Vätgasens roll i energi- och klimatomställningen

Hur ser gas- och infrastrukturbolagen på vätgasens möjligheter?

Per Sellerholm

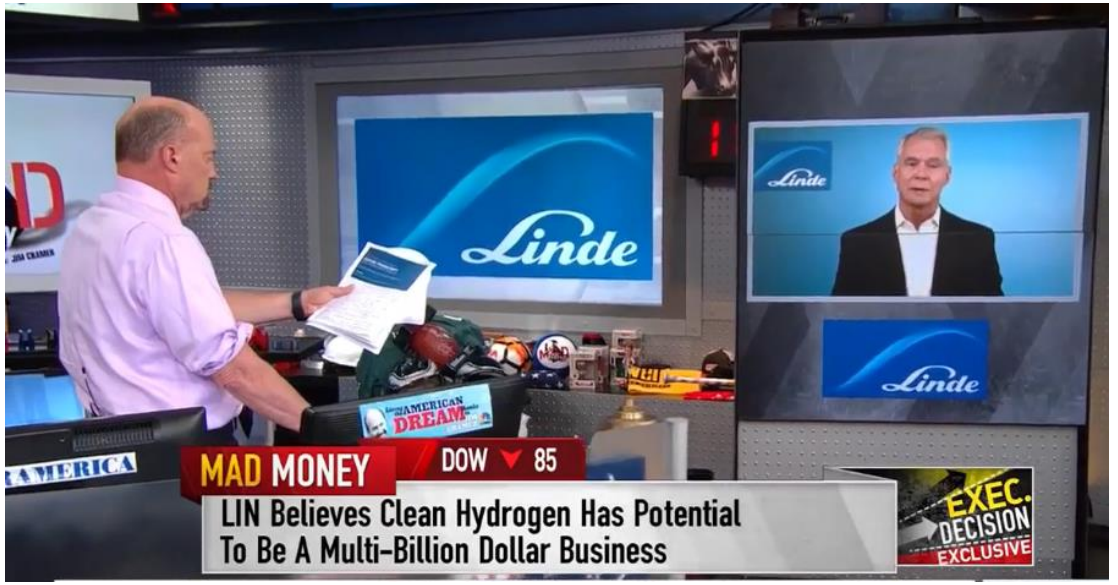
Energiforsk, November 5th, 2020

Making our world more productive

Examples - Hydrogen in Linde Q2/Q3 2020

Corporate

Linde to Contribute to EU's Hydrogen Strategy as a Member of the European Clean Hydrogen Alliance



gasworld

Hydrogen station for trains to be built in Germany by Linde

By Joanna Sampson | 28 July 2020

Linde will construct a hydrogen refuelling station for passenger trains in Bremervörde, Germany, which the industrial gases group claims will be the world's first.

Construction is due to start in September and follows a successful 18-month trial of the world's first two hydrogen trains in the region.

- Fuel 14 hydrogen-powered passenger trains
- The hydrogen station will have a capacity of around 1,600kg of hydrogen per day
- On-site hydrogen generation using electrolysis
- Ready for operation 2022

MARKETS BUSINESS INVESTING TECH POLITICS CNBC TV

SUSTAINABLE ENERGY

In Sweden, hydrogen has been used to heat steel in a bid to boost sustainability

PUBLISHED FRI, MAY 1 2020 4:53 AM EDT

Anmar Frangoul

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Executive Vice President Americas at Linde plc
3u ·

Just had a very positive discussion with Chancellor Merkel and the German Government about Clean Hydrogen. It is great to see things picking up after the announcement of Germany's National Strategy, and I look forward to further supporting the development of the clean hydrogen economy in the country.

Introduction to Linde

- The leading industrial gases and engineering company
- Formed in 2018 with the merger of Linde AG and Praxair, Inc – two world-class companies with nearly 140 years of shared history and successful achievements
- Proven critical project execution knowledge in diverse geographies
- Best-in-Class Safety Performance

One Linde

Uniting with a shared Vision, Mission and Strategic Direction, and demonstrating our Values and Behaviors in everything we do

2 million+

customers

Establishing a more diverse and balanced portfolio

100+

countries

Enabling strong, complementary positions in all key geographies and end markets

~80,000

employees

Achieving our full potential, individually and collectively

$8 million

charitable giving in 2019

Supporting our communities through contributions and employee volunteerism

6,500+

active patent assets worldwide

Leading with innovative products, solutions and technologies

RECOGNITION

MEMBER OF

Dow Jones Sustainability Indices

SAM

a RobecoSAM brand

included in ETHIBEL SUSTAINABILITY INDEX EXCELLENCE Europe

2020 = Bloomberg Gender-Equality Index

Technology and innovation in our business model: our role across the value chain.

