fives

DECARBONIZED
& SUSTAINABLE INDUSTRY

DECARBONIZING THE COMBUSTION PROCESS

October 2026

Bilbao

Fives North American Combustion EU



RICARDO GIL

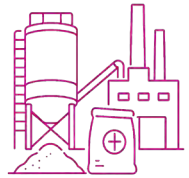
ENGINEERING DIRECTOR EUROPE

Fives North American Combustion

- ✓ >25 years of experience designing and manufacturing combustion systems for industrial processes.
- ✓ Master of Science in Engineering (MScEng).
- ✓ Currently handling the engineering of the European and Middle East projects for thermal processes

FIVES: AN INDUSTRIAL ENGINEERING GROUP





Fives supports leading global industrial players in sectors such as intralogistics, metals (steel, aluminum), cement and minerals, energy (nuclear and combustion), aerospace, defense, and automotive.

A LONG-TERM COMMITMENT:

FROM THE DESIGN OF INSTALLATIONS
(machines, process equipment and production lines),

THROUGHOUT THEIR ENTIRE LIFECYCLE
Thanks to a comprehensive range of services.

This long-term relationship is built on the deep knowledge of local markets and the expertise of:

more than 8,500 employees

operating in 25 countries worldwide



KEY FIGURES

More than **200** years of history

Over **100** locations in 25 countries

More than **8,500** employees

€2,040M
ORDER INTAKE

€2,143M
SALES

€2,010M
BACKLOG

88
DIFFERENT NATIONALITIES

€860M
SHAREHOLDERS' EQUITY

AN INTERNATIONAL PRESENCE, CLOSE TO OUR CUSTOMERS AND MARKETS



Over **100** locations

in 25 countries

FIVES NORTH AMERICAN COMBUSTION



FOUNDED IN
1917

MORE THAN
480
EMLOYEES

OVER
36K SQM
MANUFACTURING SPACE

OVER
35
GLOBAL SALES LOCATIONS

OPERATIONS:

North America

- Cleveland, OH, USA (HEADQUARTER)
- Birmingham, AL, USA
- Bolton, Ontario, CANADA

Europe

Marseille, FRANCE

Hoofdoorp, NETHERLANDS

Bilbao, SPAIN (EU and Middle East Engineering Center)

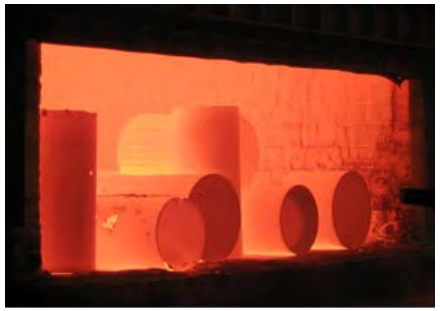
COMBUSTION EXPERTISE ACROSS A BROAD RANGE OF INDUSTRIES

Air Heating
Aluminum
Boilers
Brick
Ceramics
Copper
Ethanol Dryers
Forging
Food
Glass
Gypsum Board
Heat Treatment
Incineration
Oil Fields
Paper Drying
Iron Ore Pelletizing
Steel Strip
Steel Reheat
Pipe Annealing









