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# Valorisation of WAG and CO<sub>2</sub>

## Opportunities for Reducing CO<sub>2</sub> Emissions from Steel Industry

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Tata Steel, Research and Development

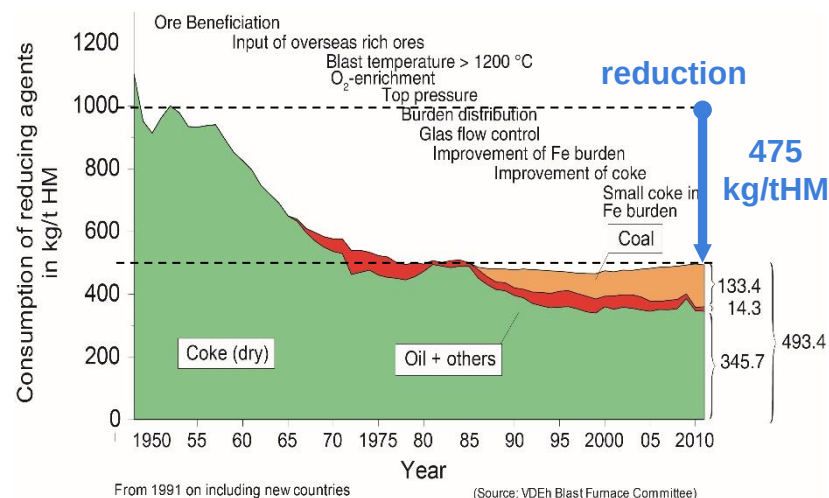
IEA Iron and Steel Industry Roadmap Workshop  
Paris, France

Together we make the difference

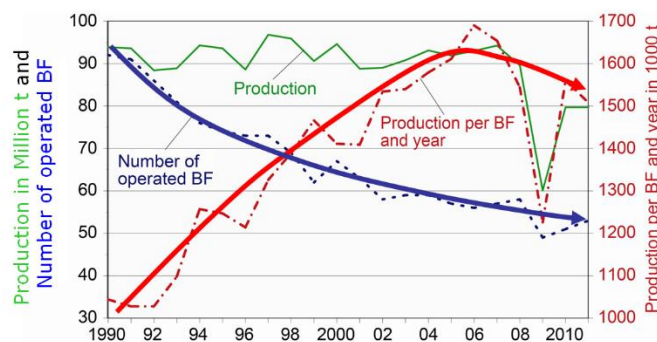


# Introduction

- Steel Industry
  - Energy and CO<sub>2</sub> intensive
  - Very high recycling rate
  - Capital intensive industry
    - Major facilities > 20 years life span
    - Large sites, large installations
- Trends in the past decades
  - Reduction in the number of blast furnaces in Europe
  - Increasing productivity
  - Close to theoretical minimum regarding reducing agents
  - BF is main producer of CO<sub>2</sub> within integrated steel works
  - Small possibilities to reduce CO<sub>2</sub> emissions with existing blast furnace operation



Evolution of Hot Metal Production in the EU 15



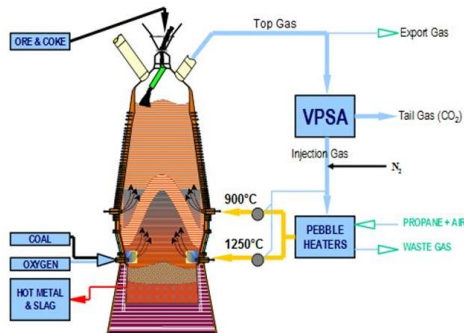
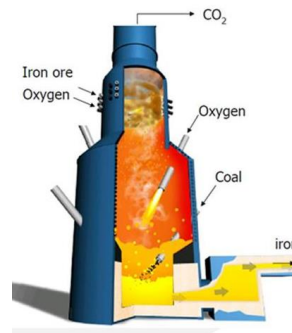
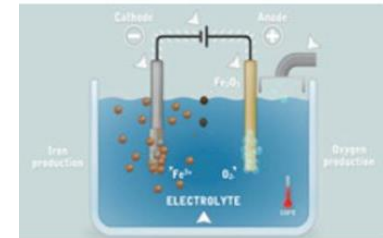
# ULCOS Programme

**ulcos** stands for **Ultra-Low Carbon Dioxide(CO<sub>2</sub>) Steelmaking**.

Coal and Sustainable Biomass

Natural Gas / Syngas from  
Coal Gasification

Electricity



TGRBF (ULCOS BF)

Hlsarna

ULCORED

ULCOWIN

ULCOS is a consortium of 48 European companies and organisations from 15 European countries that have launched a cooperative research & development initiative to enable drastic reduction in Carbon Dioxide(CO<sub>2</sub>) emissions from steel production.