Producing gases

Driving efficiency and reliability of plant operations

Supplying gases

Supporting safe, reliable and economic distribution of products and services

Including H2

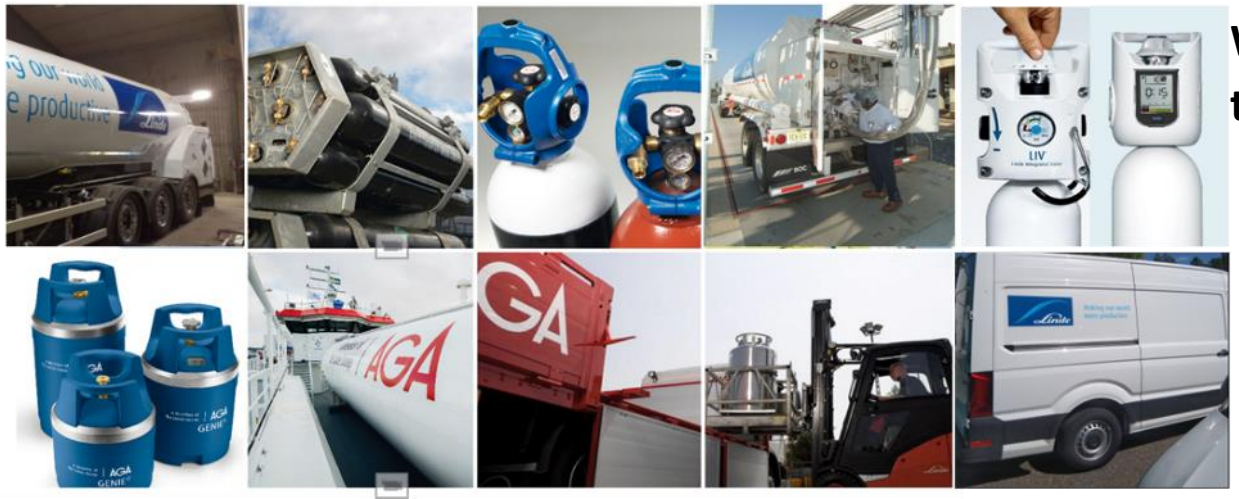
- On-site
- Cylinders/bundles/tube trailers
- Liquid

Applying gases

Creating value from gas applications for customer processes

Including H2

- Combustion (H2-O2)
- Reduction
- Equipment



We deliver gases in many ways to meet our customers needs.

Linde's competence profile in Hydrogen.

Strong technology and operational competence along full value chain.

Production

- SMR
- CCUS Technologies
- Gasification
- Electrolysis
- (Green) Power Procurement

Processing

- Purification Valorization
- Conditioning Compressing
- Liquefaction
- (De-) Hydrogenation
- Recycling

Distribution & Storage

- Pipeline
- Cavern
- Storage
- Bulk
- Energy Vector

Applications

- 'Last Mile' handling
- 'Last Mile' distribution
- Compression
- Refueling
- Combustion/ heating

End-use

- Industry Feedstock
- Transportation Fuel
- Industry Heat
- Power Gen & Buffering
- Heating & Power for Buildings

Hydrogen in Scandinavia (Examples)

