dissHEAT

Heating and burner technology

Sustainable routes towards the carbon neutrality of the reheating process

from the perspective of a technology provider

M.Fantuzzi
R&D Vice President Danieli Centro Combustion

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PASSION TO INNOVATE
AND PERFORM
IN THE METALS INDUSTRY

DANIELI TEAM
A CENTURY
OF PARTNERSHIP
EXPERIENCE

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DANIELI & DANIELI CENTRO COMBUSTION

DANIELI

- **Danieli** is a full-cycle provider
  from raw materials to finished products in the metal industry
- **10,000+** employees worldwide in **25+** companies
- **140** M€/y of investments in R&D in the last 10 years
- **4500** m^2 of labs and prototyping area

Turnkey plants, minimills and auxiliary plants

Ore processing and ironmaking plants

Scrap processing and electric steelmaking plants

Flat product casters, mills and strip processing lines

Long product casters, mills and downstream finishing lines

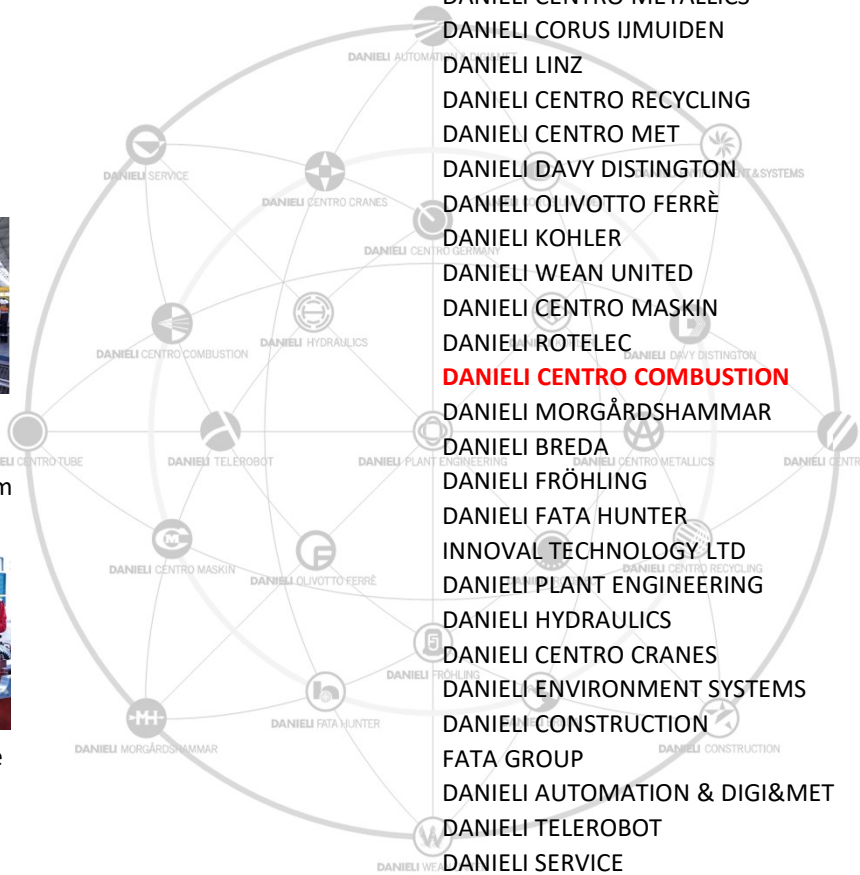
Tube, forging, extrusion, conditioning plants and cranes

Aluminum and non-ferrous metals

Automation, power and controls for the metals industry

Danieli true green metal for a sustainable production

Danieli Service Customers Support



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DANIELI CENTRO COMBUSTION

DANIELI

- **Global leader** in heating and heat treatment systems in the steeland aluminum industry.
- **Established in 1991**, in just over two decades the company has grown into a worldwide organization.
- **DCC**'s area of expertise is in the **design of combustion systems**, with an in-house R&D Centre and a full range of proprietary burners and innovative equipment applied to the steel and aluminum market for billets, blooms, slabs, plates, pipes, strips, bars and wires.
- **DCC's network** has grown constantly thanks to the acquisition of prestigious technology of the brand Olivotto-Ferrè (DFO) and the opening of regional offices located in Pune and Mumbai - India (DCC India).
- **DCC** is part of the **Danieli Group**, a privately owned company positioned among the world's leading plant makers and with many subsidiary offices across the globe.

DANIELI R&D

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CRD R&D Center at Buttrio

CRC R&D Center at Savona University Campus

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THERMAL PROCESS DECARBONIZATION

ROUTES TO DECARBONIZATION

Partial process decarbonization

1

Energy Saving Technologies

- High temperature air preheating high-performance heat recuperators
- High temperature air preheating regenerative burners
- High temperature air preheating self-recuperative burners
- Hot charging
- Oxygen enrichment, oxygen lancing, oxy-fuel combustion
- Construction techniques heat losses reduction
- Control techniques L1 and L2
- Removing cooling DRY Plus Furnace
- Downstream heat recovery Boilers, absorbers, ORC
- ……

2

- Fuel switching to carbon-free energy carriers hydrogen or ammonia
- Fuel switching to biofuels
- Carbon capture sequestration and utilization CCSU

