tenova

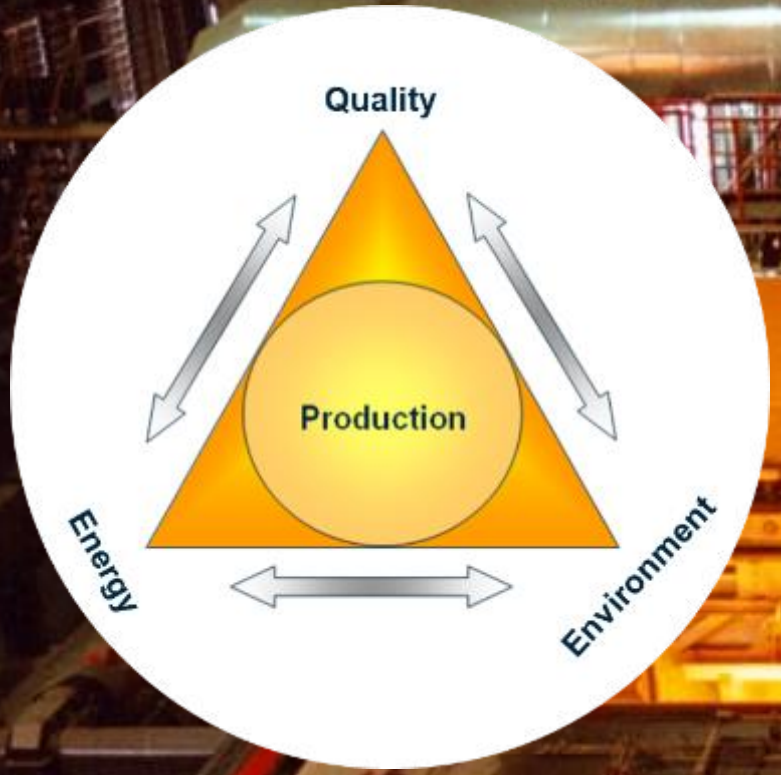
SUSTAINABLE HEATING TECHNOLOGIES FOR TODAY AND TOMORROWS METAL INDUSTRY

dissHEAT

Enrico Malfa
R&D Director

Furnaces for steel industry: targets priority

Production is always the main target of a re-heating & heat-treatment furnaces with:



the **best product quality**: minimum temperature difference, minimum thermal stress, low scale formation, low decarburization ...

the **lower pollution** in accordance with the limits permitted by the environmental standards (NOx , CO emissions)

the **minimum energy** & **carbon footprint** requirements compatible with the best quality

In the **today energy transition scenario** all the targets have to be achieved during plant modernization **securing the CAPEX** and taking under **control the OPEX**

Combustion systems in the last 30th years

tenova

Smart Carbon Usage → Carbon Direct Avoidance

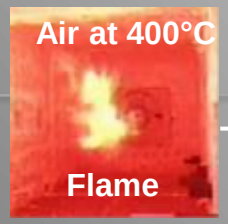
CO_2 emissions: Zero / Low / Medium / High

NOx emissions: Very High / High / Medium / Low / Very Low / Ultra Low

Flame Regenerative /oxy burners

Temperature increase

Air preheat



before 1990s

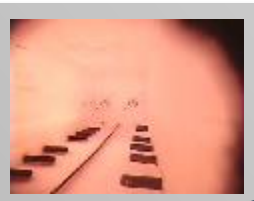
Flue gas recirculation

Cold Air

1990s

Low temperature processes

2003-10



Flameless regenerative/ oxy burners

2012-15

Flameless multi-fuel burners

2003-07

High temperature processes
Flameless (>800°C)

2019-2022

>2022
Electrification

dissHEAT

Combustion systems: RFCS projects sequencing

Research Fund for Coal & Steel

19 partners

10 RTOs
- 6 Steel produce
- 3 Plat suppliers
- 4 Combustion Lab

37 Researchers

NOxRF (2003-07)

Primary NOx reduction by testing and modelling flameless low NOx burners both high temperature air and oxy combustion

REGTGF (2003-06)

Reduction of energy consumption of top gas fired reheating and direct reduction furnaces using innovative regenerative burners

CO2RED (2006-10)

Demonstrate new combustion technology allowing a step change in environmental impact of reheating furnaces (CO_2 and NOx)

HELNOX (2012-15)

Fuel preheating for an efficient utilization of low caloric value fuels (i.e. BFG) in steel reheating furnaces, by ddeveloping new combustion systems.

BURNER4.0 (2019-23)

Industry 4.0 enabling technologies applied to the best available combustion system for better performance and reliability of furnace