INDEX

01 INTRODUCTION TO ALUMINIUM CASTHOUSE COMBUSTION

02 DECARBONIZATION BY ENERGY SAVINGS

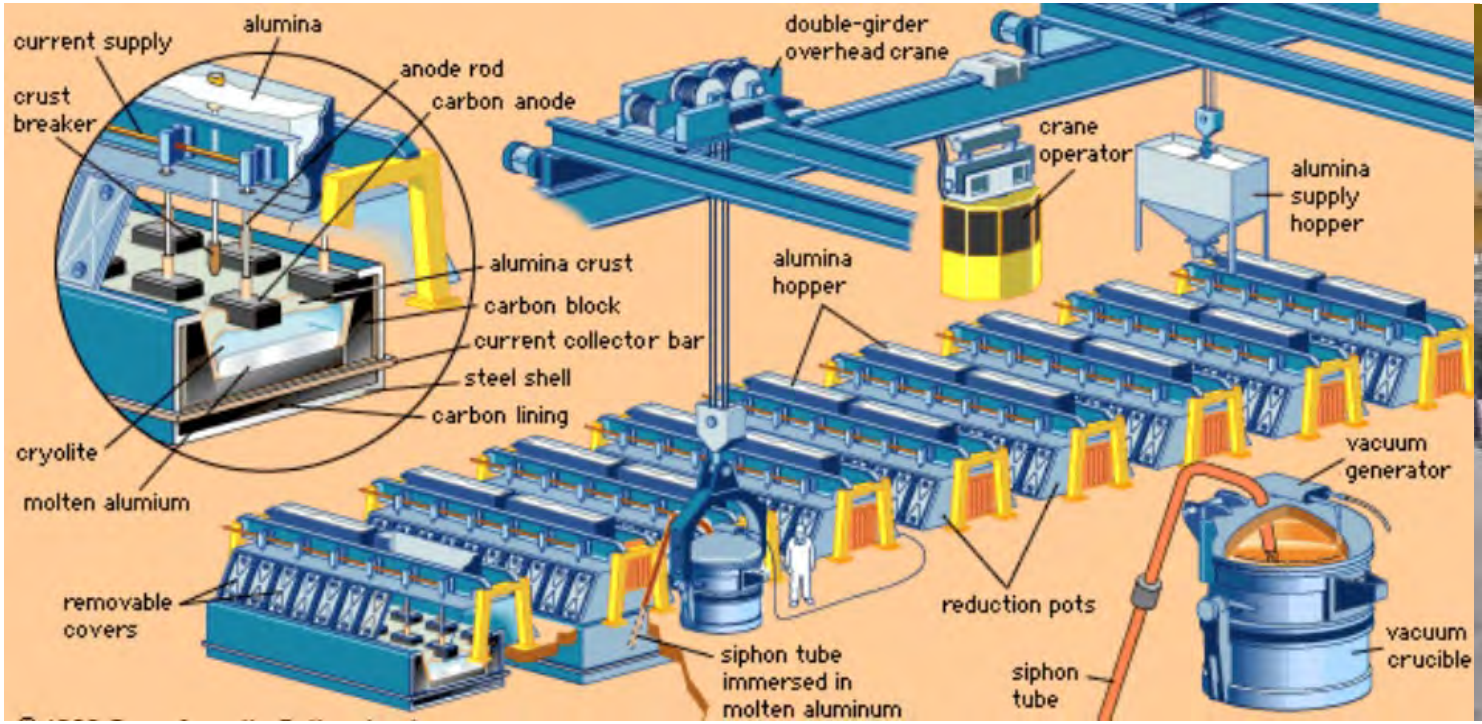
03 DECARBONIZATION BY H_2 USE

04 Q&A

01 INTRODUCTION TO ALUMINIUM CASTHOUSE COMBUSTION:

Decarbonizing by recycling

MAKING ALUMINUM – PRIMARY: STANDARD WAY





Alumina to aluminum (prime metal)

MAKING ALUMINUM – SECONDARY/RECYCLING CASTHOUSE

Energy consumption to make prime metal from mining bauxite

- Produce raw material: 8 kWh/kg
- Electrolytic process: 16 kWh/kg
- Total: 24 kWh/kg = 24.000 kWh/t