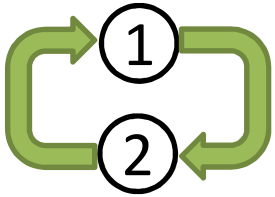
Gas-based solutions

- Electric heating and/or induction heating from green electricity

Electrical solutions

Total process decarbonization

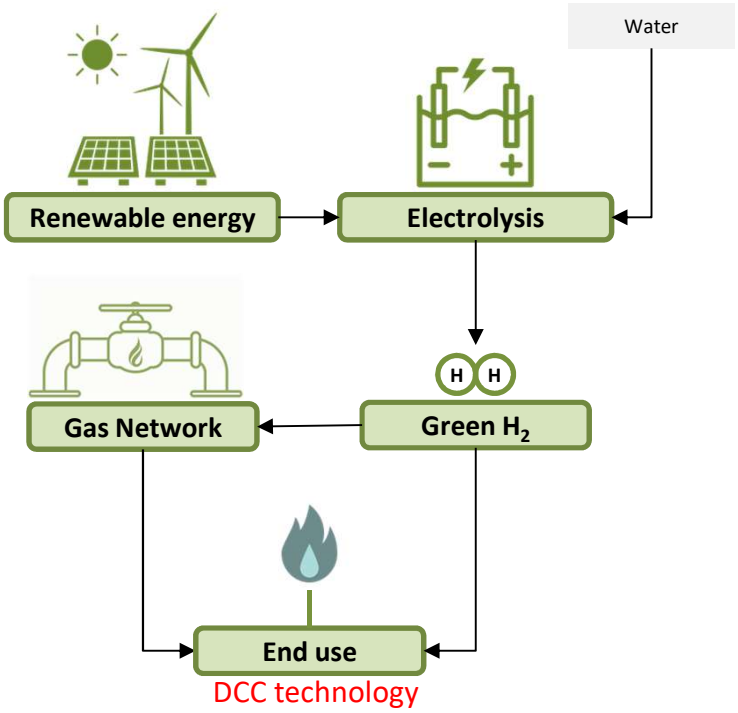
Possibility of combining different technologies *according to different strategies for managing the transition and the intermediate check-points in a framework of economic and environmental sustainability*



Fuel switching to carbon-free energy carriers like hydrogen or ammonia

Task and Technology	> Replacing or mixing carbon-based fossil fuels or by-product fuels with carbon-free energy carriers like hydrogen or ammonia; > H2 Ready Burners and combustion technology
Requisite	> Massive H_2 production infrastructure through renewable energy sources and distribution; > Combustion systems transformation.
Benefits	> Up-to-100% progressive carbon avoidance according to the percentage of carbon-free energy carrier; > Reduction of CO2 taxes (ETS).
Concerns	> Existing pipelines H2 adaptation or construction of new ones (conventional fuels are distributed by pipeline networks); > Huge amount of green energy and costs for H2 production; > Medium-to-long full decarb. time to market.

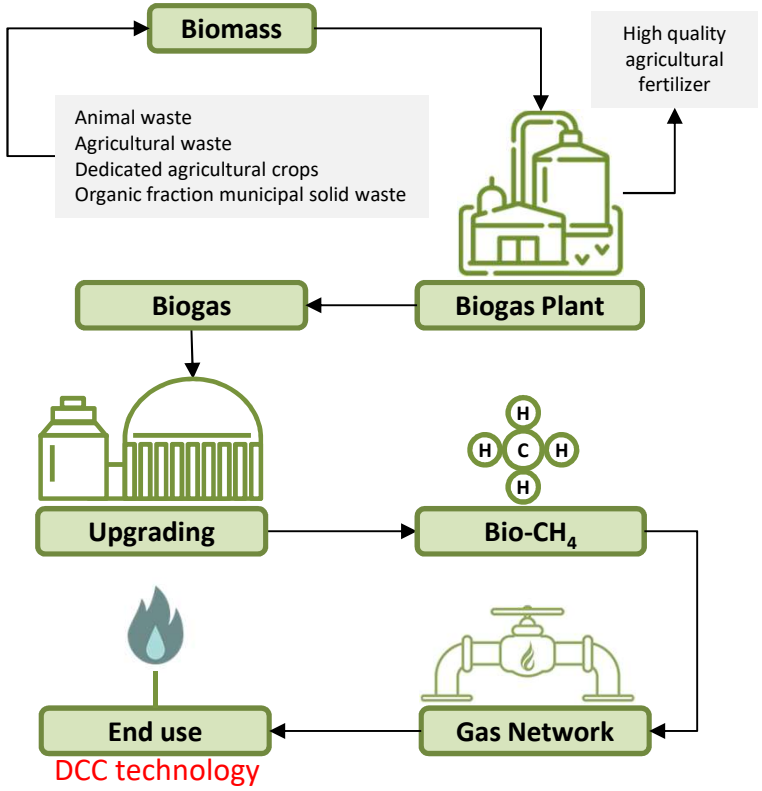
(*) red text represents DCC's approach to decarbonization



