# Carel Kleemans from Tata Steel

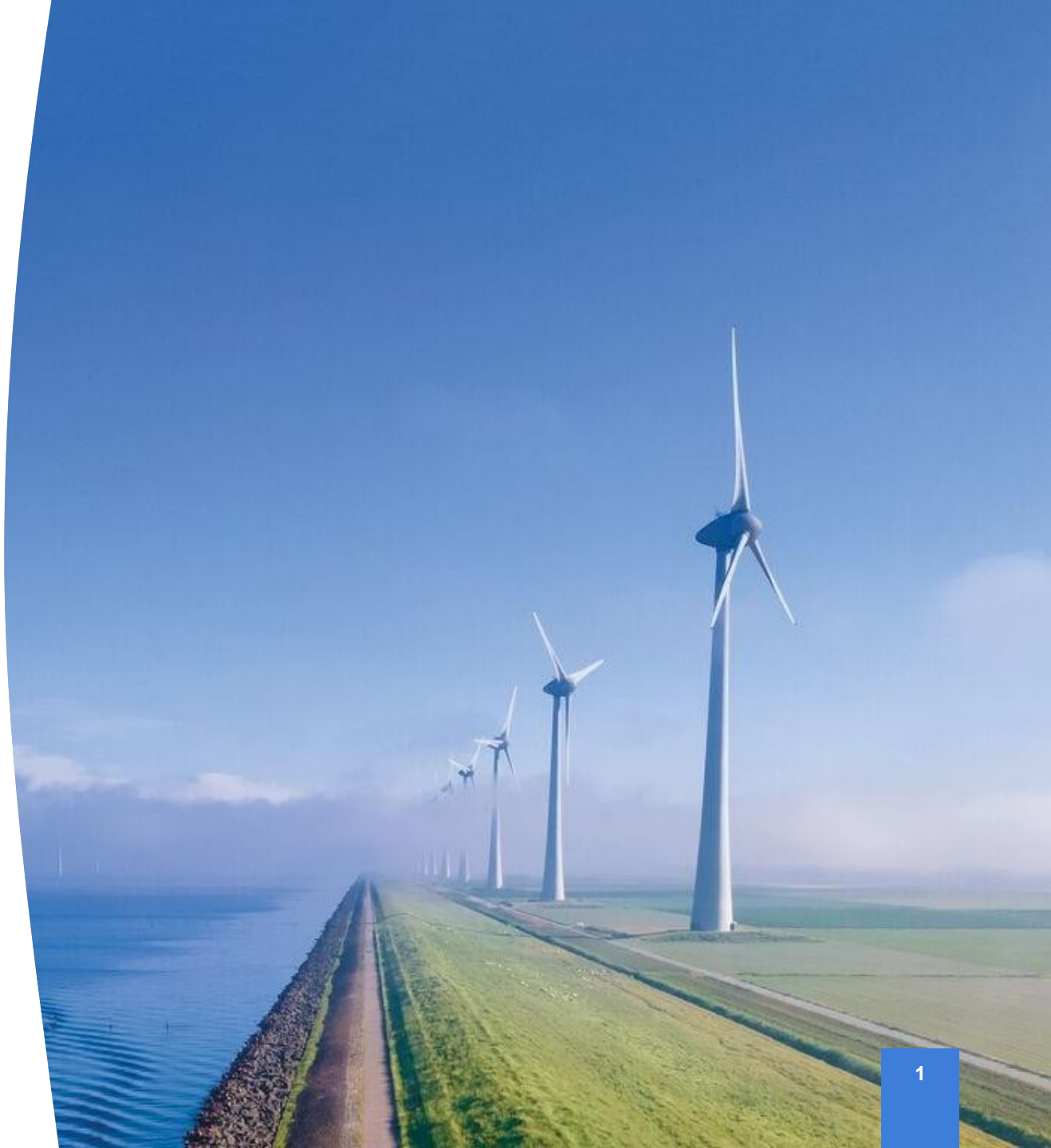
Director Technical at Tata Steel Nederland, responsible for product technology & quality and the product development for the future steelmaking route of the integrated IJmuiden steelworks.

He leads an organisation of ~250 specialists in process development, product innovation, quality assurance and customer technical service.

With over 25 years of experience in high temperature materials technology, energy conversion, and industrial innovation, he works on transformative steelmaking technologies such as HIsarna, CC(U)S, and DRP EAF transition.

Carel holds degrees in Materials Science & Engineering and Management Science, with expertise in energy infrastructure and system optimisation.

carel.kleemans@tatasteeleurope.com



# Towards a clean, green and circular steel industry

***The shifting energy mix for green steel production.***

June 2026

TATA STEEL

TATA

Clean

Green

Circular

Leadership principles

Themes

Connect

Change

Care

People & Society

Environment & Community

Decarbonisation & Sustainability

Customers & Value

# Purpose

*Why we are on the journey*

Improving how people around the world work, live and move, through sustainable steel

## Mission

*The route we follow*

To continue to play a meaningful role for all our stakeholders as a clean, green, circular steel company that creates value, is an employer of choice, and maintains an ongoing dialogue with our neighbours

## Vision

*What we expect to find when we arrive*

A clean, green and circular steel company that is sustainable in every sense

# Green, clean and circular

*What does this mean effectively?*

**Green:**
40% less $CO_2$ emissions by 2030
Equals the $CO_2$ footprint of 385.000 Dutch citizens a year.

**Clean:**

The reduction of fine dust emissions by roofing a large part of our raw materials needed for green steel.