Marine Sector

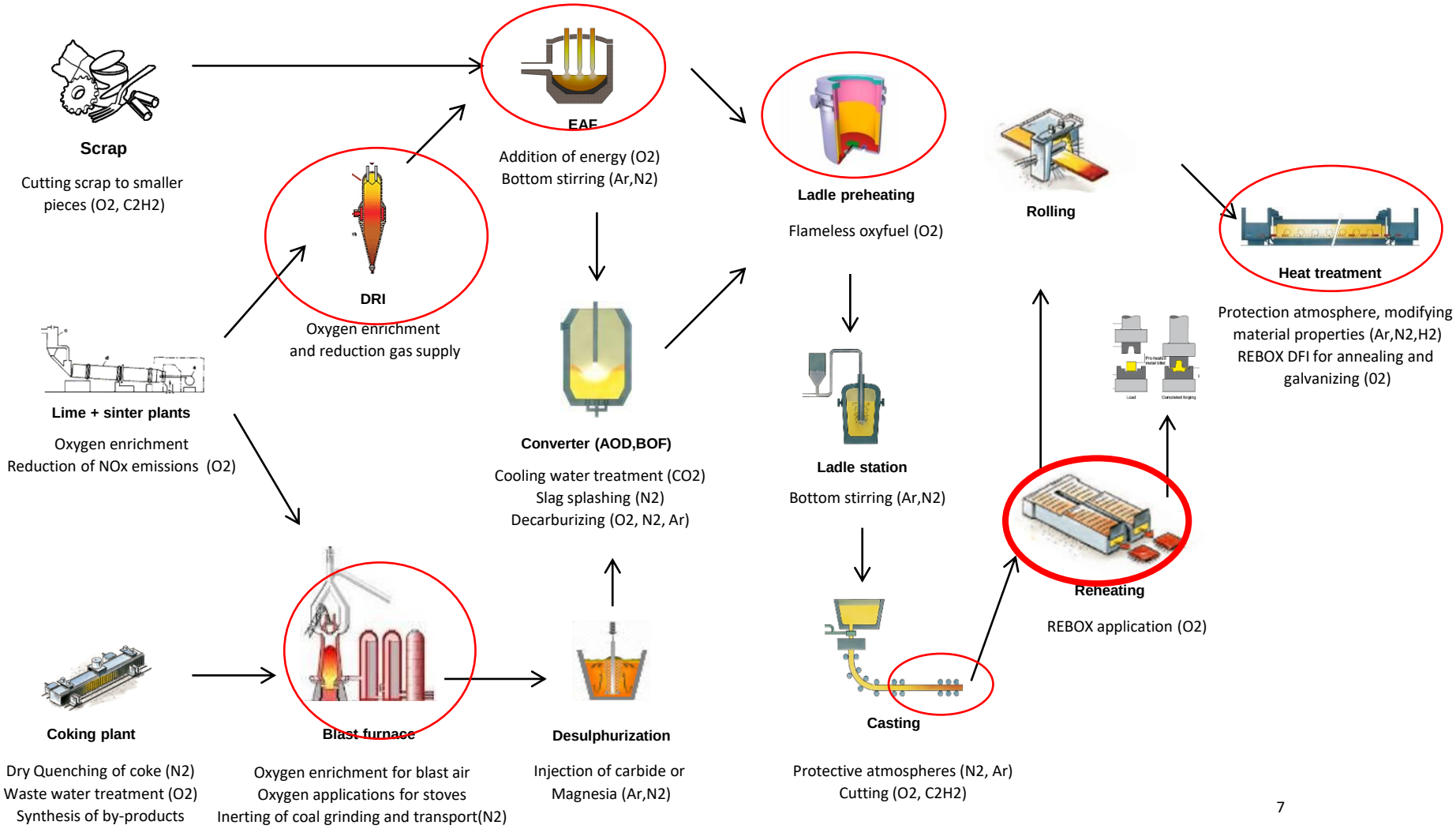
Heavy Transport – Hydrogen fuel-cell trucks

Process Industry

- Together with Ovako, leading manufacturer of engineering steel, Linde has conducted a full-scale test to heat steel with hydrogen before rolling. The test was performed with good results in one of Ovako's pit ovens at the Hofors rolling mill in Sweden.
- Heating with hydrogen did not affect the quality of the steel, which means good conditions for introducing heating of full-scale rolling mill furnaces. This would drastically reduce the carbon footprint of the steel industry.

Industrial Gas Use in the Steel Making Process

H2 possibilities in red



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Trials made in Linde pilot hall October 2019 heating with H2/O2. Good results resulted in full scale demo March 2020

Scope:

Steel samples from 4 different customers were heated with H_2-O_2 and LPG-O_2 (as reference) in furnace #2 at the Älvsjö Lab.