Fuel switching to biofuels

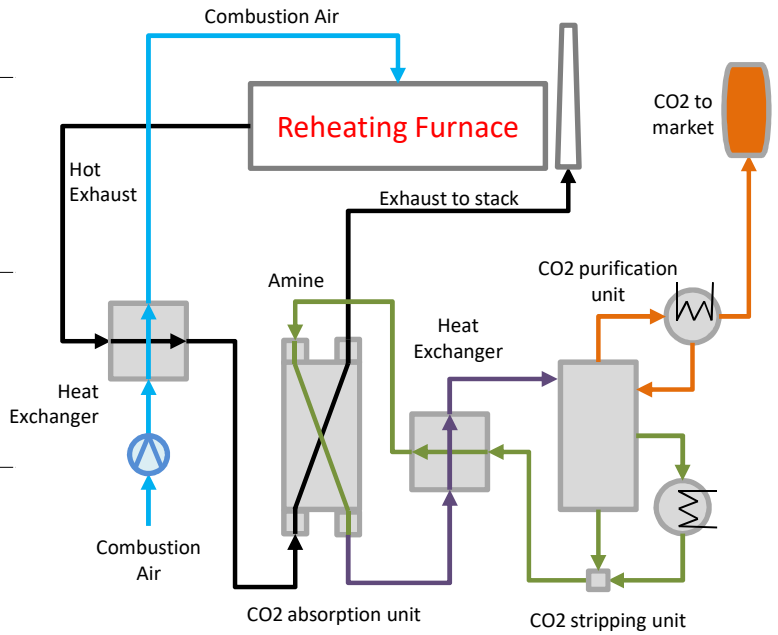
Task and Technology	> Replacing traditional fuels with biofuels produced from biomasses or synthetic fuels produced by green hydrogen and biogenic CO2
Requisite	> Infrastructure for massive production of biofuels and/or synthetic fuels by means of renewable energy
Benefits	> Up-to-100% progressive carbon avoidance according to the percentage of carbon-free energy carrier; > Reduction of CO2 taxes (ETS); > Limited change to the existing plants.
Concerns	> Large amount of green energy to produce fuels and relevant costs; > Medium-to-long full decarb. time to market..

(*) red text represents DCC's approach to decarbonization



CCS Carbon capture sequestration and utilization CCSU

Task and Technology	> CO2 separation from the stream/waste gases by means of technologies like CO2 Absorption or PSA (Pressure Swing Adsorption)
Requisite	> Infrastructure for CCS
Benefits	> No or limited transformation of the existing plants; > Possible application with green technologies, including partial hydrogen feeding
Concerns	> New plants for CCS and relevant CaPex and OpEx; > CO2 usage economic concerns; > Medium-to-long full decarb. time to market.



Electric heating and/or induction heating

Task and Technology	> Electric or magnetic heating for heat treatments and reheating
Requisite	> Green electricity availability
Benefits	> No direct CO2 or NOX emissions with green electricity; > No CO2 taxes (ETS); > Short–medium ROI; > Very effective existing application for long-product heat treatment and heating processes
Concerns	> Electricity costs; > Thick products medium throughput in reheating processes

(*) red text represents DCC's approach to decarbonization

Energy Savings

Task and Technology	> High temperature combustion air preheating through high-performance heat recuperators; > Regenerative, self-recuperative burners; > Hot charging; > Oxygen enrichment, lancing and oxyfuel combustion; > Reducing heat losses through: improved combustion, L1, L2 control systems and construction technology; > Removing cooling (e.g. DRY plus Furnace) > Downstream heat recovery from cooling systems through boilers
Requisite	> Conventional fuels availability
Benefits	> Existing efficient and sustainable tech; > Great contribution to progressive decarb. on plants which can be made more efficient; > Possible application with green technologies, including partial hydrogen feeding; > No need for additional large infrastructures; > Short time to market and fast ROI
Concerns	> Partial carbon avoidance; > Limited CO2 taxes (ETS) reduction

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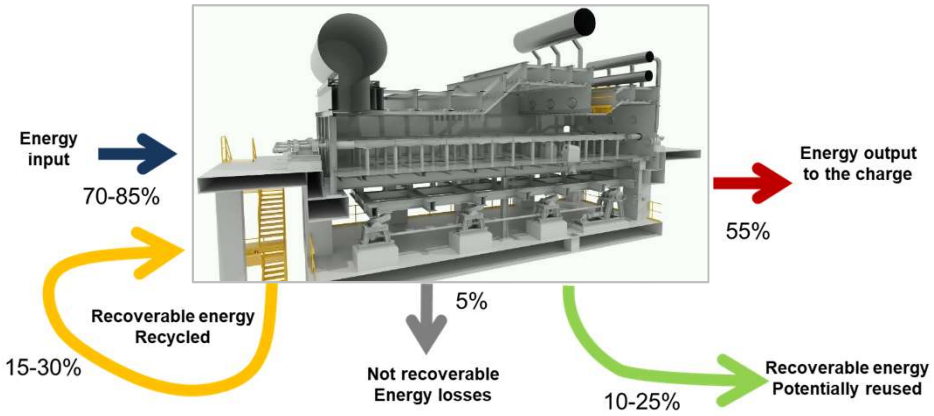
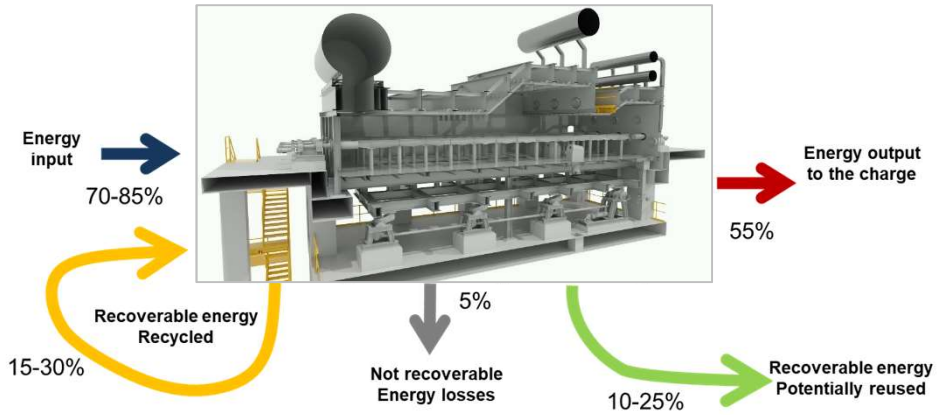
ENERGY SAVING TECHNOLOGIES



- Energy output to the charge is fixed according to the process temperature.
- The target is to minimize energy input considering that part of the energy is lost and cannot be recovered.
- A part of energy cannot be recovered and can oly be minimized
  Part of the energy input can be recovered and conveyed back to the furnace (recycling)
  Part of the energy input can be recovered and potentially used for other facilities outside the furnace (reuse) on example by means of a boiler or of ORC systems.