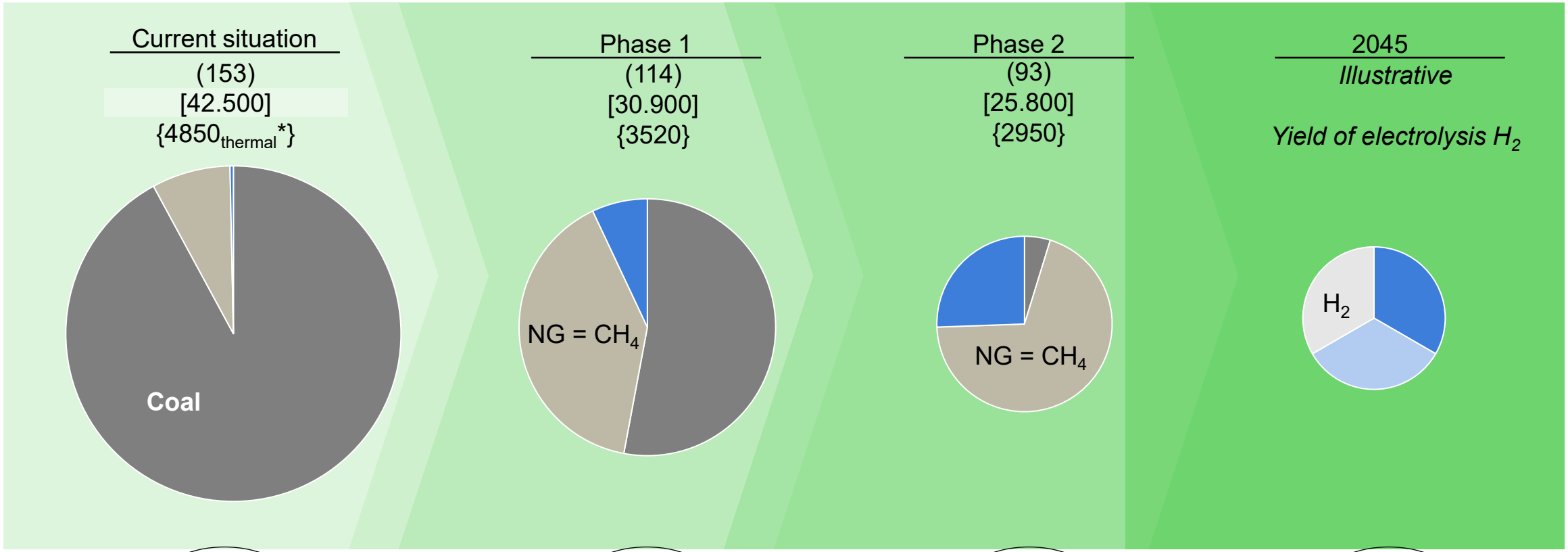
**Circular:**
The use of steel scrap will be increased from 20% to about 30% from 2030 onwards.

| | |
|---|---|
| Unit | 1,00E+00 |
| Kilo | 1,00E+03 |
| Mega | 1,00E+06 |
| Giga | 1,00E+09 |
| Tera | 1,00E+12 |
| Peta | 1,00E+15 |

# TSN aims to be climate neutral by 2045

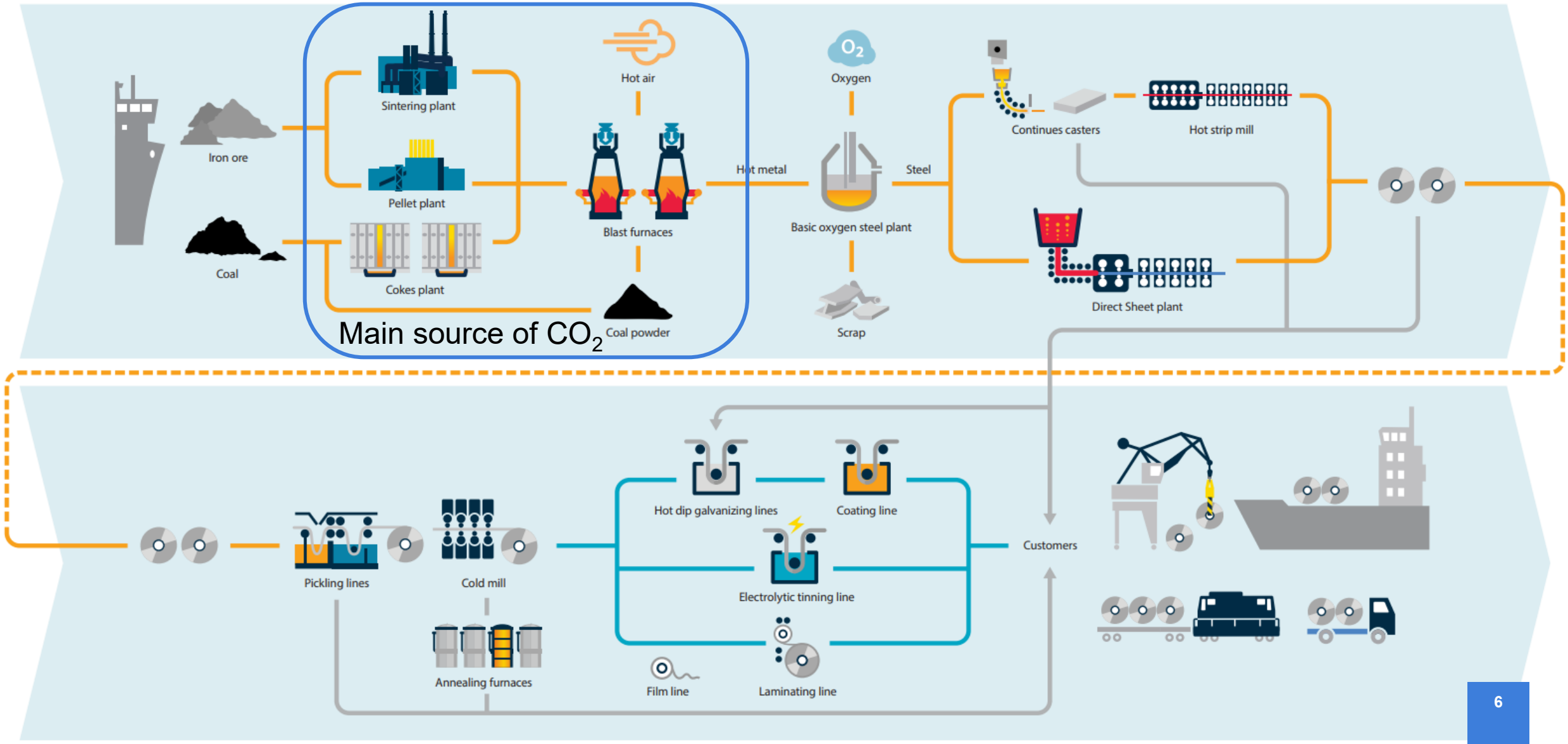
## What does this mean for the energy mix?