”Probably the First Fossil free Heating In the world”

99% H_2O in furnace atmosphere

<u>No quality issues for any steel grades</u>

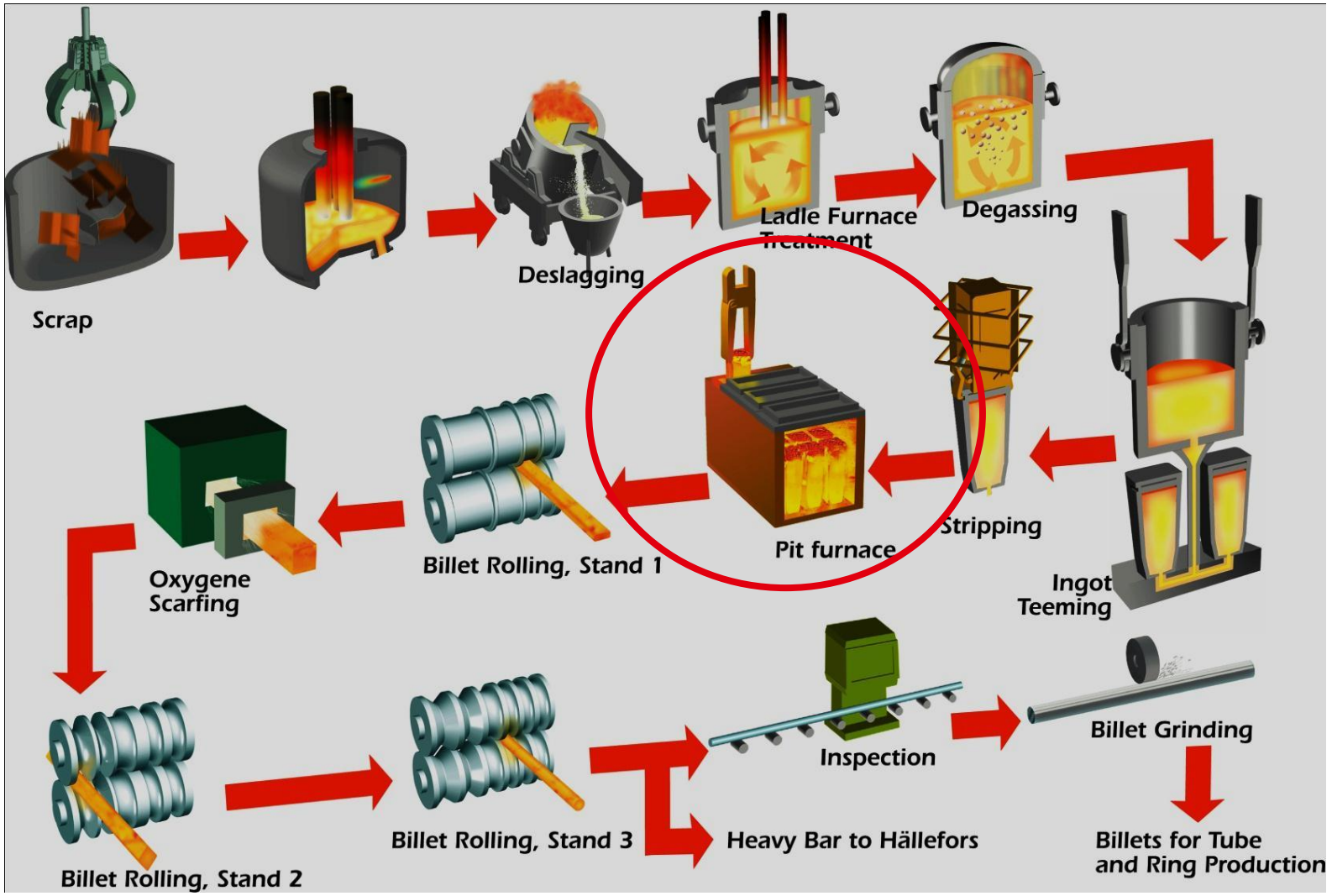
Ovako Hofors production route

Already in use:

- CO2 free electricity
- Scrap based
- Hot charging of billets
- Oxyfuel in high temperature furnaces
- Electric heating in T<1000 oC

Next potential step:

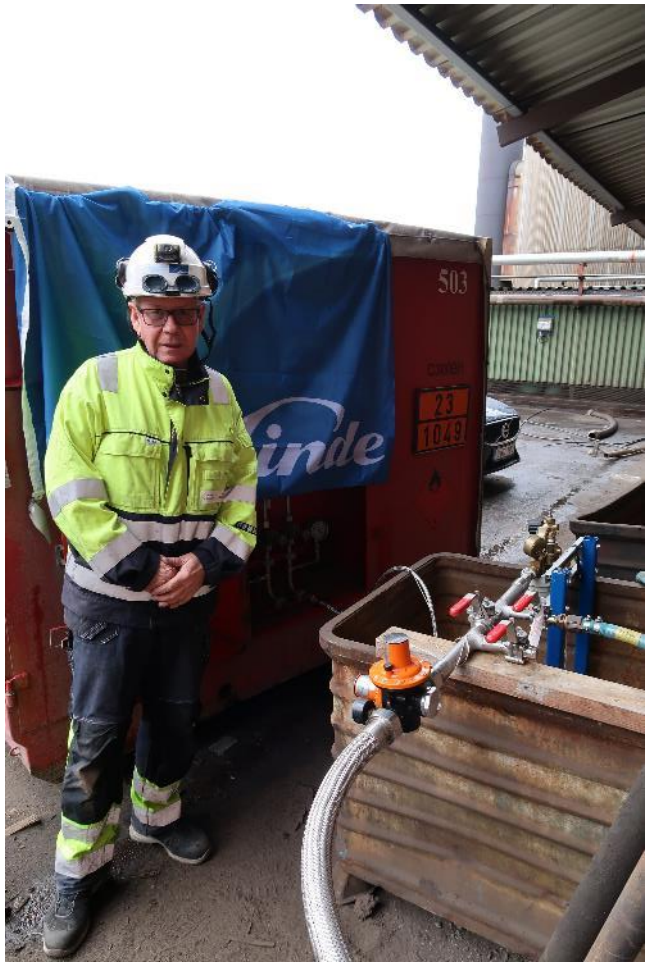
- Avoiding CO2 from heating by using H2-O2 combustion
  (avoids 50% of todays CO2 emission)



H_2 supplied from e-lyser operating with CO2 free electricity by Swap bodies, pressure regulator and tie in to LPG flow train

147 *50 l cylinders, 200 bar(g)

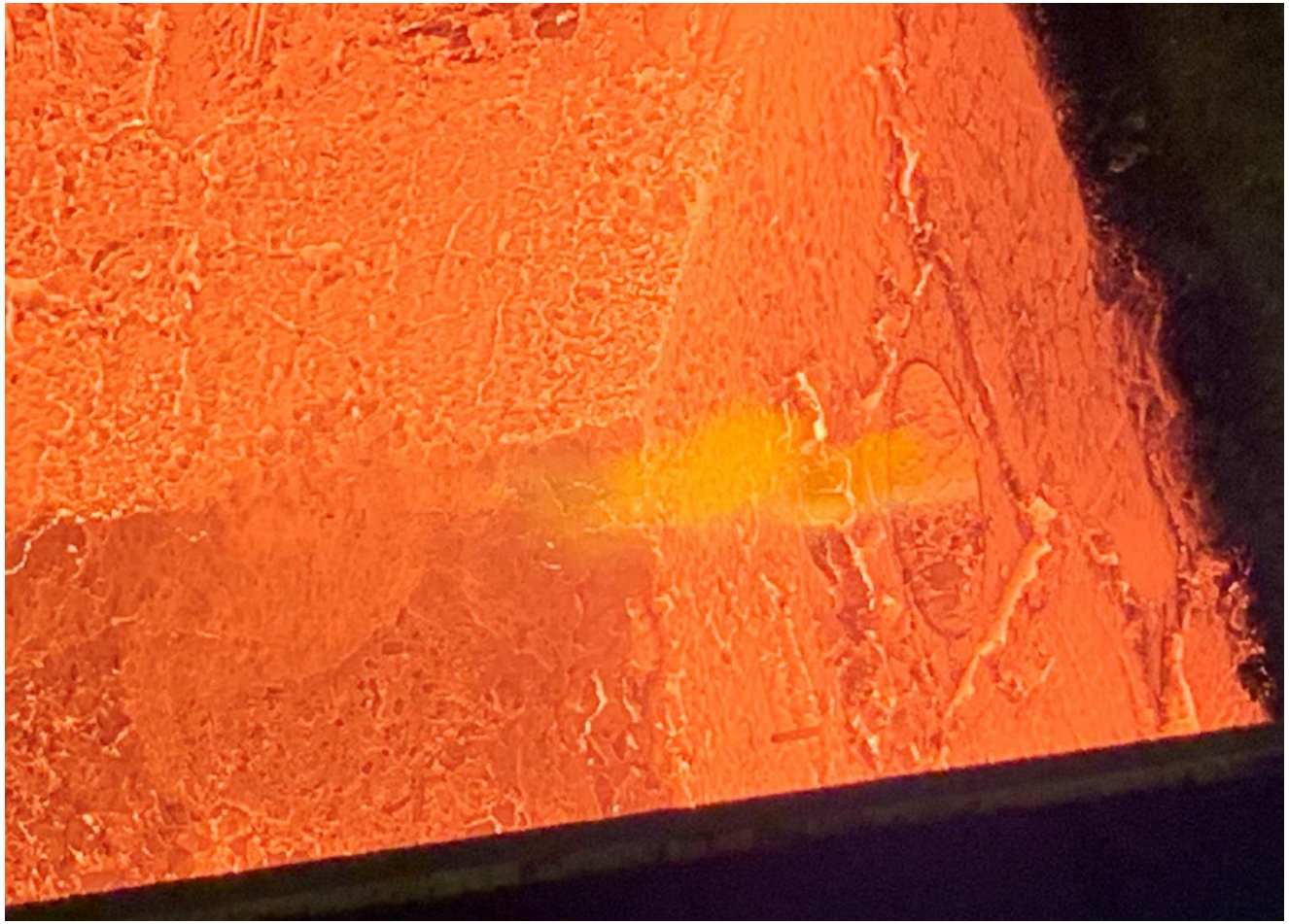
Pressure reducer to 2 bar(g) and slam shut