SMARTFIRE *(2005-08)*
Diagnostic techniques to improve the operation

CONSTOX *(2006-10)*
Control of steel oxidation in reheating operations

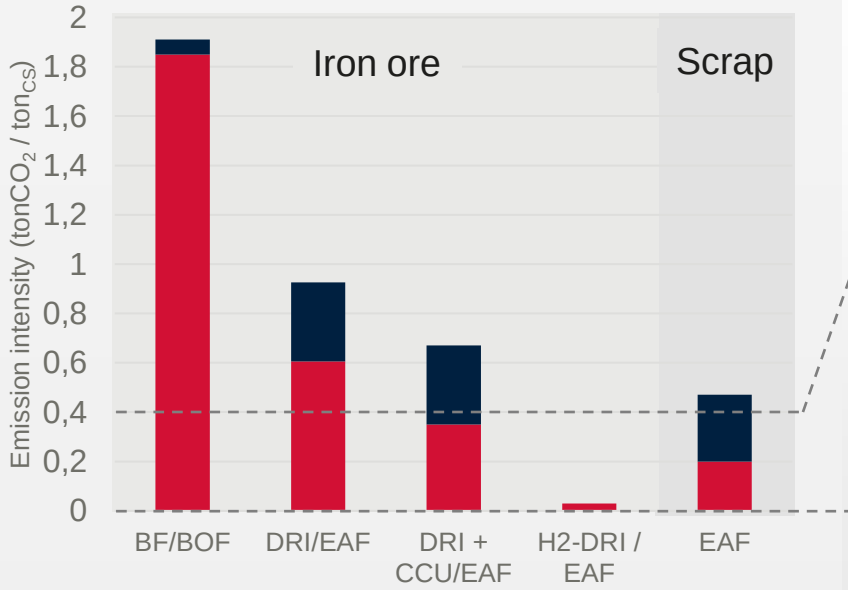
dissHEAT

Source: ESTEP Dissemination Day 2022

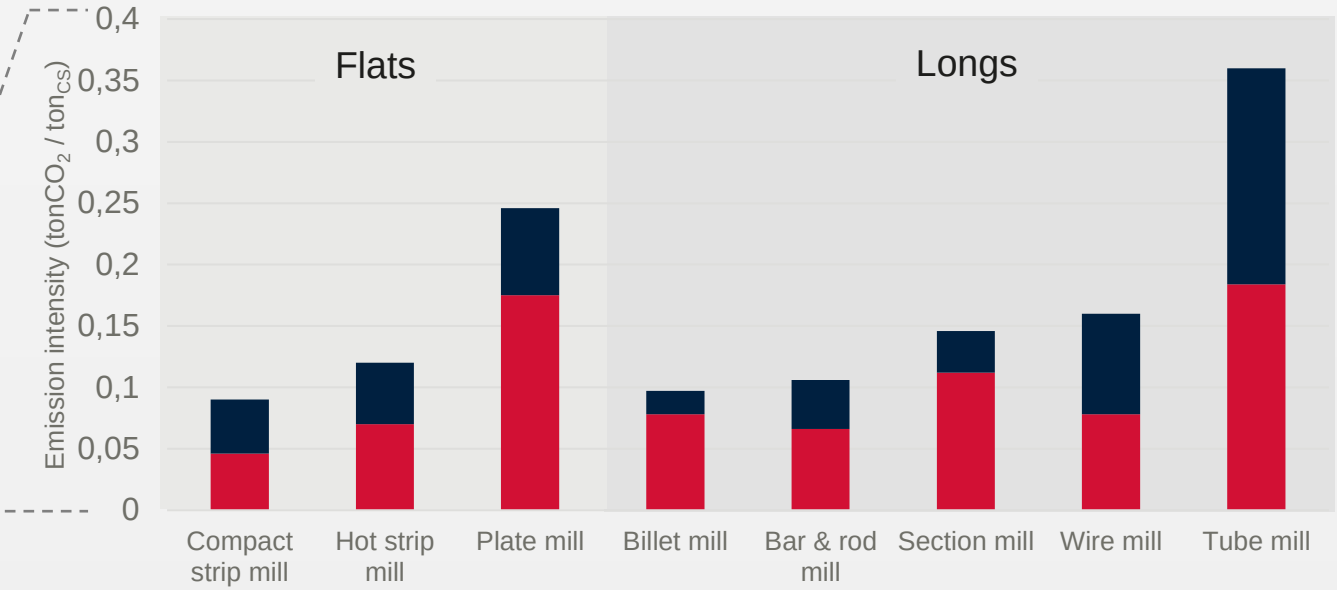
A look at DOWNSTREAM decarbonization

MORE IS THE TRANSFORMATION OF UPSTREAM MORE DOWNSTREAM INCREASES THE RELATIVE IMPACT

UPSTREAM



DOWNSTREAM



Data sources: EUROFER, *Determination of GHG emissions in energy-intensive industries*, 2020
ENERGIRON process data, 2015.
Internal evaluations, 2022. (*Grid factor 0,376 tonCO$_2$/MWh)*