Since the early 2000's, the steel industry has invested significant amount of resources in evaluating technologies that could reduce the carbon footprint of steel production

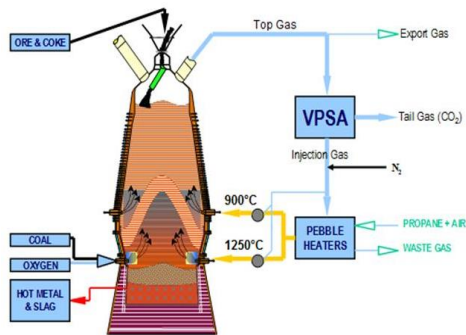
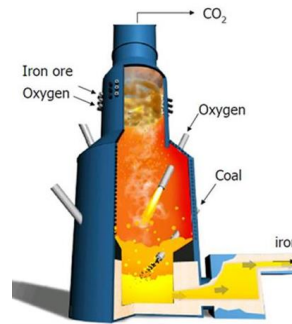
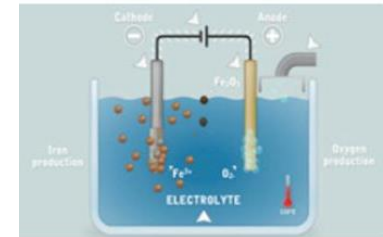
# CO<sub>2</sub> Capture and Storage

**ulcos** stands for **Ultra-Low Carbon Dioxide(CO<sub>2</sub>) Steelmaking**.

Coal and Sustainable Biomass

Natural Gas / Syngas from  
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TGRBF (ULCOS BF)

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**+ CO<sub>2</sub> Capture & Storage**