0’05 x 24.000 kWh/t = 1.200 kWh/t

DECARBONIZING BY RECYCLING

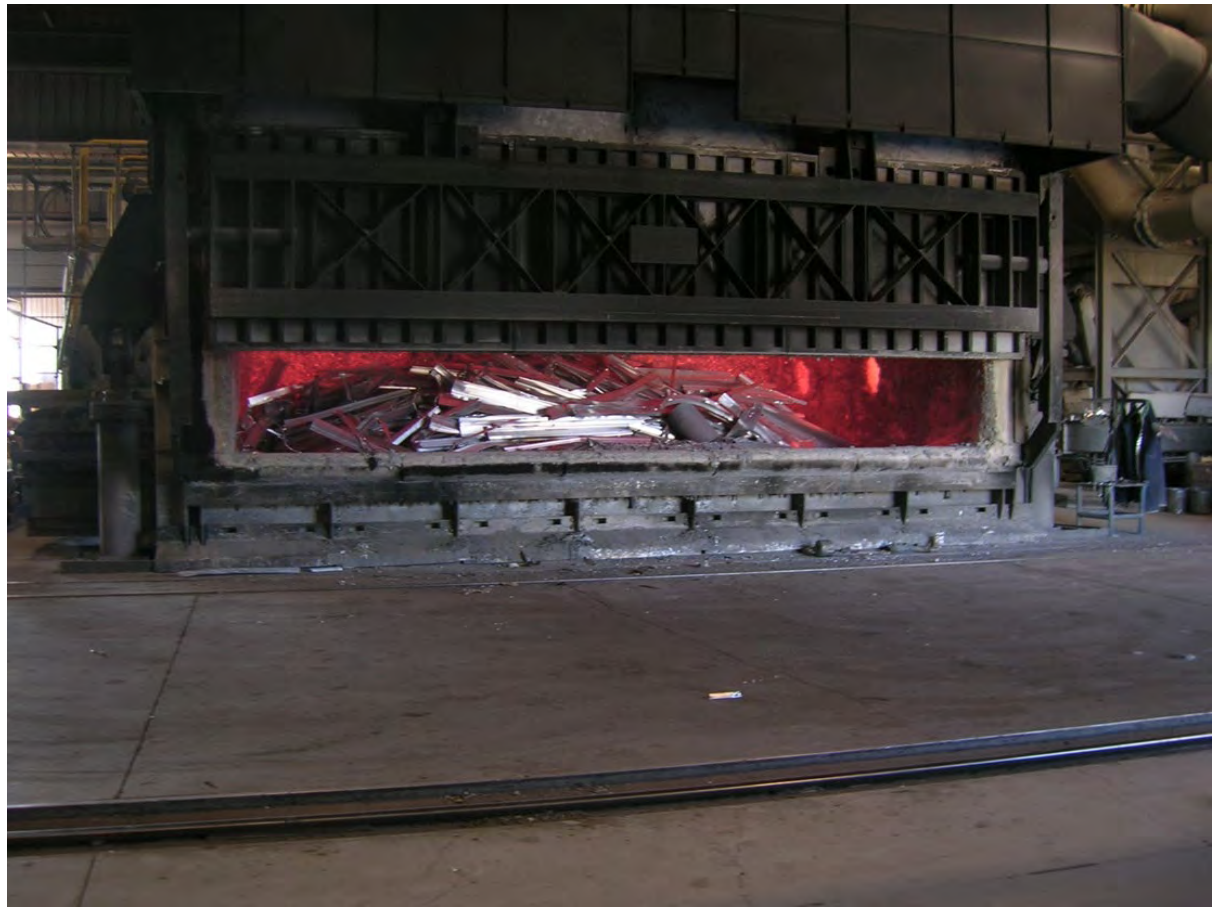
Recycling