What we can do today

tenova

AN EXAMPLE FOR REHEATING FURNACES

Efficiency Improvement

Recuperative Systems

Air preheating up to 650°C

4-6% CO_2 reduction

Regenerative Burners

Air preheating up to 1150°C

8-12% CO2 reduction

Digital Packages

Improving furnace performance

1-3% CO_2 reduction

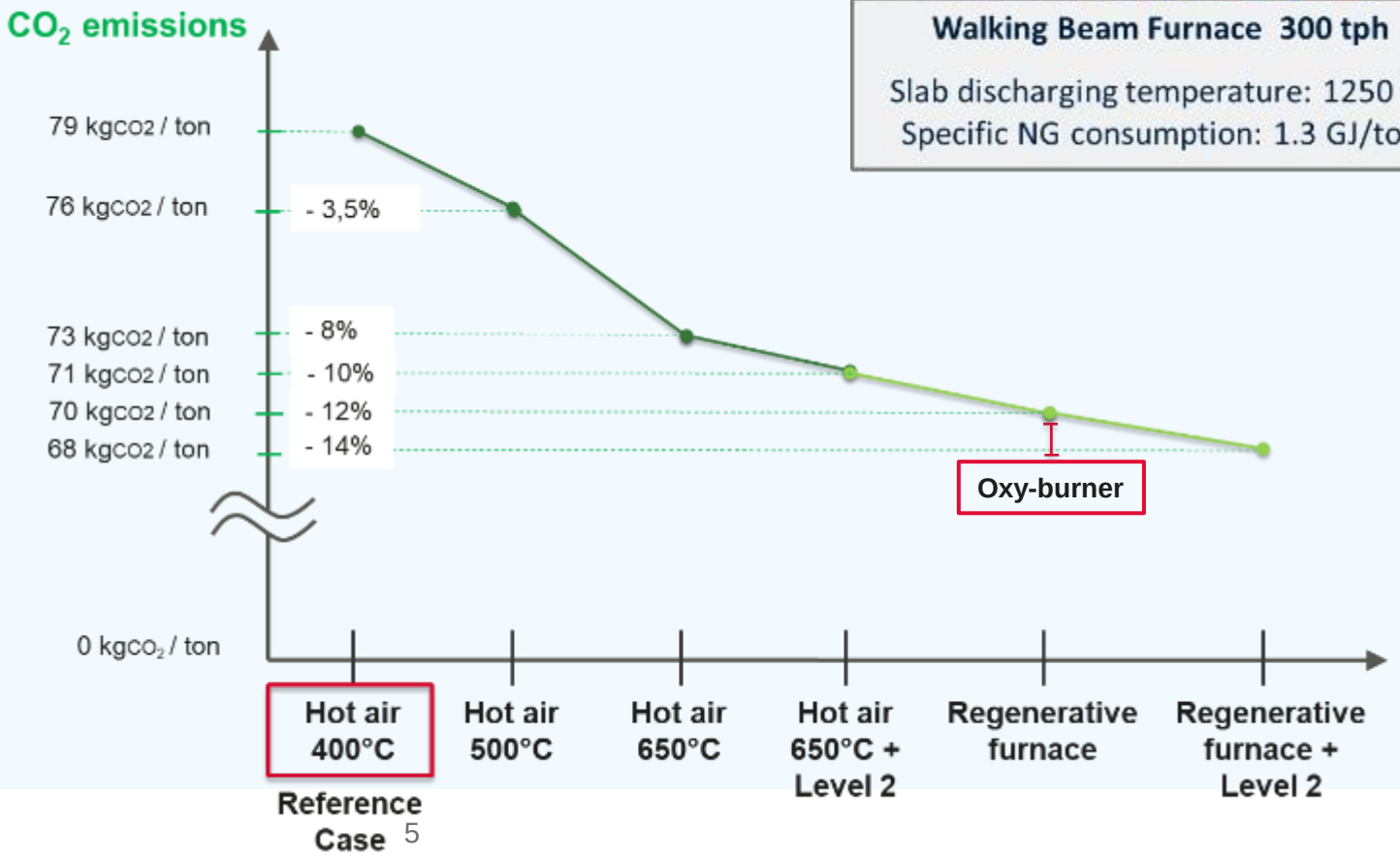
Waste Gas Heat Recovery

Steam for use/power generation

7-20% CO_2 reduction

Walking Beam Furnace 300 tph

Slab discharging temperature: 1250 °C
Specific NG consumption: 1.3 GJ/ton



dissHEAT

What we is on-going: H_2 combustion