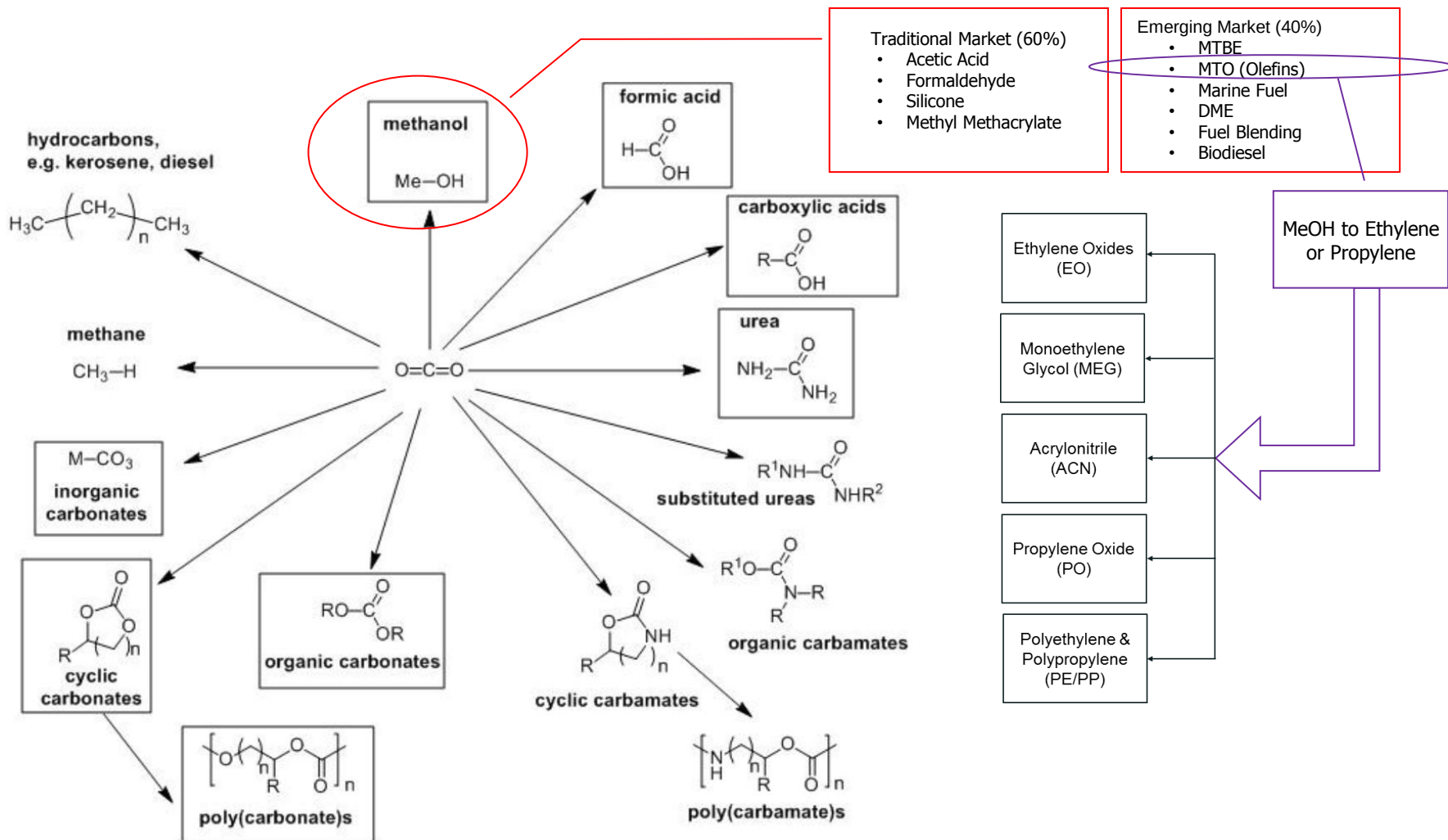
**Decarbonised  
Electricity**

To achieve greater than 80% CO<sub>2</sub> Reduction –  
CO<sub>2</sub> Capture and Storage will be needed

# Emergence of CCU

## CO<sub>2</sub> as