Perspectives on hydrogen use in the steel industry

April 13th, 2021 | Dr. Markus Schöffel | Manager Sustainable Production | thyssenkrupp Steel Europe AG
We have defined clear climate targets

-30% Emissions from our own production operations and processes\(^1\)

2030 -30% Emissions from energy procurement\(^2\)

\(^1\) SCOPE 1-Emissions; \(^2\) SCOPE 2-Emissions (Base year 2018)
Gas and electricity will replace coal in future steelmaking

Blast furnace needs coke as reduction and structural agent to produce liquid hot metal

Direct reduction plant uses gas (natural gas, coke oven gas or hydrogen) to produce solid sponge iron subsequently liquefied in electric melter

About – 95% kg CO₂ emissions per t crude steel

1,800

100 (remaining emissions when using hydrogen and green electricity)

Additional reduction agent (pulverized coal, natural gas, coke oven gas, H₂)

Gas as reduction agent in DR plant

Green electricity as energy carrier in the melter

Gas and electricity will replace coal in future steelmaking
Carbon2Chem® will support decarbonization parallel to hydrogen metallurgy.

- **H₂**
- **Syngas**
- **Methanol**
  - 1st production: 20th September 2018
- **Ammonia**
  - 1st production: 21st December 2018

Cleaning of gases from coke oven, blast furnace and basic oxygen furnace.
Steel mills can be integrated in sustainable green value chains

e-fuels for heavy duty and individual mobility

Bulk Chemicals and e-fuels
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**2020 onwards**

**Industrialization**

The pilot system at the Duisburg steel plant uses steel mill gases to produce base chemicals.

**2025 onwards**

**Large-scale production**

We will use the unavoidable CO\(_2\) as a raw material on an industrial scale. The Carbon2Chem® technology can also be used in other sectors, like the cement industry.

**2026 onwards**

**The melting unit**

We will optimize the hot metal system using a new, electrically powered melting unit. The sponge iron from the DR plant is thus liquified for the BOF meltpshop. In this way, we will replace the first coal-based blast furnace.

**2030 onwards**

**Climate-neutrality**

We will produce our steel climate-neutrally in four DR plants and four melting units.

**2030 onwards**

**The scale-up**

We will replace another coal-based blast furnace using a second, larger DR plant and another melting unit.

**2040 onwards**

**The milestone**

Using a large-scale direct reduction (DR) plant which will be operated using green H\(_2\) in the future, thyssenkrupp will produce sponge iron which will then be processed in the blast furnaces (BF), allowing a further reduction in emissions.

**2050 onwards**

**Climate-neutrality**

We will produce our steel climate-neutrally in four DR plants and four melting units.

**2019 - 2022**

**H\(_2\) in the blast furnace**

We have been testing the use of hydrogen in a working blast furnace since 2019. The goal: The equipment of blast furnace 9.

**Available quantity of climate-neutral steel (per year)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 2022:</td>
<td>50,000 t</td>
</tr>
<tr>
<td>From 2025:</td>
<td>400,000 t</td>
</tr>
<tr>
<td>From 2027:</td>
<td>950,000 t</td>
</tr>
<tr>
<td>From 2030:</td>
<td>3m t</td>
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</tbody>
</table>

**2018**

**The world first**

The concept: CO\(_2\) becomes raw materials. In September 2018, thyssenkrupp produced methanol from steel mill gases for the first time at its Carbon2Chem® technical center in Duisburg.

**From 2022:**

50,000 t

**From 2027:**

950,000 t

**From 2030:**

3m t
The energy demand is significant compared to the German electricity and gas market.

Assumption: 10 mtpa steel from hydrogen direct reduction, Carbon2Chem not included

Sources:
https://www.energy-charts.de/energy_pie_de.htm?year=2019
https://www.bdew.de/media/documents/Erdgasverbrauch_Vgl_2018_2019_monatlich_online_o_monatlich_Ki_12032020.pdf
German green domestic hydrogen production will not be sufficient.
We follow an technology open approach in hydrogen supply projects

H2morrow steel

Completed feasibility study for 2.7 GW ATR with CCOS

Blue hydrogen

Today: Hydrogen injection to blast furnace

From 2024: Hydrogen based direct reduction

Cooperation for 100 MW electrolysis in Lingen

Green hydrogen

RWE

Feasibility study for 500 MW electrolysis in Duisburg-Walsum

Green hydrogen

steag

Pre feasibility study

Turquoise hydrogen

Production of Natural Gas

Pipeline Transport

Pyrolysis Plant

Natural Gas

Solid Carbon

Special Chemistry

Construction

Agriculture

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Hydrogen pipeline connection is a prerequisite for a successful transformation ...

Grid development plan gas 2020-30 (green gas variant):

37 km new built H₂ pipeline and conversion of existing NG pipelines to H₂ for supply of tk SE Duisburg by end of 2026
... and enables further future partnerships

- **HySupply**
  - Ship transport from Australia

- **NorthH₂**
  - Connection to green projects in the NL
  - Production in Lingen

- **GETH₂**
  - Connection to NL hydrogen backbone

- **gasunet**
  - Pipeline from North Africa

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Pipeline from Russia

- Short- to medium-term vision
- Long-term vision

Source: FNB Gas
Thank you for your attention!