tenova

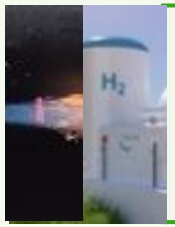
AN EXAMPLE FOR REHEATING FURNACES

Green Hydrogen Combustion

requires > 35% H_2 in volume

and

H_2 ready combustion system



H_2-Ready Burners #1

27% NG + 73% H_2

Electrical energy for H_2 67 MW

45% CO_2 reduction

H_2-Ready Burners #2

5% NG + 95% H_2

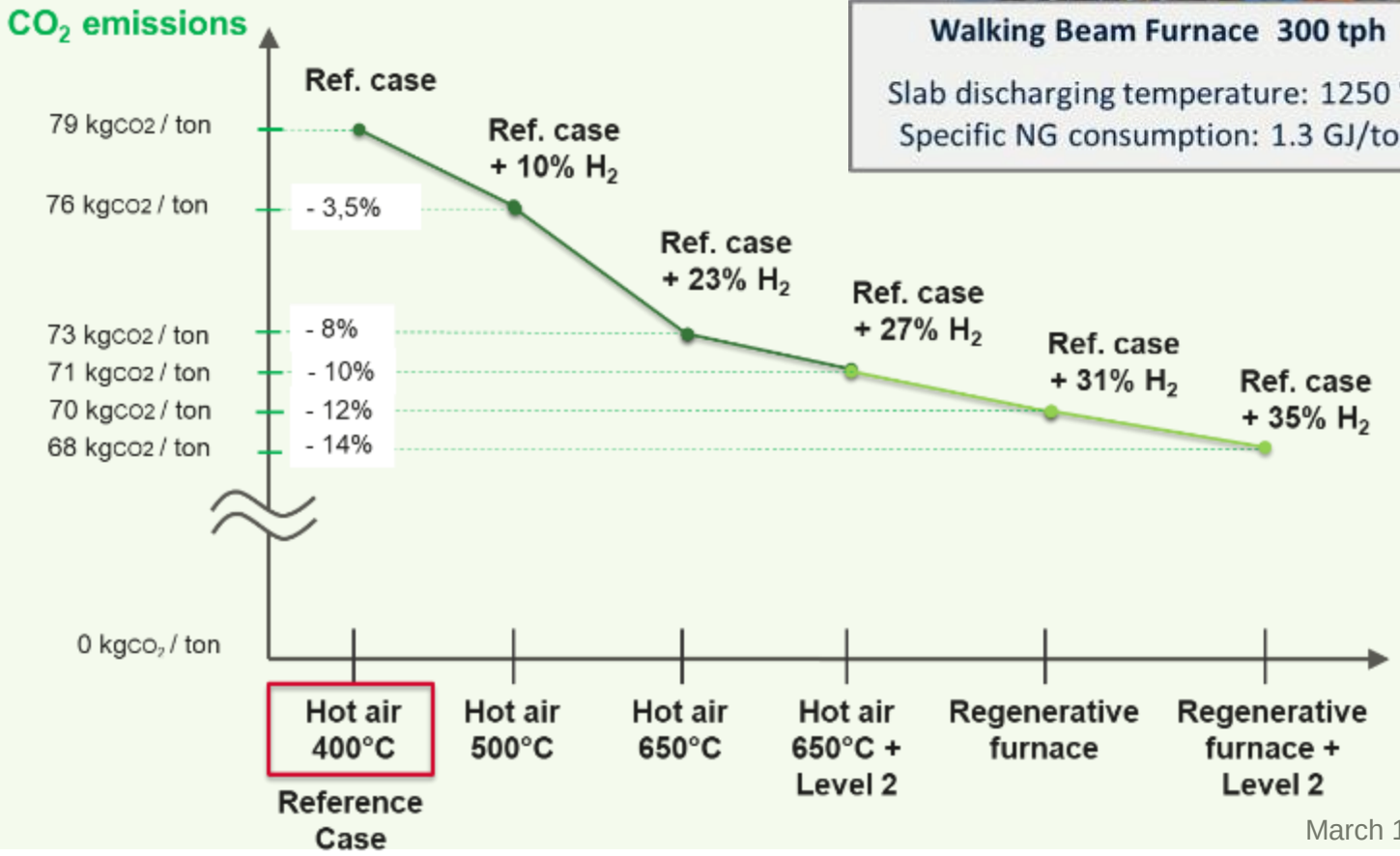
Electrical energy for H_2 126 MW

85% CO_2 reduction

Walking Beam Furnace 300 tph

Slab discharging temperature: 1250 °C

Specific NG consumption: 1.3 GJ/ton



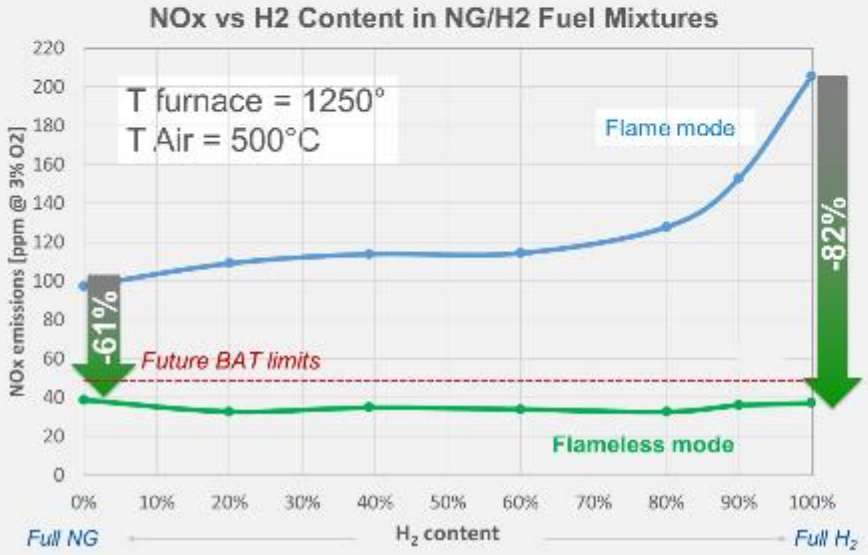
dissHEAT