Raw Materials to Different Chemical Industries

Figure adapted from P. Styring (CO<sub>2</sub>Chem), Methanex



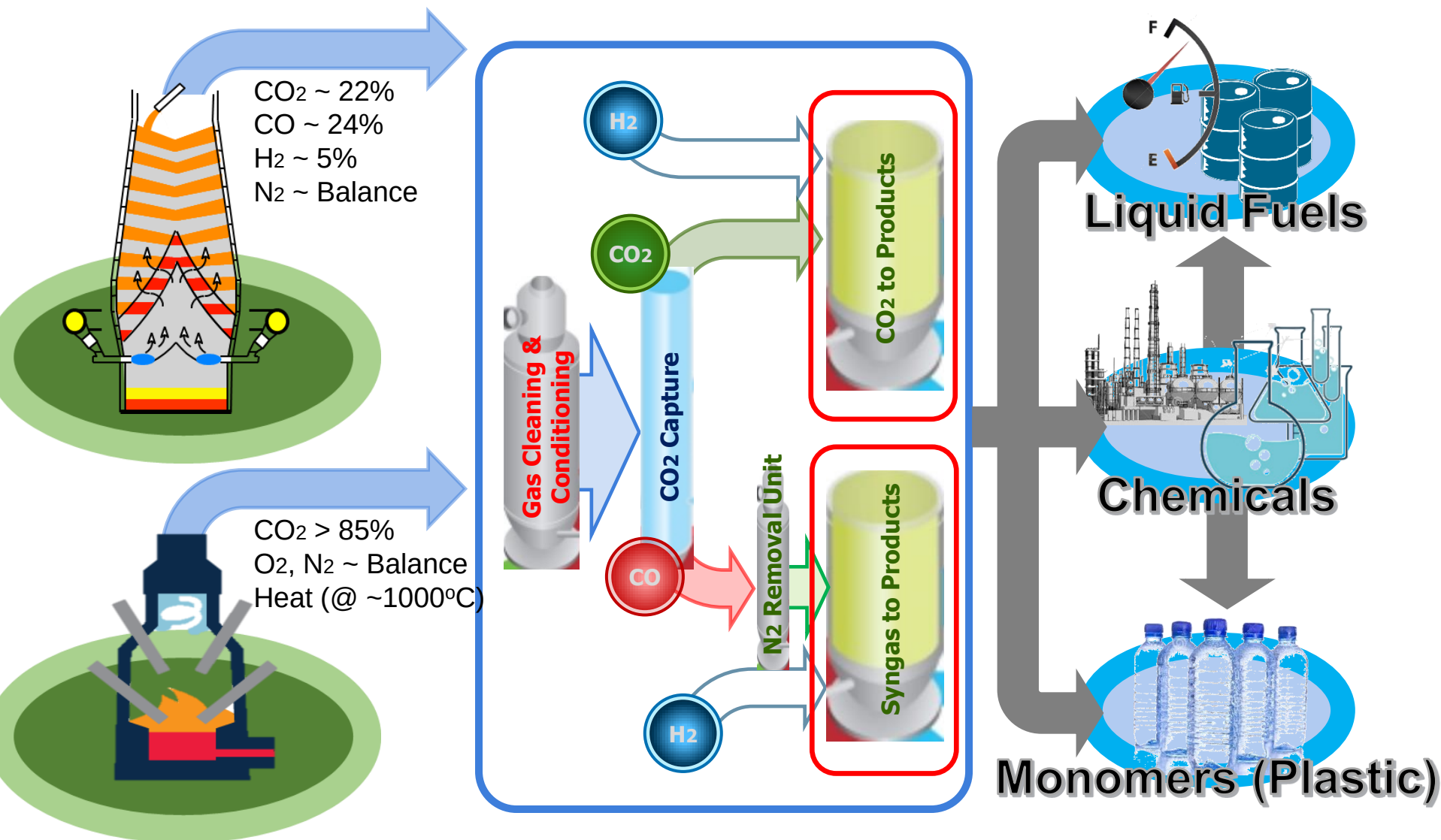
# CCU in the Perspective to the Steel Industry



