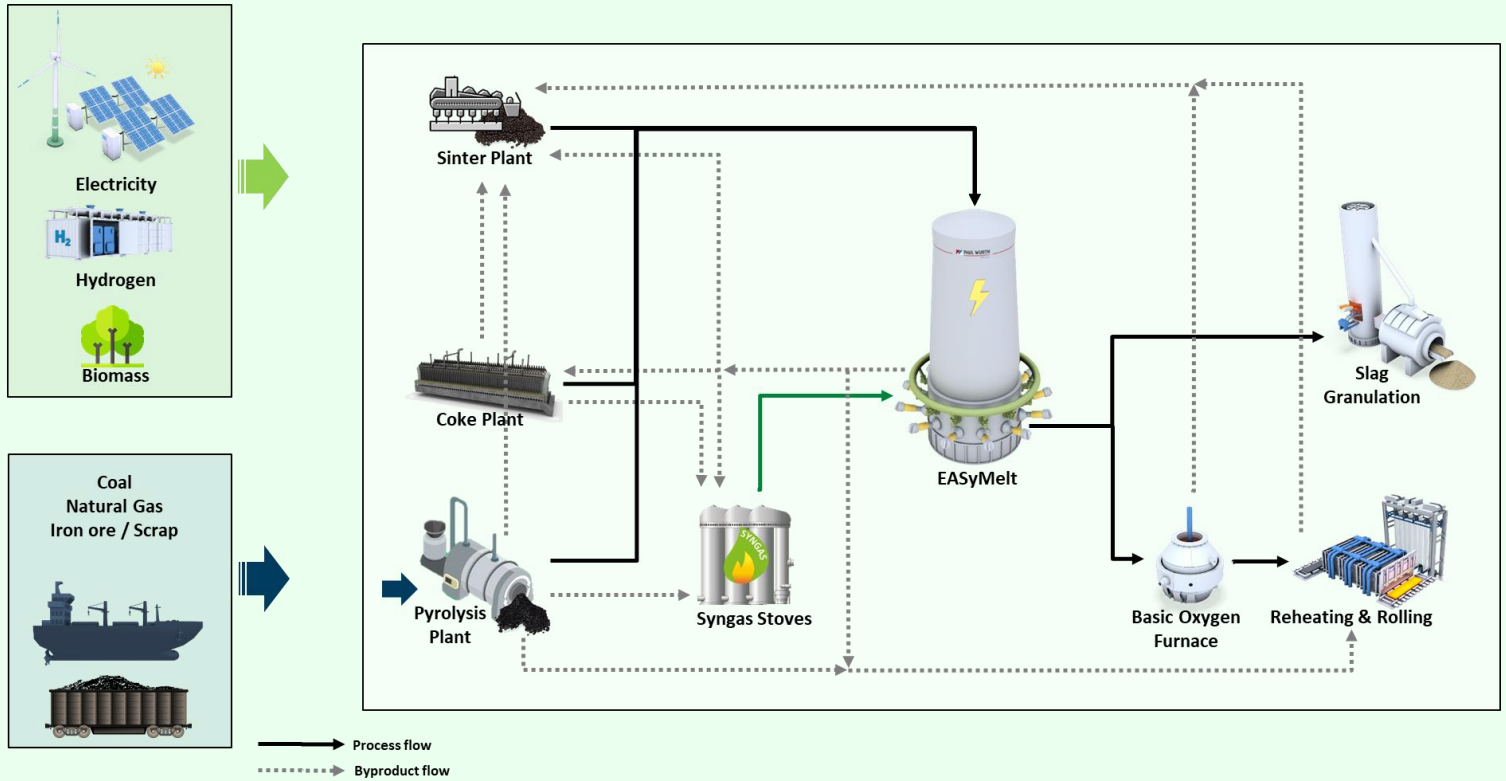
› **Machine features** → Onboard dedusting, Pushing Emission Control System



Principle of coke dry quenching

PW SOPRECO

Conclusion



Holistic decarbonization & modernization of integrated steel making is key to maximize process efficiency and environmental sustainability

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