Hydrogen ready combustion systems

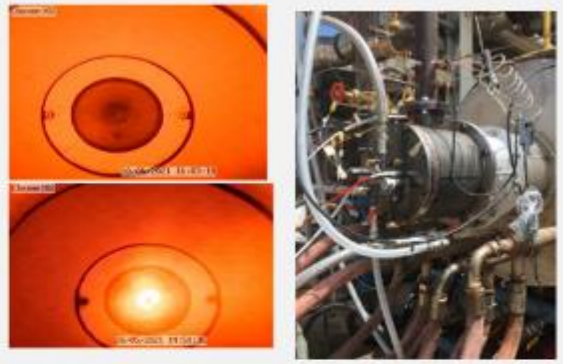
tenova

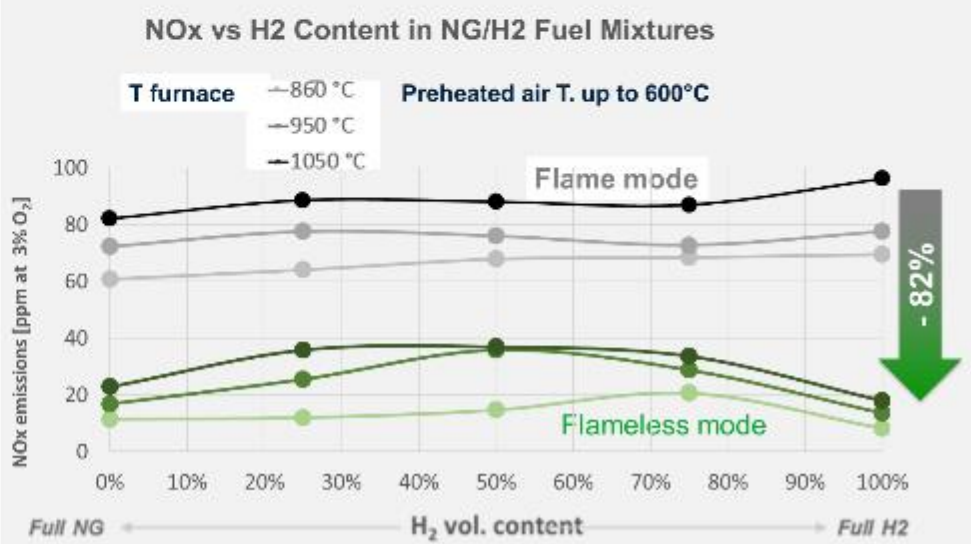
EXAMPLE OF TENOVA DEVELOPMENT

Re-heating / Lateral / TSX



Treatment / Lateral / TRKSX





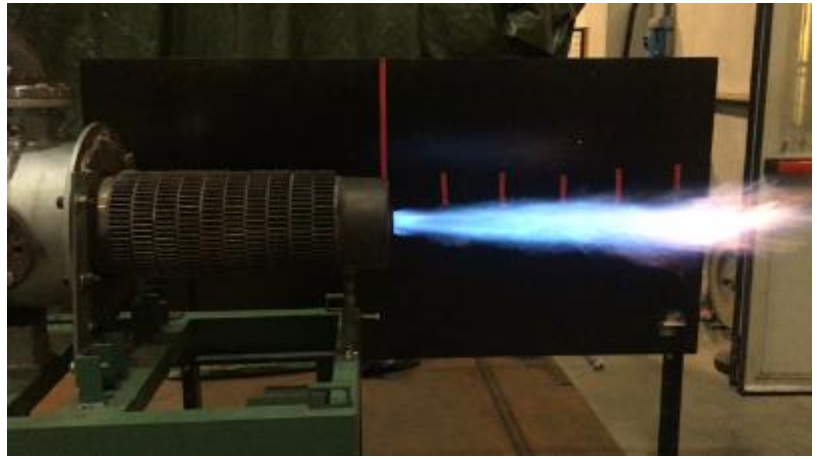
dissHEAT

Tenova first industrial H_2 ready furnace

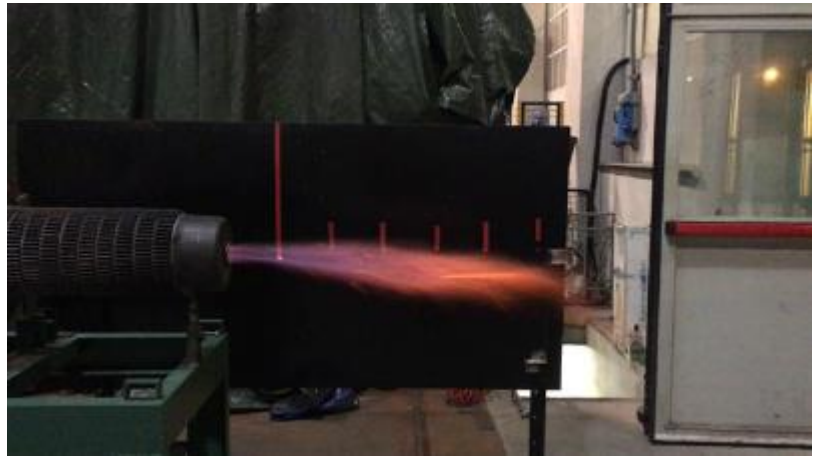
tenova

HYDROGEN / NATURAL GAS FIRING IN A HEAT TREATMENT FURNACE

First industrial furnace for full H_2 firing using our **TRKS H_2/NG** is running. The furnace is able to work with 100% NG up to 100% H_2 (CO_2 = zero).