ENERGY SAVING TECHNOLOGIES



Minimizing energy input:

- Hot charging
- Control techniques (Level 1 / Level 2)
- Combustion technology (Air enrichment by O2 Oxygen lancing and Oxy-fuel)

Maximizing Recoverable Energy: Recycled

- High efficiency heat recuperators (up to 650°C)
- Combustion technology (Regenerative burners)

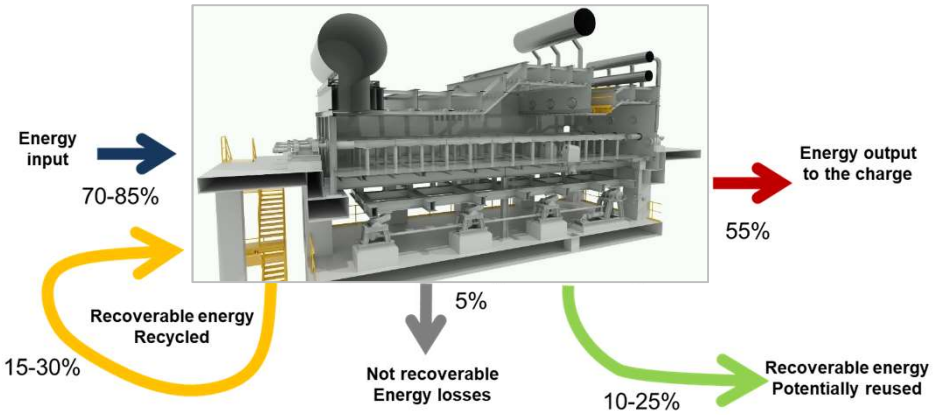
Minimizing Not-Recoverable Energy

- Construction techniques and material choice
- Combustion technology (Regenerative burners)
- Control techniques (Level 1 / Level 2)

Part of the energy input can be recovered downstream (at lower enthalpy) and **potentially reused** in other facilities outside the furnace

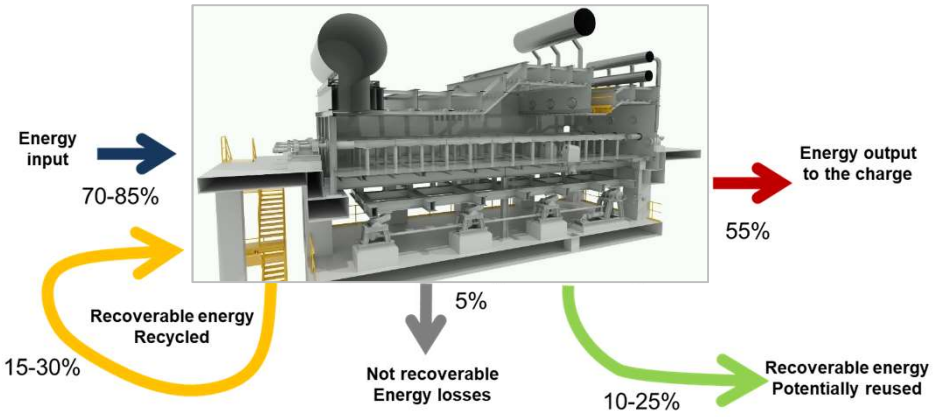
- Steam production by means of a boiler from the pressurized cooling water
- Steam production by means of a boiler from the waste gases
- Electric energy produce by means of turbogenerators with ORC
- Hot water production

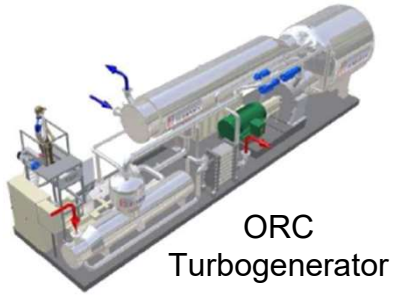
ENERGY SAVING TECHNOLOGIES
ENERGY RECYCLING FROM WASTE GASES



- Regenerative burners for air preheating (>1100°C) and/or gas preheating
- Recuperators for air preheating (up to 650°C)
- Recuperators for gas preheating (up to 400°C according to the calorific value)

ENERGY SAVING TECHNOLOGIES
ENERGY REUSE FROM WASTE GASES AND COOLING WATER





ORC Turbogenerator

A part of the energy leaving the furnace can potentially be reused for other processes operated progressively at lower temperature or for other plants nearby the furnace. If, for many reasons, it is not "convenient" to reuse such energy it will definitively be lost.

- Steam generators from cooling water
- Steam generators from waste gases
- Electric power generation through ORC (Organic Rankine Cycle) from cooling water and/or from waste gases
- Hot water production

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DANIELI CENTRO COMBUSTION'S HYDROGEN BURNERS

DCC HYDROGEN BURNERS

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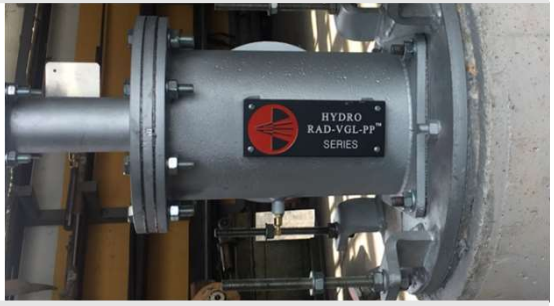
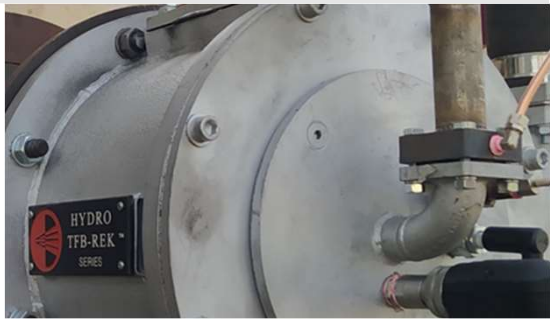
During 2019 Danieli Centro Combustion decided to cover the maximum number of furnaces and processes types with the development of three types of burners families able to fire natural gas and hydrogen mixtures up to 100% hydrogen.