**Energy usage,** (PJ/a) [GWh] {MW at 100% utilisation}



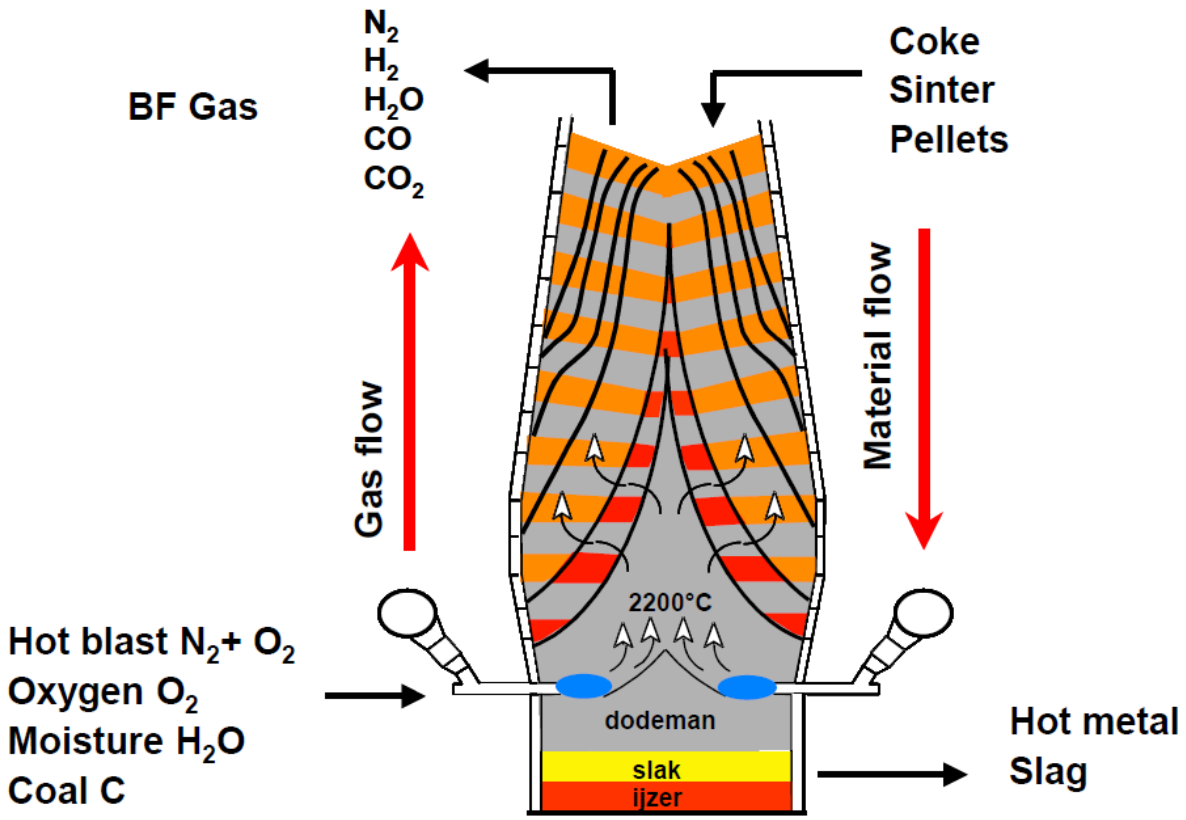

* Around 1 unit “Hinckley Point C” thermal equivalent

# Current production of iron & steel at an integrated (BF based) plant



# The seize of an integrated steel plant

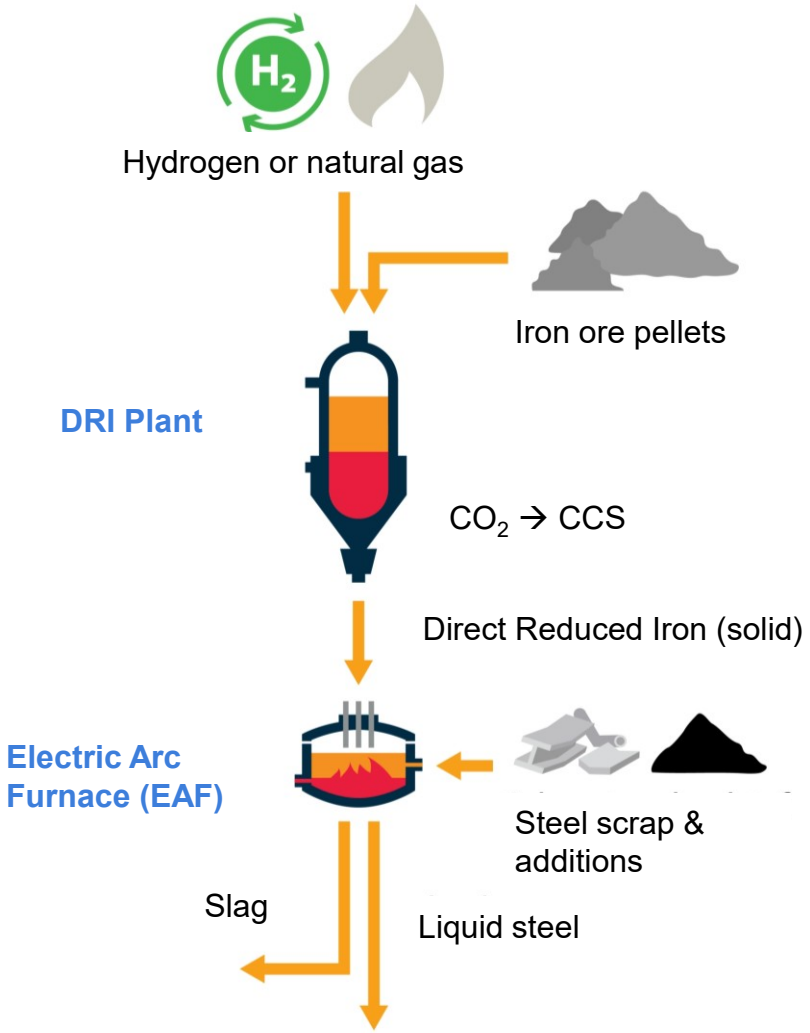
# Coal is not just a fuel generating heat but a reductant!