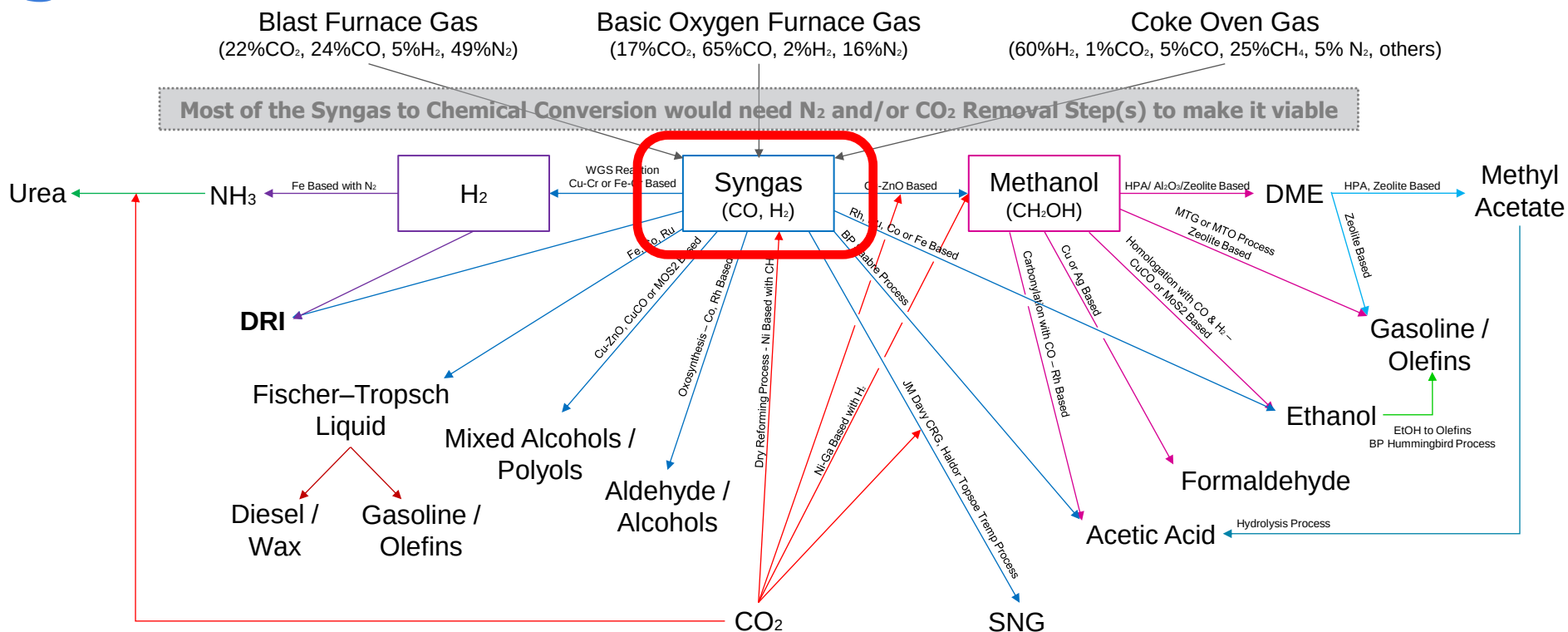
Step 1: Ironmaking & Off-gas Production

Step 2: Gas Cleaning & Preparation

Step 3: CO<sub>2</sub> / CO to Products



# Chemical conversion of works arising gasses



The R&D for the alternative routes for the works arising gases and solutions for CO<sub>2</sub> will:

Create multi-disciplinary knowledge on the chemistry and technology for future engineering solutions on: Carbon Capture and Storage (CCS) **and** Carbon Capture and Usage (CCU) – CO<sub>2</sub> and/or syngas to chemicals & fuel.

# CCU via Chemical Conversion

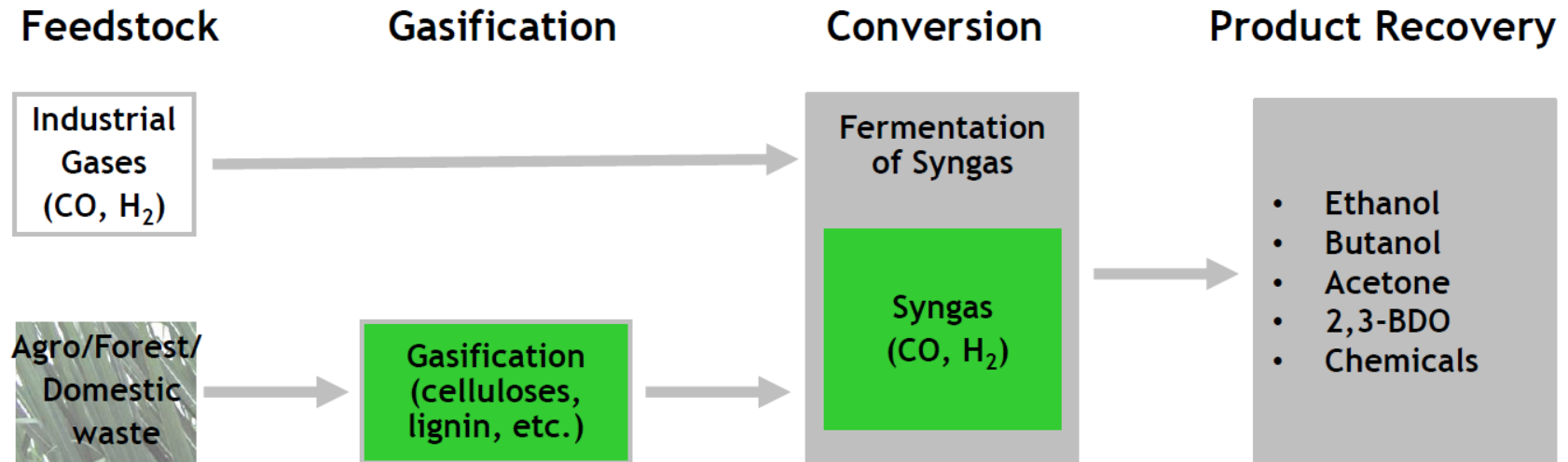


## Key Challenges

- Use of CO<sub>2</sub> and/or Works Arising Gases would require gas preparation / conditioning steps.
  - To remove impurities that could poison the catalyst.
  - To separate nitrogen from CO or CO<sub>2</sub> to reduce energy penalty in the chemical conversion step.
- Use of CO (as syngas) is more energy efficient than using CO<sub>2</sub>.
- A lot of CO<sub>2</sub> Conversion to Chemicals / Fuel Technologies are still immature.
  - Most technology is in development phase (lower TRL)
  - Most of the reactions require continuous operation.
- **The hydrogen balance is a critical factor to achieve maximum conversion of carbon (as CO<sub>2</sub> and/or CO) to chemicals / fuel production.**

# 2<sup>nd</sup> Generation Technology – Syngas Fermentation to Ethanol or Other Products

(Figure courtesy of Prof. H. Noorman, DSM/TU Delft)



2<sup>nd</sup> Generation Fermentation Technology that will not compete with the Food Production Cycle

# Gas Fermentation of Syngas – Status & Challenges

## Development of Bacterial Strain

- Resistant to impurities – particularly HCN

## Development of Process

- Development of gas clean-up.
- Reduction in energy consumption
  - Mainly in the product recovery and purification.