Tie-in to existing LPG flow train

Oxy-H_2 firing

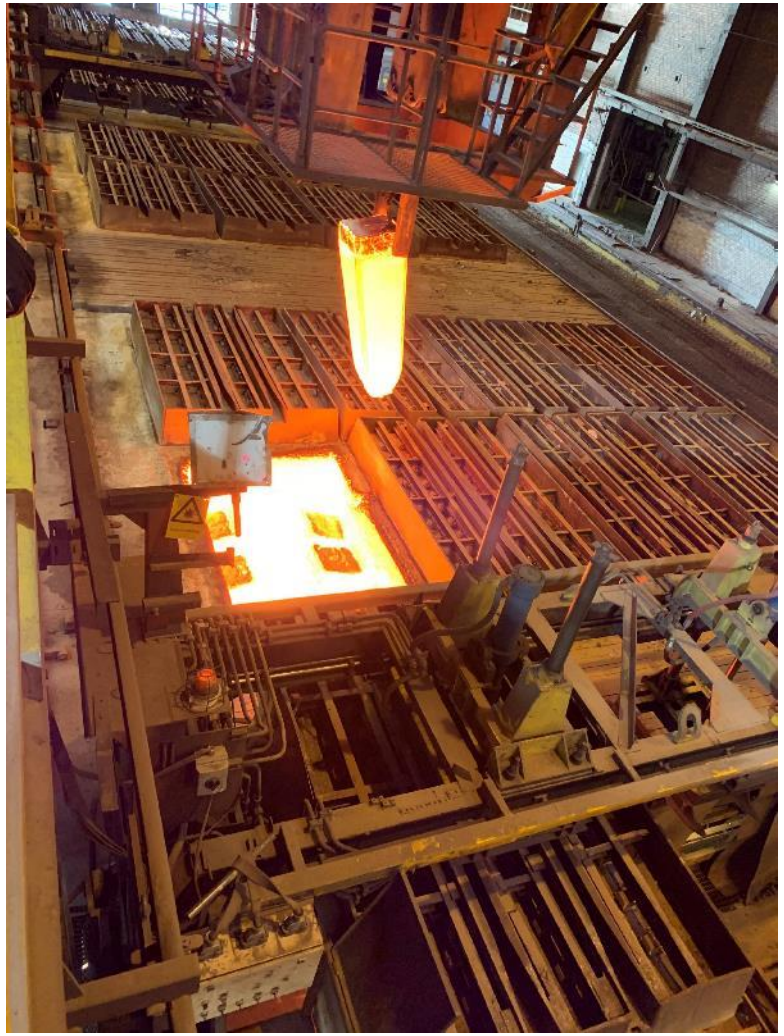
In pit before charging



In Lab, flame less mode

Charging (6*4,2 ton ingots/cell) ball bearing steel 100Cr6 (Ovako 803J)

Discharging and rolling first fossile free heated ingot in the world



Taking test samples and cooling bed
All quality tests ok and normal, possible to use H2 in reheating!

Making our world more productive

Thank you for your attention.

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