HYDRO-MAB
Low NO_X side recuperative flame and flameless burner for reheating furnaces

HYDRO-RAD
Low NO_X roof recuperative flame and flameless burner for reheating furnaces



HYDRO-TFB-REK
Low NO_X self-recuperative flame and flameless burner for heat treatment furnaces and strip processing lines



HYDRO MAB200 F-FL-PP	Value (metric)
Nominal Power	580 kW
Air Temperature (°C)	500 °C
Fuel Temperature (°C)	Ambient
Air Excess (%)	5%
Air Pressure (daPa)	500 daPa
Gas Pressure (daPa)	2500 daPa
Air Flow with NG	490 Nm^3/h
NG Flow	49 Nm^3/h
Air flow with H_2	417 Nm^3/h
H_2 Flowrate	167 Nm^3/h

HYDRO-MAB

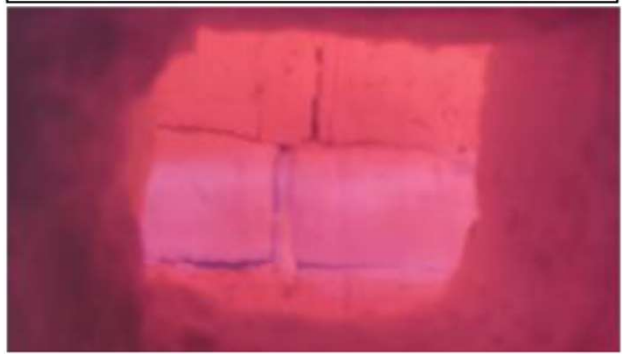
- HYDRO-MAB series is designed to operate with hydrogen and natural gas mixtures in the range 0-100%. During ignition HYDRO-MAB burner operate in Flame mode;
- Low NO_X emissions are accomplished by means of multi-air staging combustion;
- Once reached autoignition temperature, HYDRO-MAB works in Flameless mode in order to achieve very low NO_X emissions with any NG-H_2 mixture.

HYDRO-MAB

- HYDRO-MAB burner was installed on a sperimental test rig in Italy and the tests confirmed the results of the CFD simulations.
- After the transition from flame to flameless operating mode at a temperature of 880°C, NOx emissions of HYDRO-MAB drop down as much as is higher the hydrogen content in the fuel mixture.
- Hot tests and measures have been carried out starting from 0% H2 up to 100% H2 in the mixture with an average furnace temperature of 1230°C

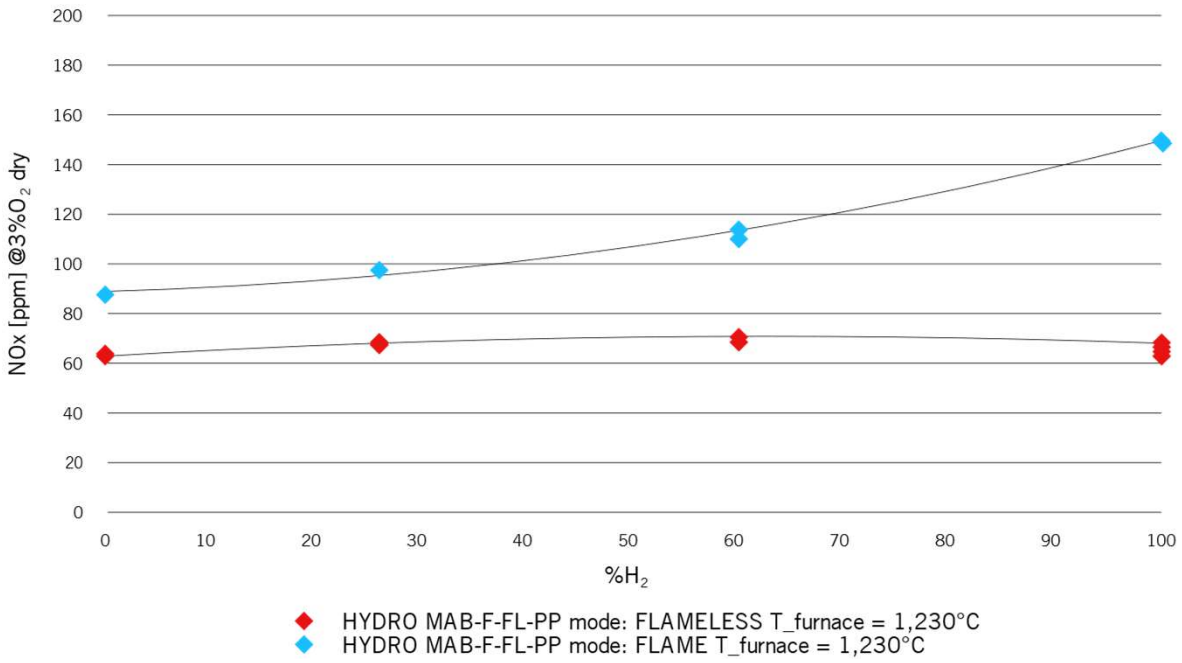
HYDRO MAB200 F-FL-PP – FLAME MODE

HYDRO MAB200 F-FL-PP – FLAMELESS MODE



HYDRO-MAB

- In flame mode NO_X emissions raise as much is higher the hydrogen content
- In flameless mode NO_X emissions are kept almost flat for any mixture of natural gas and hydrogen