## Close cooperation with DSM/TU Delft (Prof. H. Noorman)

- Three critical lessons
  - Lesson A – Design with the end in mind!
  - Lesson B – It is all about feedstock
  - Lesson C – Under promise, over deliver.
- We have also looked on 19 other lessons to be learned...

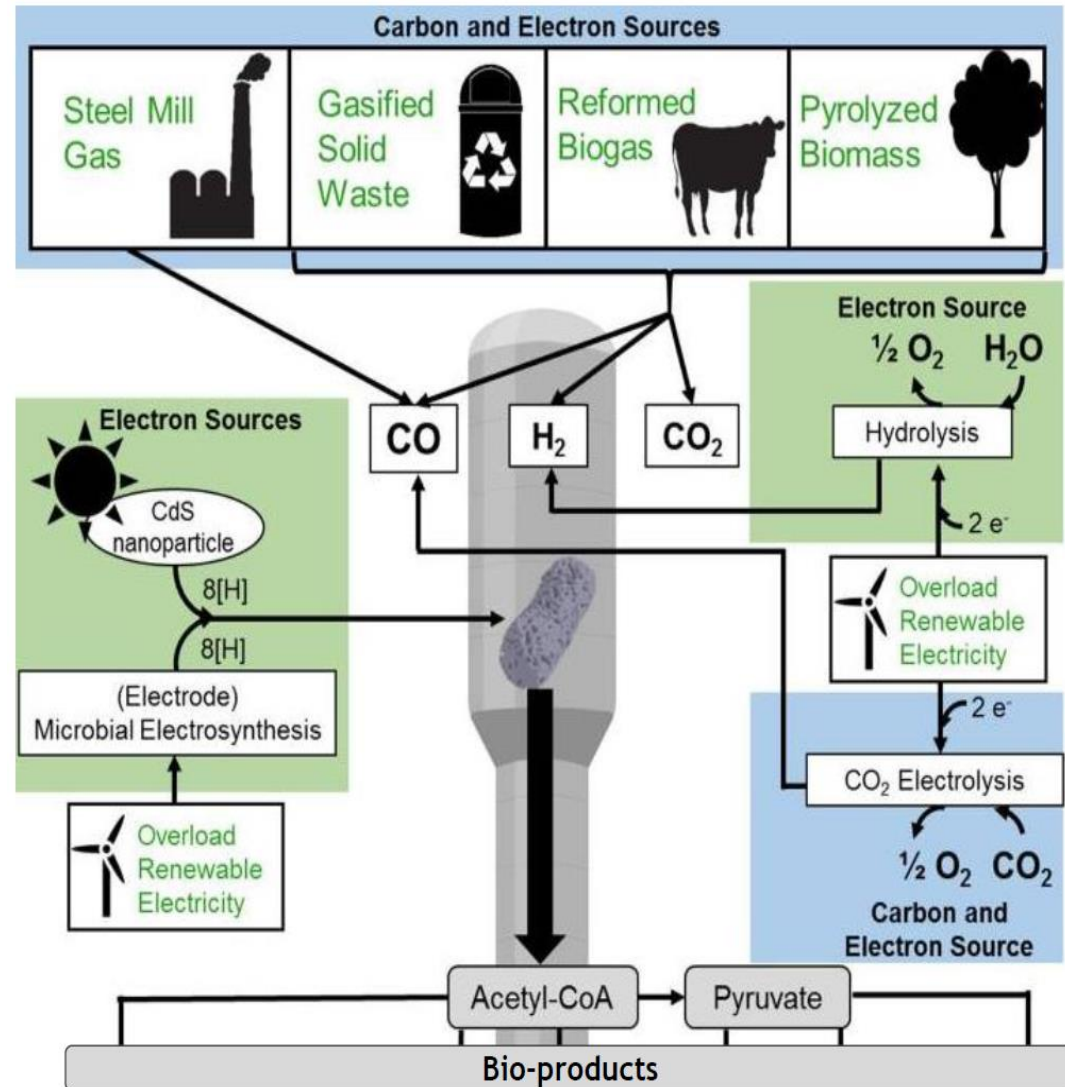


Figure from Liew et. al. (2016)