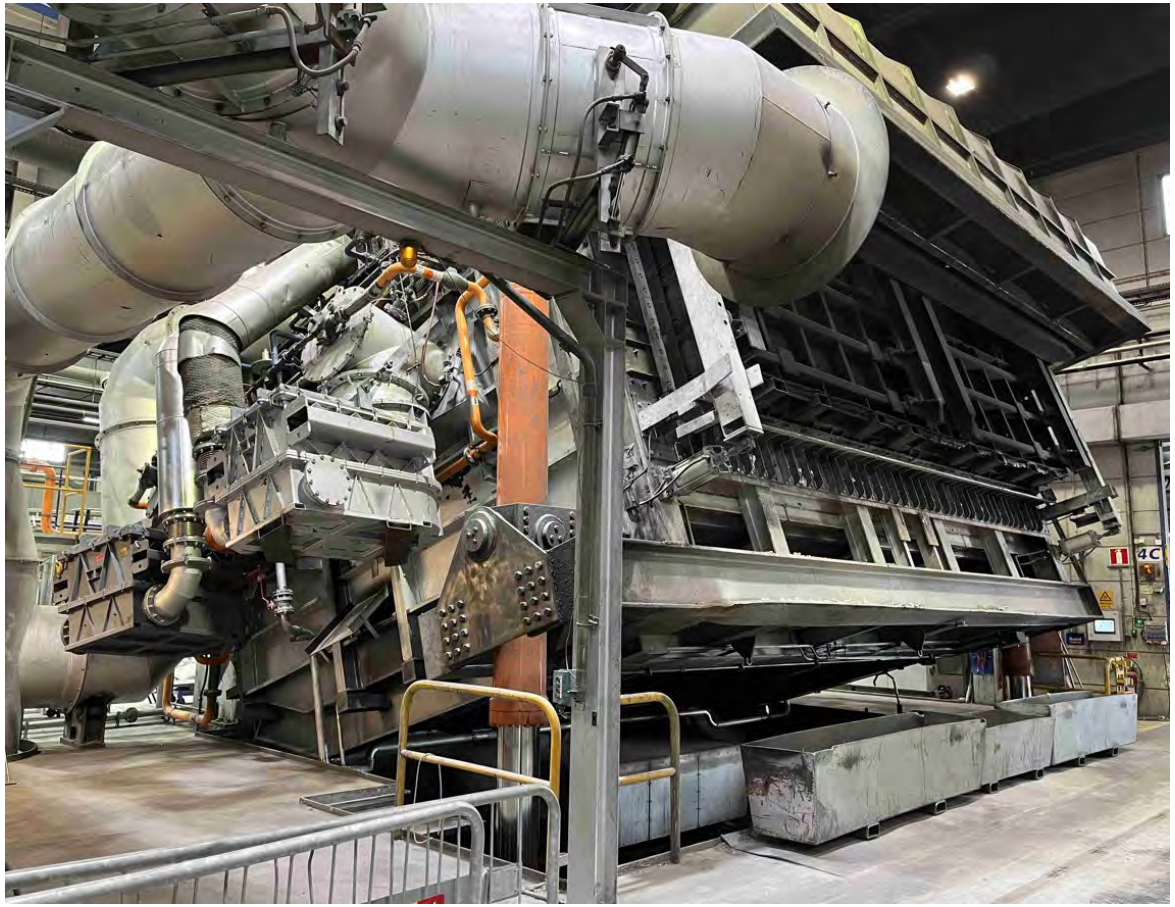
Unlike iron, aluminum is corrosion resistant so it can be remelted and reused an infinite number of times.