- Reduction reaction (simplified & equilibrium)
  - iron ore + carbon monoxide ⇌ iron + carbon dioxide
  - $Fe_2O_3 + 3\ CO \rightleftharpoons 2\ Fe + 3\ CO_2$
- BF off gas (~30% of energy) Typically
  - $N_2$ 50-60 %
  - $CO_2$ 15-25%
  - $H_2$ 2-5%
  - CO 20-30 %
- Calorific value of CO & $H_2$ is utilised for power generation in in-house power plant(s) and steam boilers.

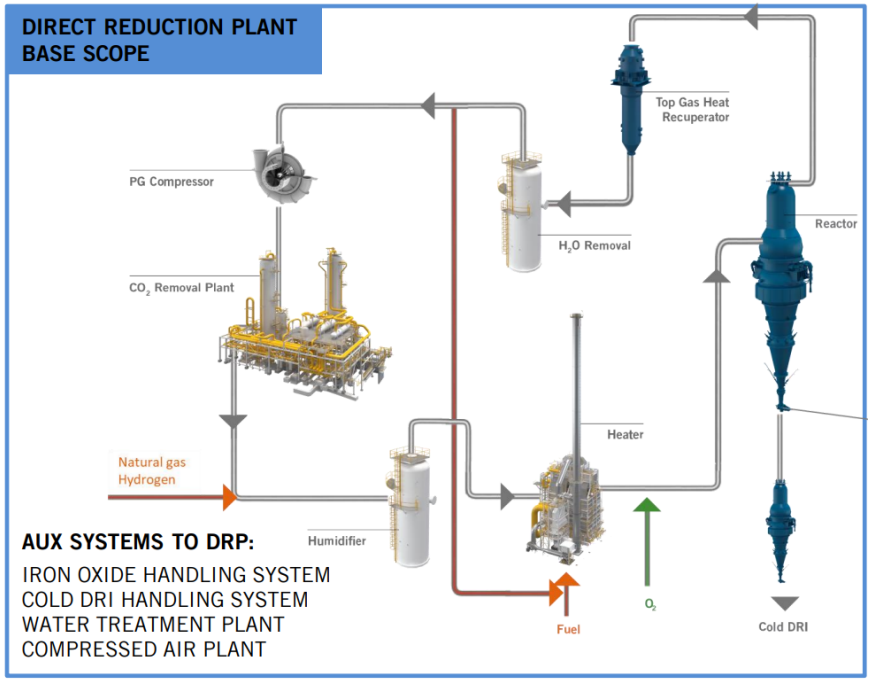
Operational of BF uptime is ~91%

# Direct Reduced Iron uses NG ($CH_4$) or $H_2$ (max 80%) for reduction



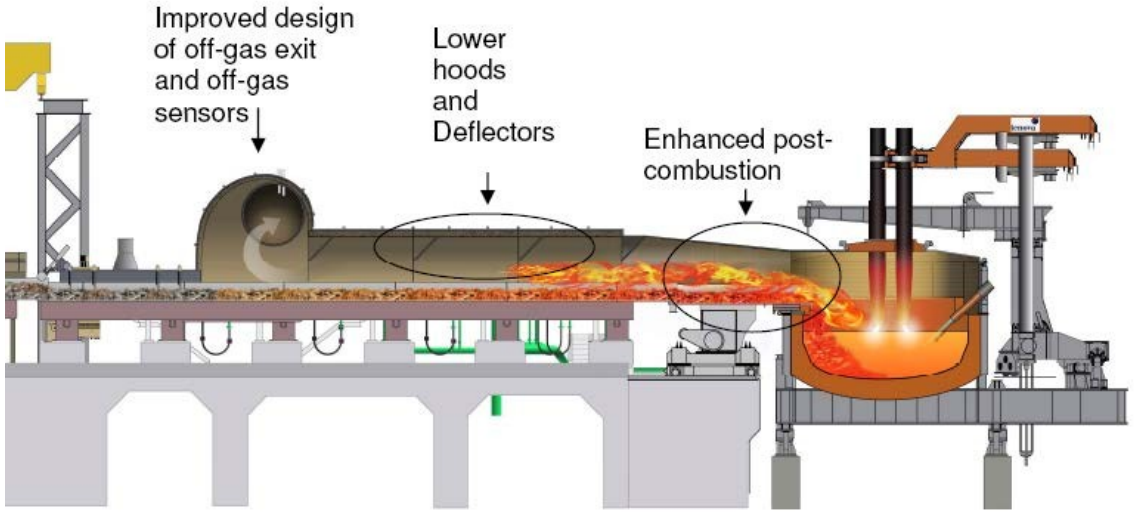

- Natural gas is treated in a reformer:
  - natural gas + water → carbon monoxide + hydrogen
  - $CH_4 + H_2O \rightarrow CO + 3H_2$.
  - $CH_4 + CO_2 \rightarrow 2CO + 2H_2$.
- Reduction reaction (simplified and/or equilibrium)
  - iron ore + carbon monoxide & hydrogen ⇌ iron + carbon dioxide + water + iron carbide
  - $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
  - $Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$
  - $3Fe + CH_4 \rightarrow Fe_3C + 2H_2$
- $CO_2$ is close to capture ready quality for CCS
- DRI pellets melted in continuously fed Electric Arc Furnace (EAF)