100% natural gas combustion



100% hydrogen combustion

dissHEAT

What we can do next: hybrid heating

SOLUTIONS FOR REHEATING AND HEAT TREATMENT FURNACES

Efficiency Improvements

Recuperative Systems

Air preheating up to 650°C

4-6% CO_2 reduction

Regenerative Burners

Air preheating up to 1150°C

8-12% CO2 reduction

Waste Gas Heat Recovery

Steam for use/power generation

7-20% CO_2 reduction

Digital Packages

Improving furnace performance

1-3% CO_2 reduction

Hybrid Heating Technology

Induction pre-heating

Inductive pre-heating to 650°C, followed by soaking in furnace

Electrical energy 43 MW

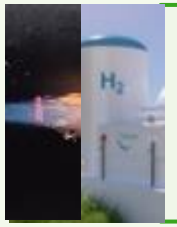
45 % CO_2 reduction

Walking Beam Furnace 300 tph

Slab discharging temperature: 1250 °C

Specific NG consumption: 1.3 GJ/ton

Green Hydrogen Combustion



H_2-Ready Burners #1

27% NG + 73% H_2

Electrical energy 67 MW

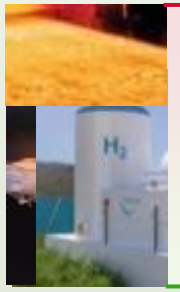
45% CO_2 reduction

H_2-Ready Burners #2

5% NG + 95% H_2

Electrical energy 126 MW

85% CO_2 reduction



H_2 Hybrid Heating

Induction followed by

8% NG + 92% H_2 combustion

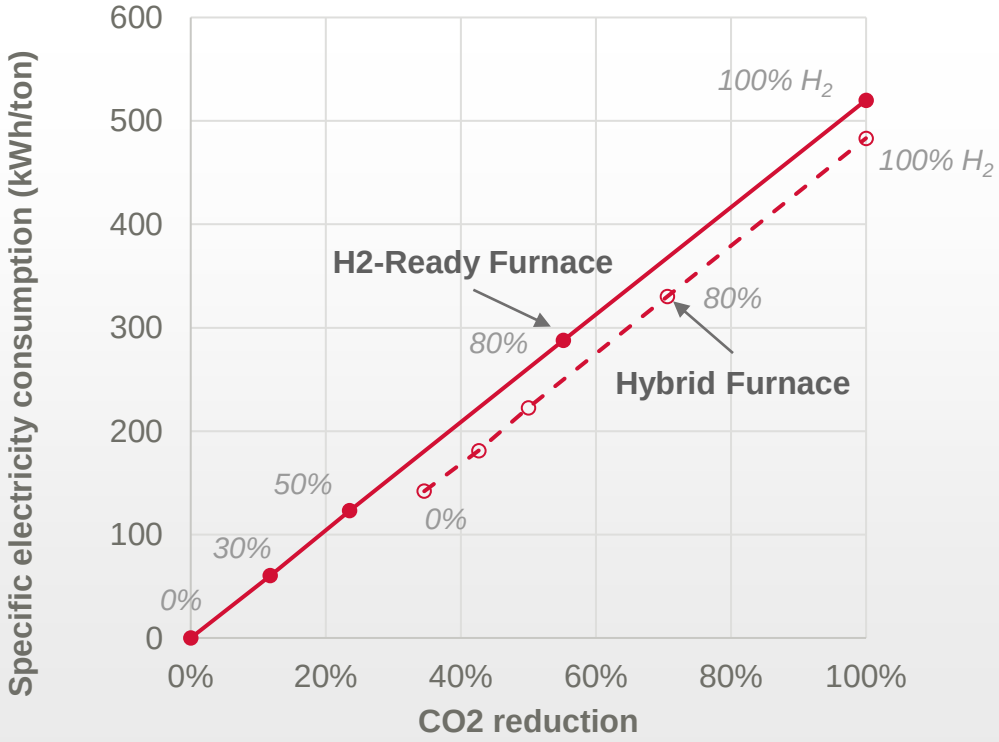
Electrical energy 118 MW

85% CO_2 reduction

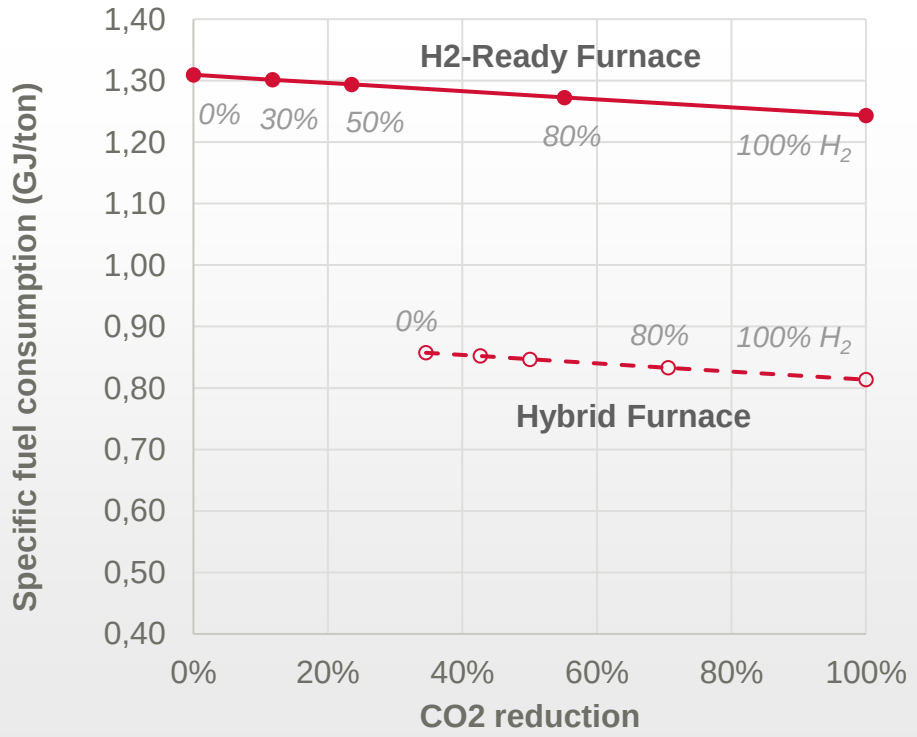
Tenova Hybrid Furnace Economics

OPEX MINIMIZATION & SCALABLE DECARBONIZATION

- 10% electrical consumption
with respect to green hydrogen



- 40% specific fuel consumption



What we need for further developments

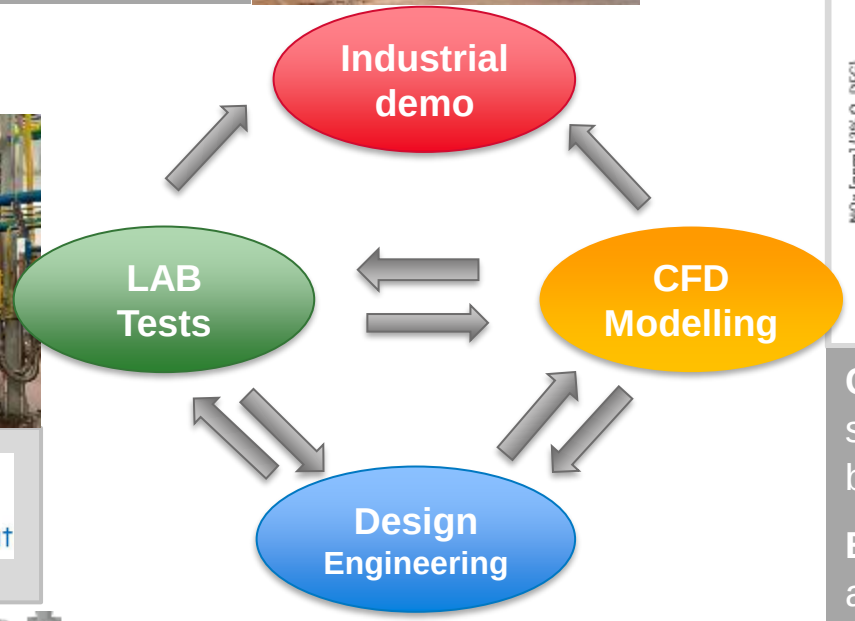
tenova

WORKFLOW FOR BURNER R&D BASED ON TENOVA EXPERIENCE

Need:
- availability of H_2 for long duration tests (on site electrolyzer or pipeline)
- data collection (IoT / cloud)

Installation on industrial furnace for long duration run to test the life time of the component and system integration

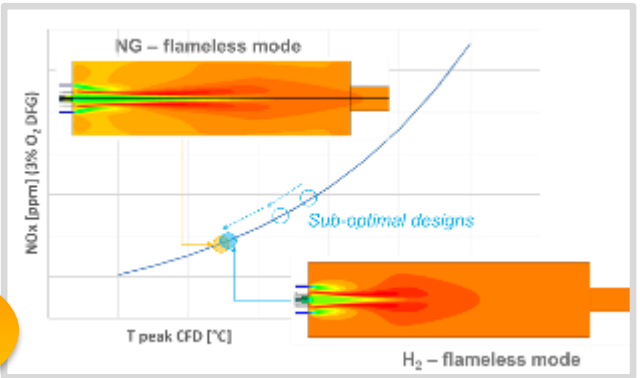
First-of-a-Kind installation



Industrial scale lab characterisation:
burner tests to deep understanding of combustion phenomena and effect on products

Need:
adaptation of existing lab to test 100% H2 Burner up to 3MW

HyTecHeat

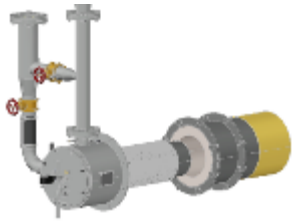


Conceptual design:
simulation of different configurations before prototype stage

Burner scaling:
a reliable method of scaling to larger or smaller applications

Need:
kinetic and radiation model for H_2 combustion

HyTecHeat



Burner prototype design

Need:
fast prototyping (e.g. 3D printing)