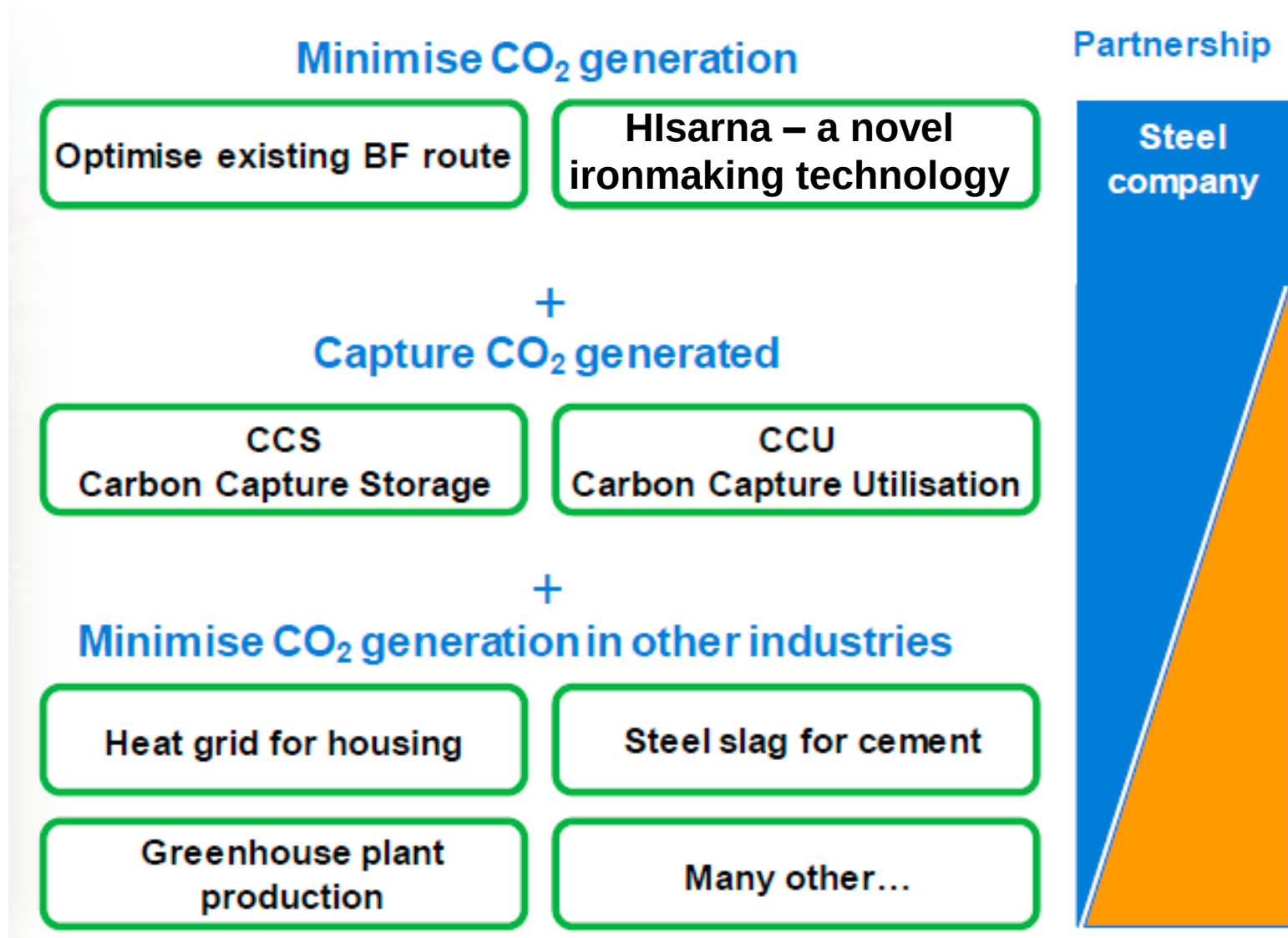
# Hydrogen and Steel Industry



- Does H<sub>2</sub> has an important role in iron & steel production in the future?
- Does H<sub>2</sub> replace coke in the BF?
- Does H<sub>2</sub> provides the sustainable feedstock to DRI?
- Will there be sufficient decarbonised H<sub>2</sub> to provide sustainable steel production in the future?