# Energiron ZR 2,5 Mt DRI plant





# Tenova continuous feed 3,0 Mt EAF




# Current situation


**Plants**

| 2 | 2 |
|---|---|
| blast furnaces | coke plants |

# Situation after step 1


**Plants**

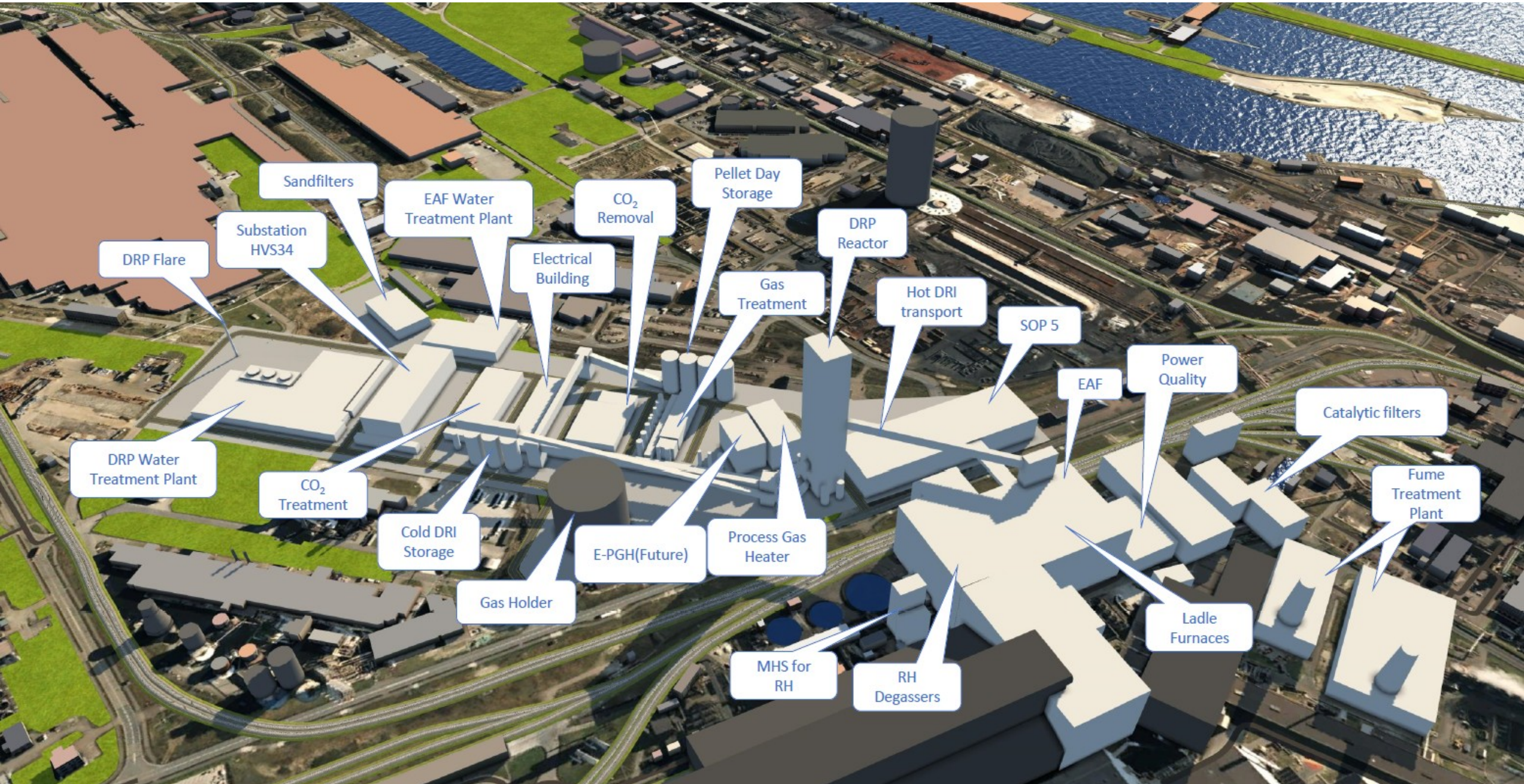
| | |
|---|---|
| 1 DRI plant | 1 electric oven |
| 1 blast furnace | 1 coke plant |