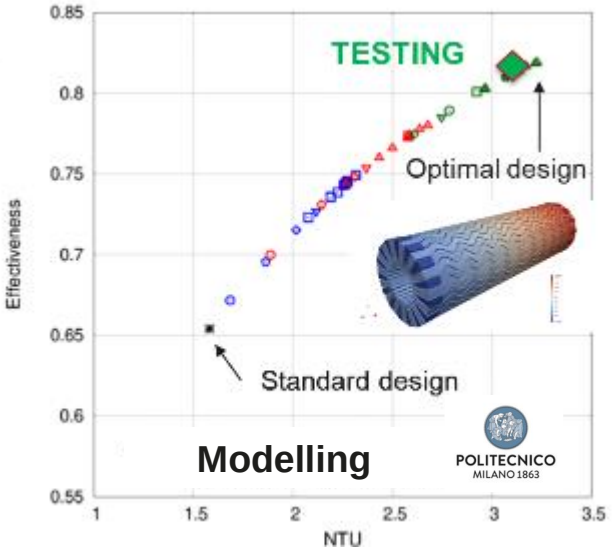
dissHEAT

RFCS BURNER 4.0

TENOVA ACTIVITIES FOR HIGH EFFICIENCY SMART BURNER DEVELOPMENT

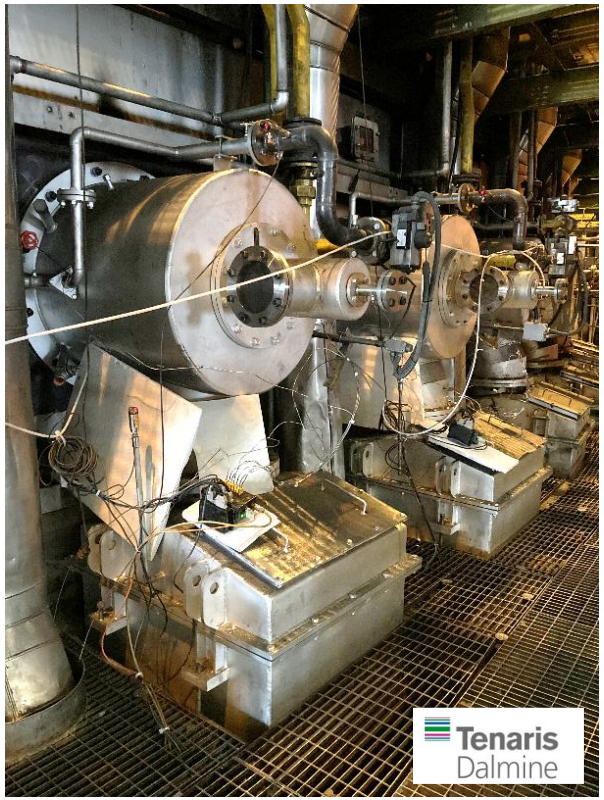
RECUPERATOR PROTOTYPE (3D PRINTING)

Acknowledgements:
This work is supported by the European Commission, under the RFCS project "BURNER 4.0" with Grant Agreement 847237.



REGENERATIVE SMART COMBUSTION SYSTEMS (IOT)

Tenova AlphaEdge IoT unit



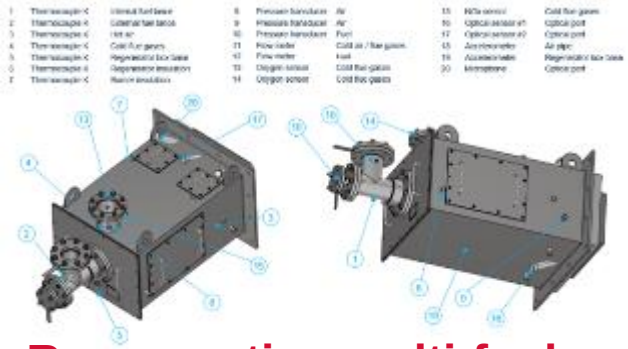
Tenova TRGX flameless regenerative burners installed at **Tenaris Dalmine RHF** for long term tests to collect data to elaborate KPIs and KHIs relevant for process operation and maintenance