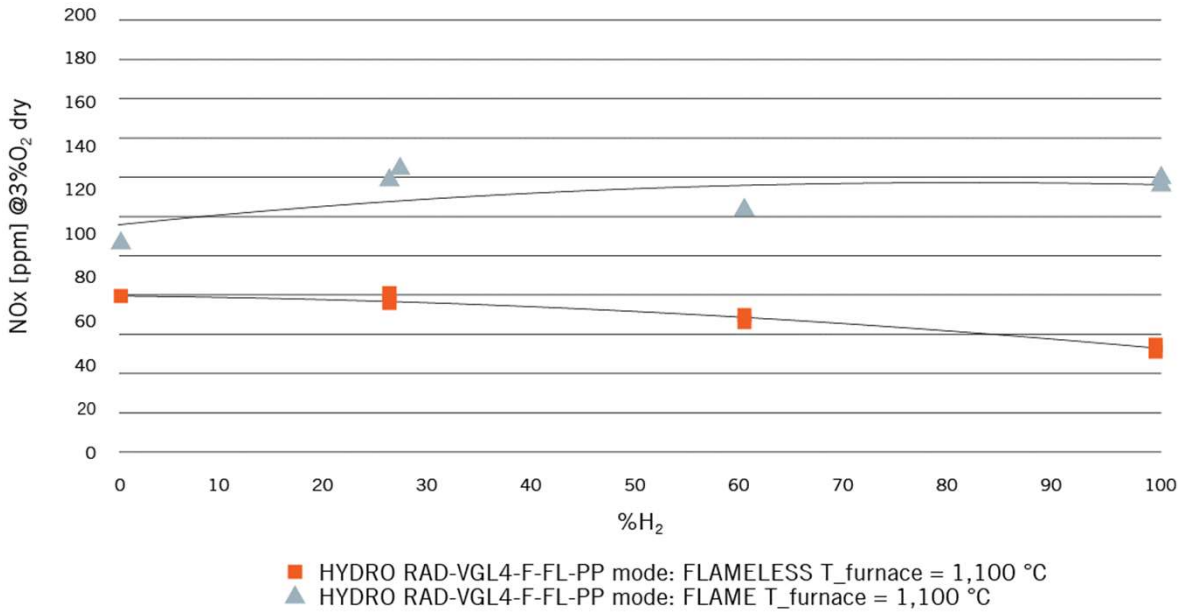
HYDRO RAD-VGL4 F-FL-PP	Value (metric)
Nominal Power	230 kW
Air Temperature (°C)	500 °C
Fuel Temperature (°C)	Ambient
Air Excess (%)	5%
Air Pressure (daPa)	500 daPa
Gas Pressure (daPa)	2500 daPa
Air Flow with NG	193 Nm^3/h
NG Flow	19 Nm^3/h
Air flow with H_2	167 Nm^3/h
H_2 Flowrate	67 Nm^3/h

HYDRO-RAD

- HYDRO-RAD series is designed to operate with hydrogen and natural gas mixtures in the range 0-100%.
- During ignition HYDRO-RAD burner operate in Flame mode.
- Once reached autoignition temperature, HYDRO-RAD works in Flameless mode in order to achieve ultra-Low NOx emissions with any NG-H_2 mixture.

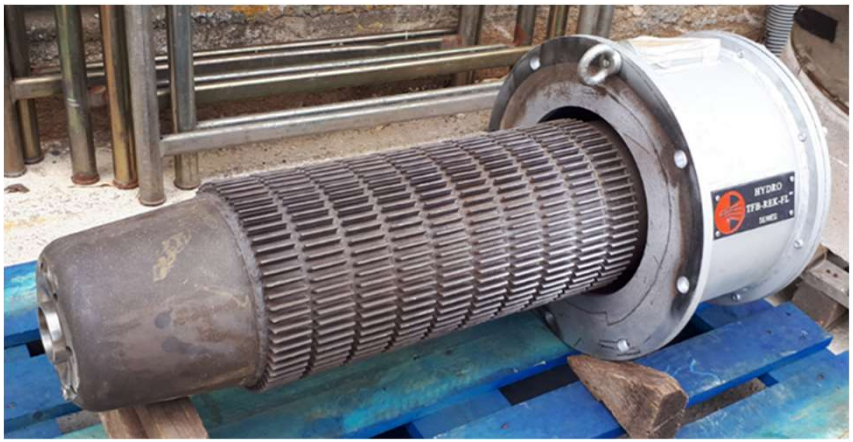
HYDRO-RAD

- HYDRO-RAD burner was installed on a sperimental test rig in Italy and the tests confirmed the results of the CFD simulations.
- In flame mode NO_X emissions are higher than those in flameless mode which were lowered with full hydrogen