# Situation after final step


**Plants**

| 2 | 3 |
|---|---|
| DRI plants | electric ovens |

# Impression of Phase 1



# Large challenge: unequal & unpredictability of level playing field with other European countries

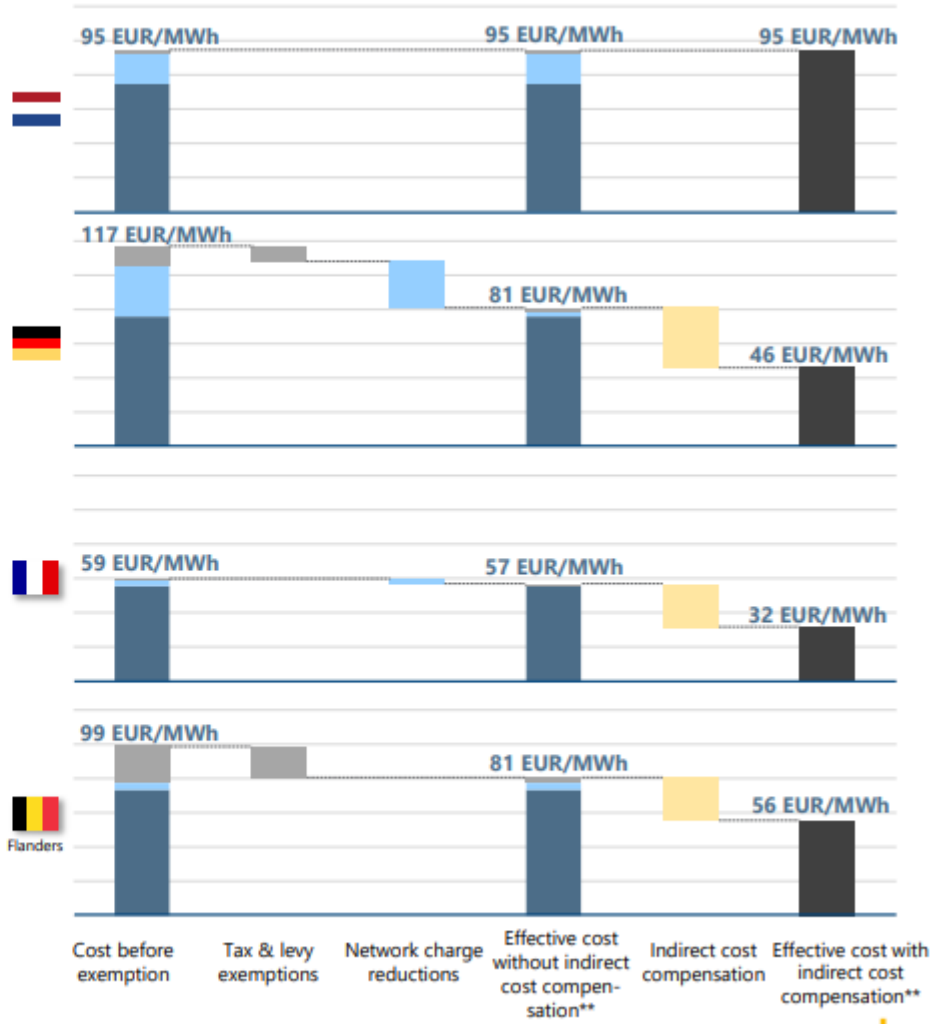
## Management summary II/IV

**In 2024 large baseload industry users (~ 1 TWh/a) in the Netherlands are paying 14-63 EUR/MWh more for their electricity than their industry peers in the other countries (approx. 95 vs. 32-81 EUR/MWh).**

This creates a **competitive disadvantage for large industrial customers in the Netherlands** (with extra high-voltage connection).

There are three main drivers and one additional specific driver for France:

1. **Substantially higher network charges**
2. No reliefs or exemptions on taxes and levies for large industry
3. **Absence of indirect cost compensation since it was terminated in 2023.**
   (Applicable sectors: production of various metals, hydrogen, chemicals, wood and paper)
4. France enables its industrial customers to obtain a large share of nuclear power at a regulated low price through the ARENH scheme.




E-Bridge competence in energy

**Applicable sectors: production of various metals, hydrogen, chemicals, wood and paper

Electricity cost assessment for large industry | 6

https://open.overheid.nl/documenten/73e26e32-ebd3-4f50-86d2-e1a8065e15d4/file

# Asset symbiosis & agility with nuclear energy options

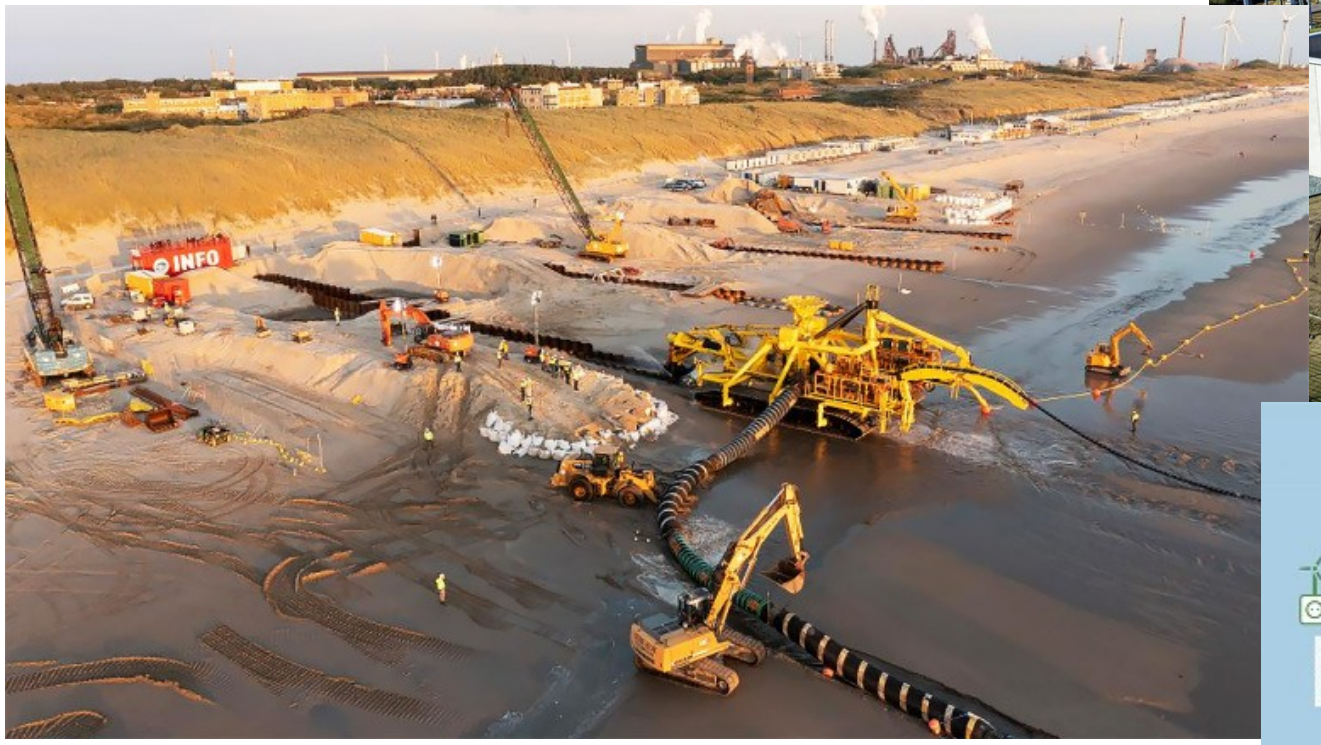
## Co-location examples & experiences:

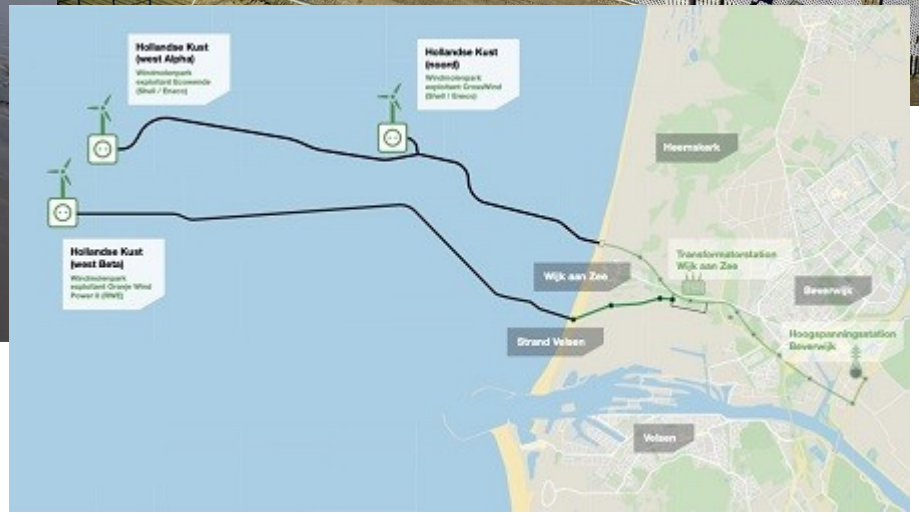
- Air Separation Unit for $O_2$ supply
- COG/BF/BOS/NG fired powerplants
- Cement industry utilising Granulated Blast Furnace slags.

## Increase business agility for energy supply:

- Power grid connection, incl. landing spot for offshore wind power
- (L)NG supply Amsterdam area, incl. NG pipe lines
- Connection to hydrogen backbone (GasUnie)
- Link to $CO_2$ pipe line for CC(U)S

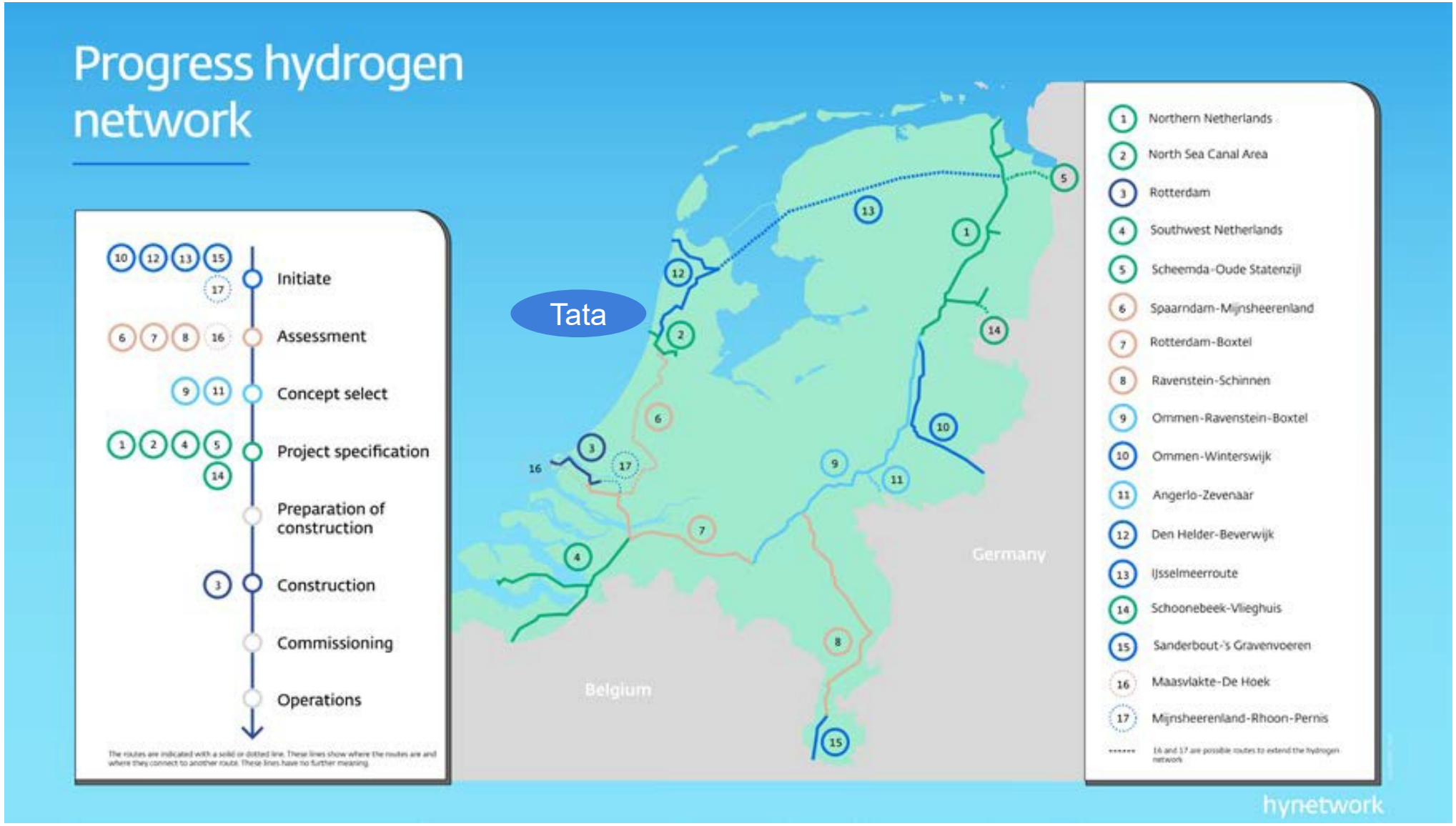
# Wind power lines landing next to Tata Steel IJmuiden