RFCS BURNER 4.0: FINAL STEPS

TENOVA BURNERS INDUSTRIAL LONG TERM TESTS

ArcelorMittal

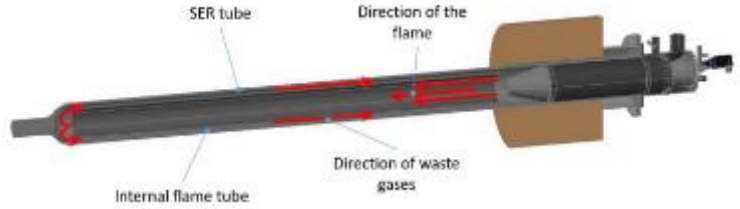
GasLab



Regenerative multi-fuel burner

tenova

Heat Treatments Furnace



Self-recuperative burner

tenova

dissHEAT

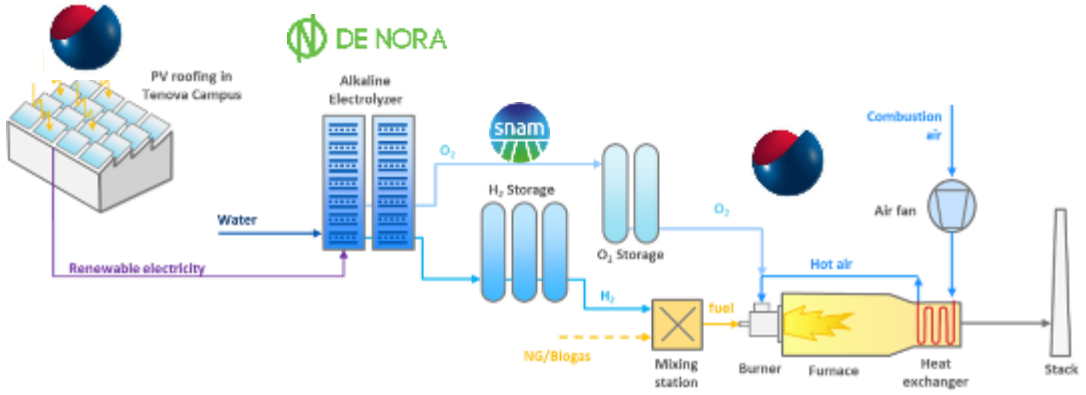
HORIZON EU HyTecHeat

HyTecHeat

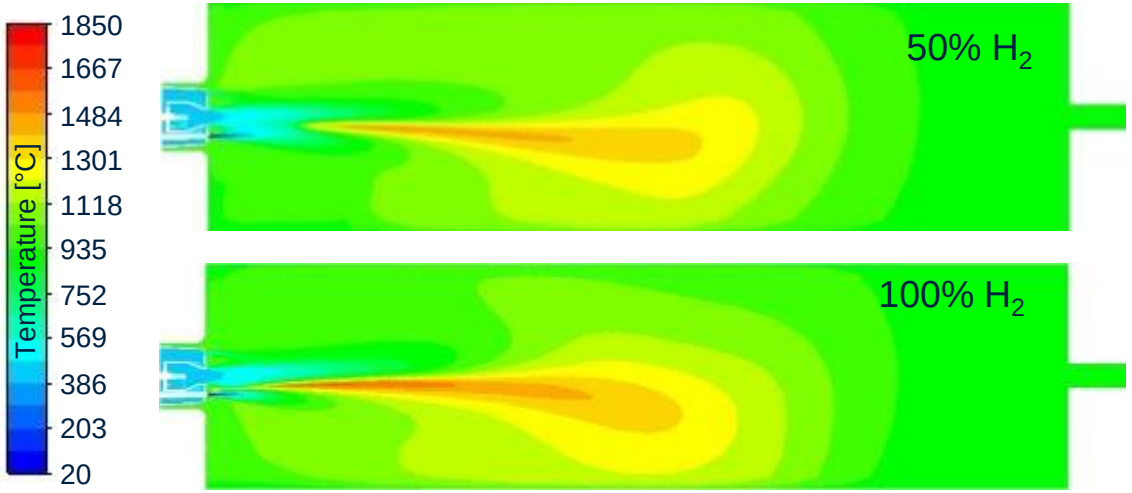
tenova

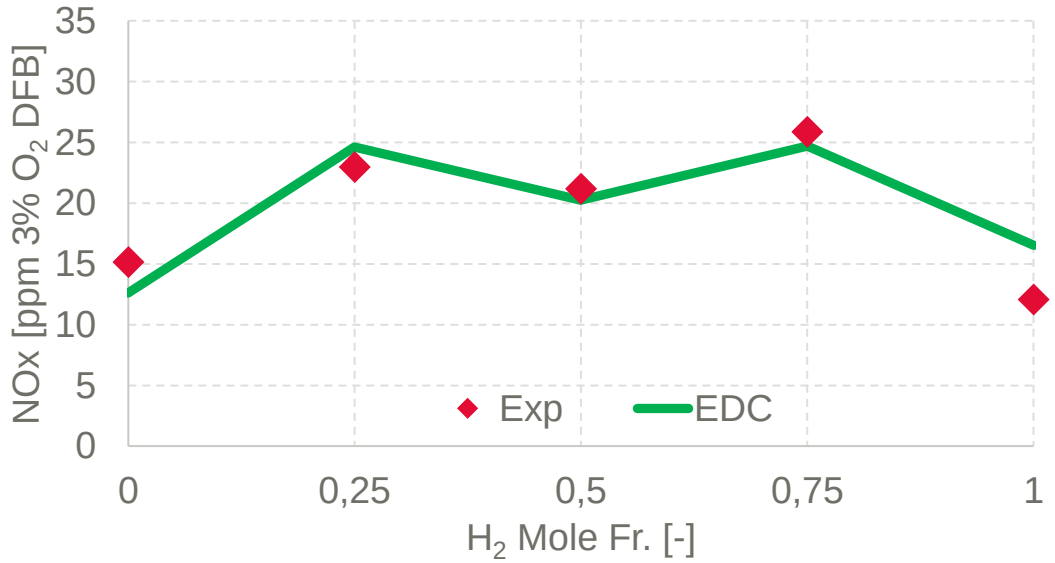
TENOVA ACTIVITIES AS SUPPORT TO H_2 READY COMBUSTION SYSTEM DEVELOPMENT

INDUSTRIAL SCALE LAB UPDATE



CFD MODELING IMPROVEMENT





Acknowledgements:
This work is supported by the European Commission, under the HEU project HytechHeat" with Grant Agreement 101092087

General Summary

SUSTAINABLE HEATING CONCEPTS

- Decarbonization concepts in heating system started several years ago thanks to the furnace energy optimisation
- Flexible solutions are required for the next decarbonisation steps to securing the CAPEX (e.g. H_2-ready combustion systems, hybrid heating) and taking under control the OPEX
- R&D is necessary for consolidate the on-going development (e.g. in the annealing-pickling and galvanizing processes), for system integration (i.e. H_2 generation, storage and control systems) and effect of the furnace atmosphere on the product quality (i.e. scale formation)

SUSTAINABLE NEW PLANTS

- Suitable new plant or revamping concepts are strongly dependent on:
  - the existing infrastructure
  - the product
  - the type of furnace - especially in the case of revamps
- Up to now, the limit is represented by the availability and cost of RES / H_2
- In coming 5-10 year it is expected a progressive increase of green energy availability
- In the meantime, the opportunities of plant modernization must be managed using flexible technologies

tenova

GREEN SOLUTIONS

FOR DECARBONIZATION AND SUSTAINABLE TECHNOLOGIES FOR METALS

➡THERE IS NO “ONE & ONLY” DECARBONIZATION CONCEPT !

➡BUT THERE ARE ALWAYS SUITABLE CONCEPTS !

dissHEAT

tenova

METEC

12-16 June 2023
Düsseldorf
Germany

JOIN US AT OUR BOOTH
HALL4 #A21

Tenova. Follow the **beat**

Global R&D

enrico.malfa@tenova.com

www.tenova.com

TECHINT GROUP