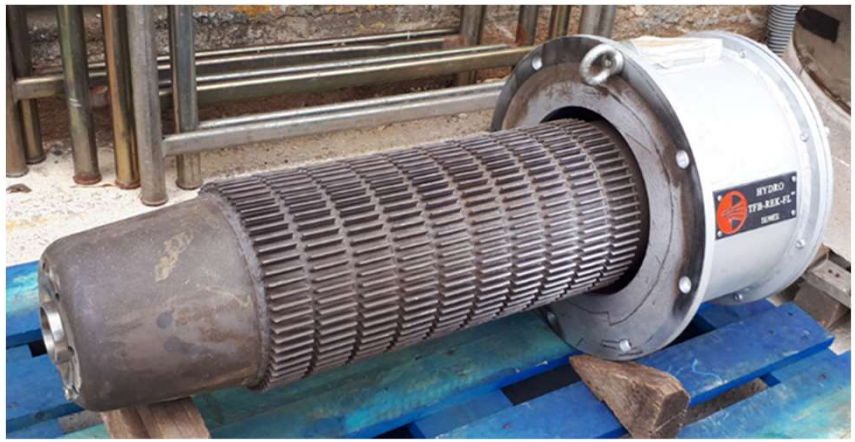
HYDRO-TFB-REK

HYDRO MAB200 F-FL-PP	Value (metric)
Nominal Power	250 kW
Air Temperature (°C)	up to 650 °C
Fuel Temperature (°C)	Ambient
Air Excess (%)	10%
Air Pressure (daPa)	500 daPa
Gas Pressure (daPa)	710 daPa
Air Flow with NG	220 Nm3/h
NG Flow	21 Nm3/h
Air flow with H_2	183 Nm3/h
H_2 Flowrate	70 Nm3/h



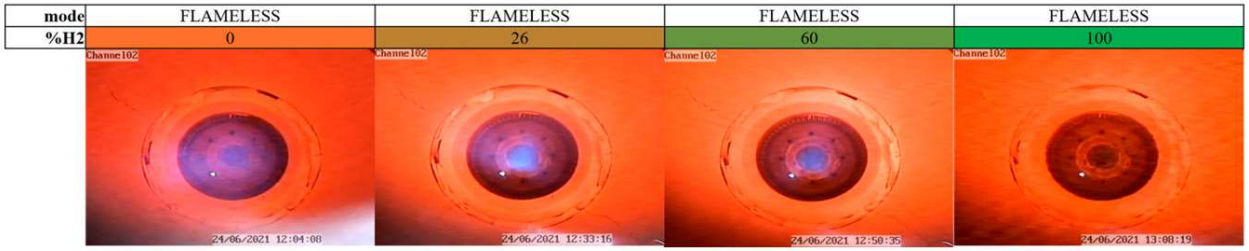
HYDRO-TFB-REK

- HYDRO-TFB-REK series is designed to operate with hydrogen and natural gas mixtures in the range 0-100%;
- Starting point was the TFB-REK burner, typically installed on the heat treatment furnaces. A version can be coupled with P or double-P radiant tubes for vertical HDGL;
- TFB-REK burner has been tested in two versions: Low NO_X and F-FL. The first one is suitable for furnace temperatures up to 950°C, the second version can operate at higher furnace temperatures both in flame and flameless mode;
- During ignition HYDRO-TFB-REK burner operate in Flame mode;
- Once reached autoignition temperature, HYDRO-TFB-REK works in Flameless mode in order to achieve very low NOx emissions with any NG-H_2 mixture.



HYDRO-TFB-REK (F, FL—FLAME AND FLAMELESS MODE)

- HYDRO TFB-REK80 F-FL version has been fueled from 0% H_2 up to 100% H_2 in the mixture.
- Average furnace temperatures selected for hot tests are 930 °C and 1,100°C.



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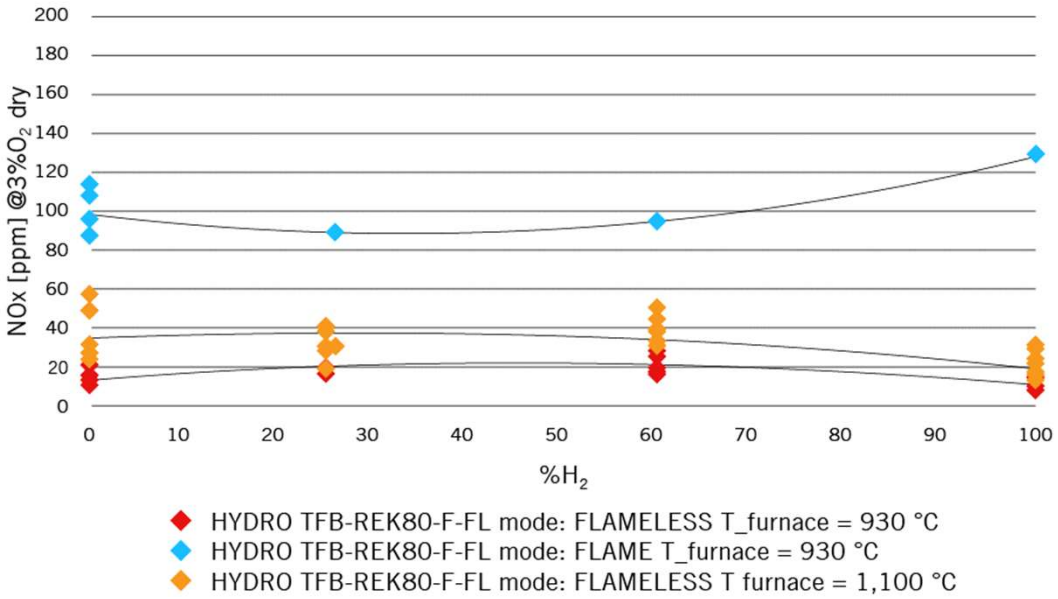