[Dikke stroomkabels en converterstation voor windparken op zee: Castricum en Egmond in beeld]

# Hynetwork (100% GasUnie) phased completion




[The roll-out plan | Hynetwork]

# CO2 pipe line OCAP linking Tata to Utilisation & Storage options


https://www.ocap.nl/regios

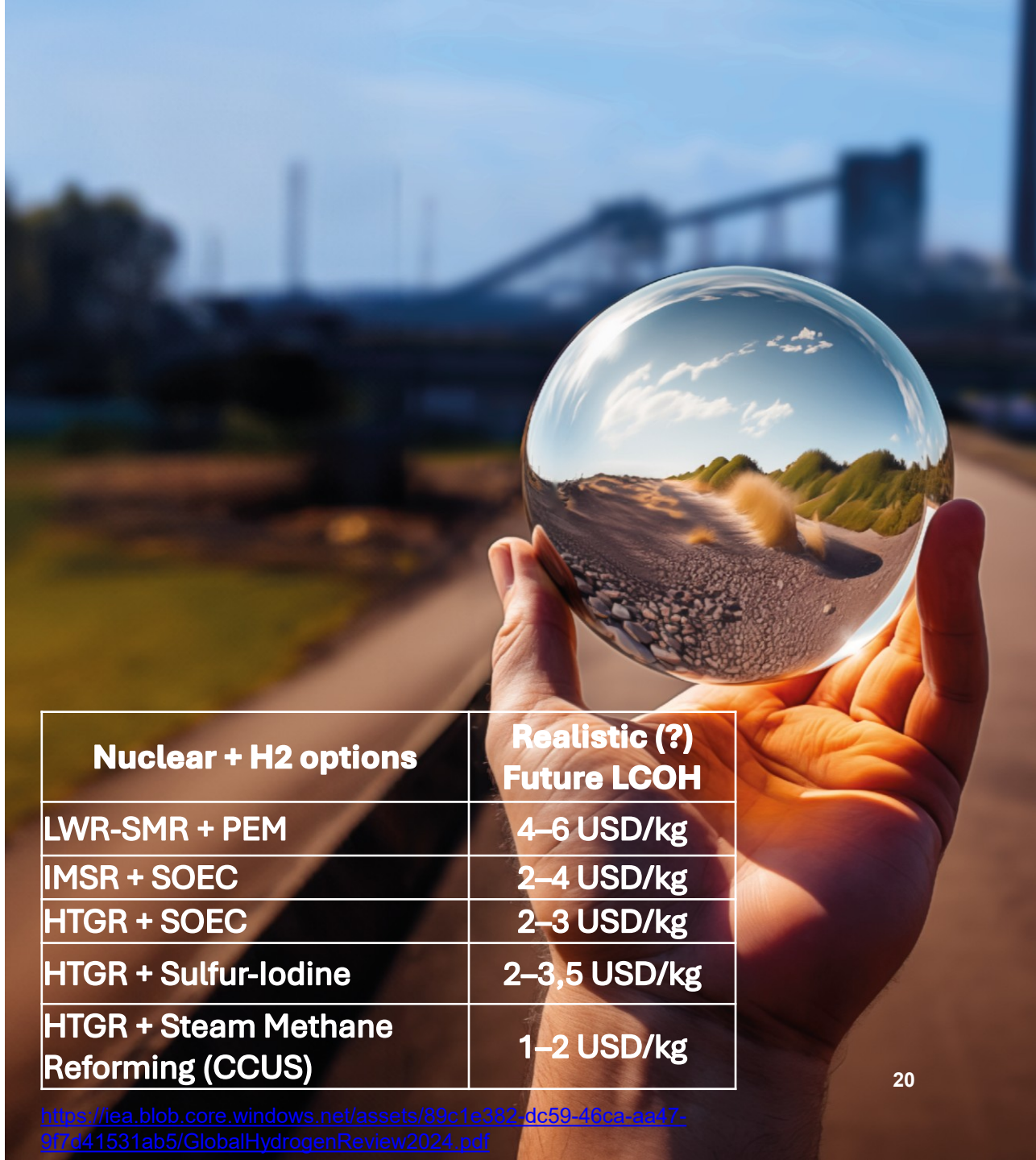
# Not in plans, but how could nuclear fit in steelmaking energy transition?

## Considerations

- Both the steelmakers asset and any nuclear option should fit the complete life span (60yrs?) of any symbiosis.
- What seize of nuclear would fit steelmakers energy need longer term?

## What energy type based on nuclear can be competitive?

- **Electric power** (base load) electricity or via power grid (vs wind & solar)
- **Heat** at elevated temperatures >> 450C for (pre)heating. Probably co-location required.
- **Hydrogen** supply via hydrogen backbone of GasUnie or co-location:pro's & con's to be evaluated.



| Nuclear + H2 options | Realistic (?) Future LCOH |
|---|---|
| LWR-SMR + PEM | 4–6 USD/kg |
| IMSR + SOEC | 2–4 USD/kg |
| HTGR + SOEC | 2–3 USD/kg |
| HTGR + Sulfur-Iodine | 2–3,5 USD/kg |
| HTGR + Steam Methane Reforming (CCUS) | 1–2 USD/kg |

https://iea.blob.core.windows.net/assets/89c1e382-dc59-46ca-aa47-9f7d41531ab5/GlobalHydrogenReview2024.pdf

# Questions?



Tata Steel Nederland

www.tatasteelnederland.com

# Link related to Green Steel Plan Tata Steel IJmuiden

- Milieu Effect Rapport (MER) | Tata Steel