# Vision of Adapting Low CO<sub>2</sub> World by 2050...

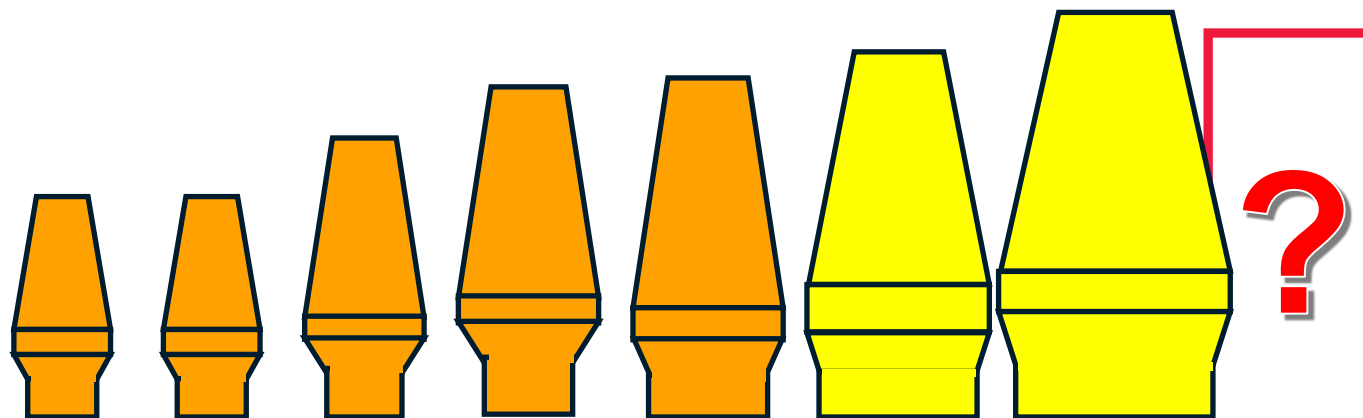


# Concluding Remarks



- Since the early 2000's, the steel industry has put in a significant amount of investment in R&D to reduce their carbon footprint further:
  - Extensive work in making the blast furnace carbon lean and CO<sub>2</sub> capture ready (i.e. TGRBF).
  - New alternative processes (i.e. HIsarna) are being developed to intensify the steel production process. HIsarna is CO<sub>2</sub> capture ready.
- Both CCS and CCU have an important role in reducing the CO<sub>2</sub> emissions of the integrated steelworks:
  - In particular (given the right economic conditions), the use of Works Arising Gasses is an opportunity to replace crude oil to produce valuable chemical products and/or transport fuel.
- For a final thought, the steel industry recognises its responsibility to address the climate change issues. Therefore, it will continue to put in the efforts and investment needed to exploit any opportunities to reduce its CO<sub>2</sub> emissions.

# BF Development at Tata Steel IJmuiden



| Blast Furnace No.           |     | 1    | 2    | 3    | 4    | 5    | 6         | 7     | 8 |
|-----------------------------|-----|------|------|------|------|------|-----------|-------|---|
| Year Built                  |     | 1924 | 1926 | 1930 | 1958 | 1961 | 1967      | 1972  |   |
| Hearth Diameter             | m.  | 5.6  | 5.6  | 5.8  | 8.5  | 9.0  | 11.0      | 13.8  |   |
| Last Revamp / Reline        |     |      |      |      |      |      | 2002      | 2006  |   |
| Initial Productivity        | t/d | 280  | 280  | 360  | 1380 | 1700 | 3000      | 5000  |   |
| Current / Last Productivity | t/d | 800  | 800  | 1200 | 3600 | 3600 | 7500      | 10000 |   |
| Demolished                  |     | 1974 | 1974 | 1991 | 1997 | 1997 | Operating |       |   |

**What is the next generation ironmaking process:**

**(A.) Carbon Lean BF Process and/or (B.) Alternative Ironmaking Process - i.e. Hisarna**