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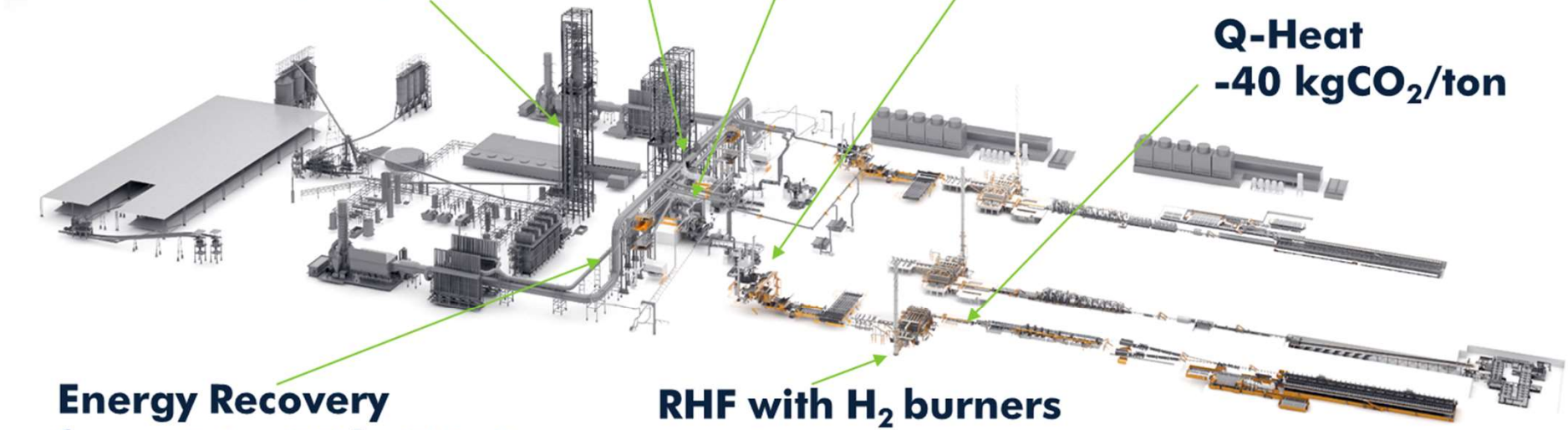
CONCLUSIONS

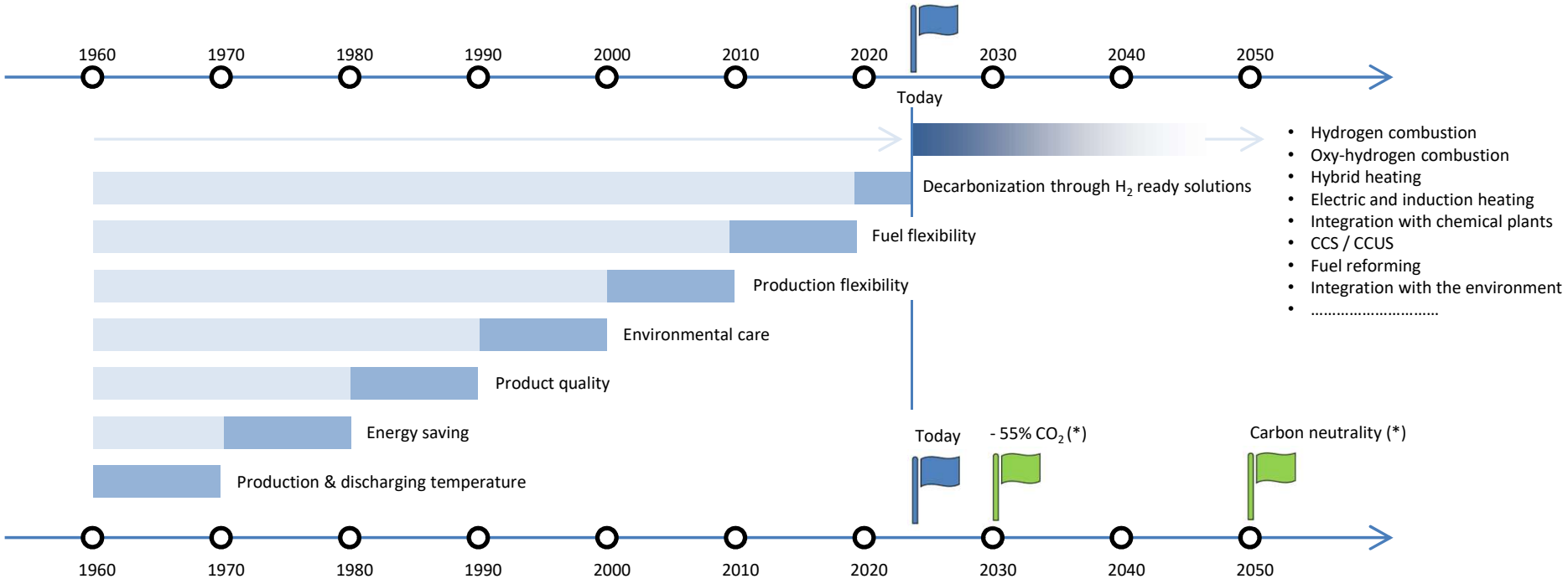
The green line for production of Zero Emission Steel



CO_2 reduction expressed as kilograms of CO_2 per ton of liquid steel as LCA of product

Reheating furnaces evolution

Each decade (from the '60s of the past century) was characterized by trends and targets and a correspondent development and application of new technologies, solutions, materials with a progressive attention to the environmental issues and to the concept of **sustainability**. Automation, process control and level 2, digitalization of the thermal processes and the application of Industry 4.0 technologies (artificial intelligence, robotics, additive manufacturing, augmented reality…) are supporting this progressive evolution.



(*) CO_2 reduction is referred to the average value of 1990 emissions according to the EU Green Deal Initiative.

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Online Seminar

May 2

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