The added benefit is that recycling aluminum requires only 5% of the energy needed to make the same of amount of primary aluminum.



DIRECT CHARGE REVERBERATORY MELTER



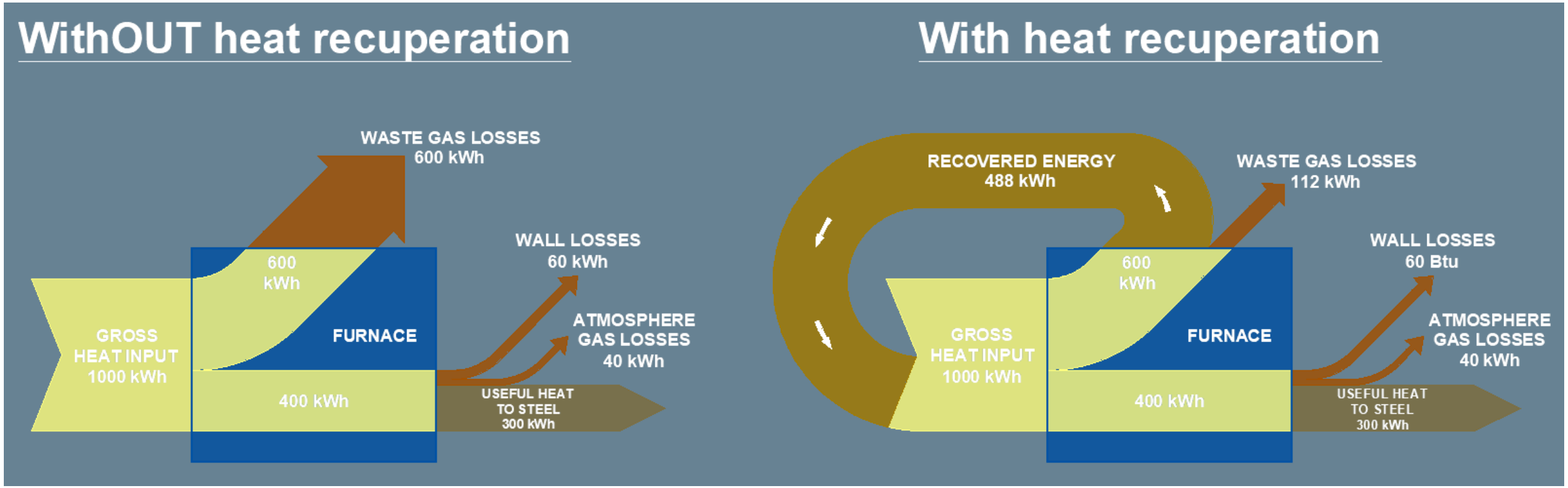


Recycling aluminium scrap using combustion systems in Melting Furnaces

02

DECARBONIZATION BY ENERGY SAVINGS

DECARBONIZATION BY ENERGY SAVINGS

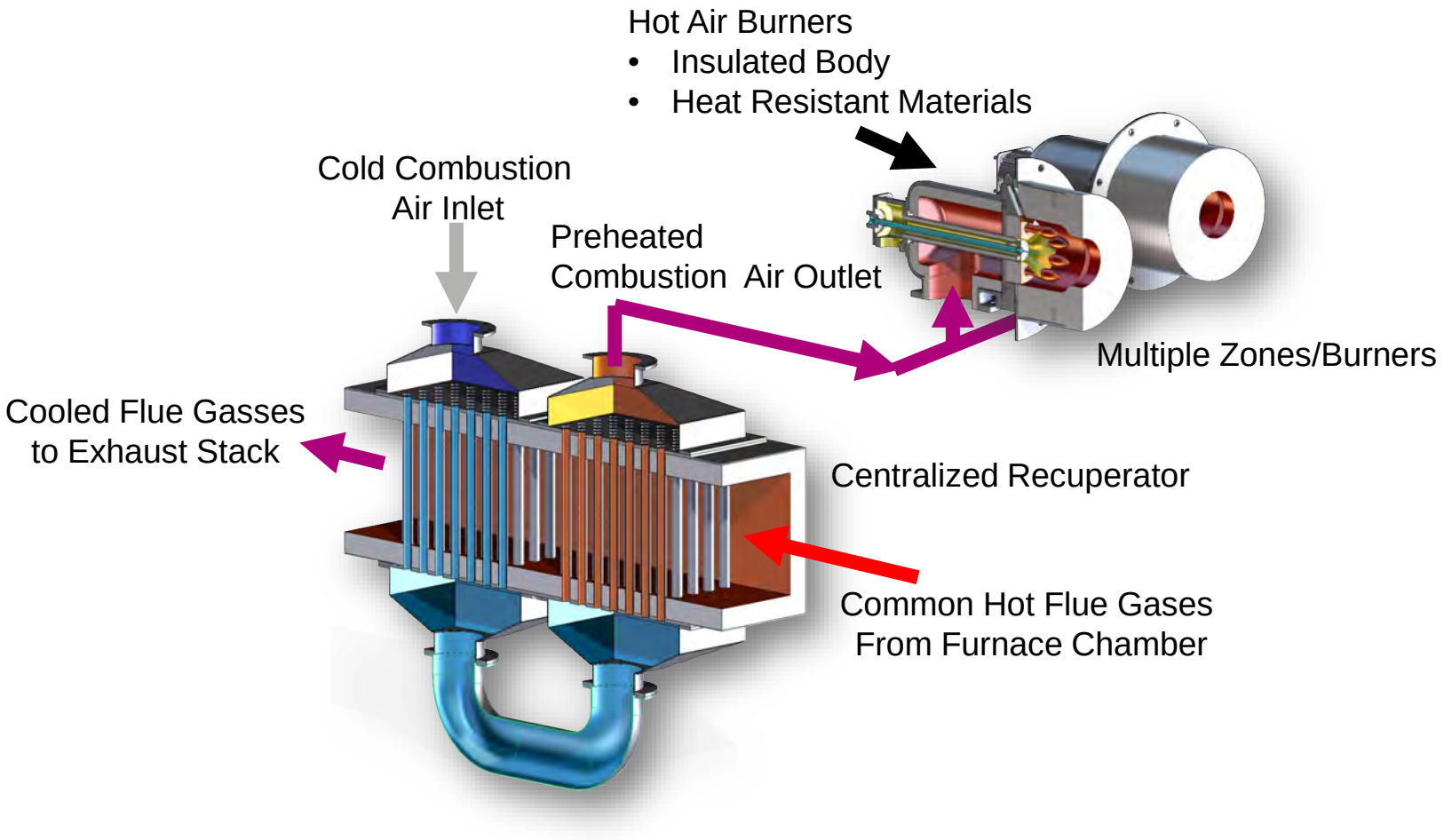


"The furnace was recently commissioned, resulting in a **more than 40% reduction in carbon footprint**, based on gas consumption, compared to pre-upgrade levels measured in mid-2023 at the Voerde casthouse..."

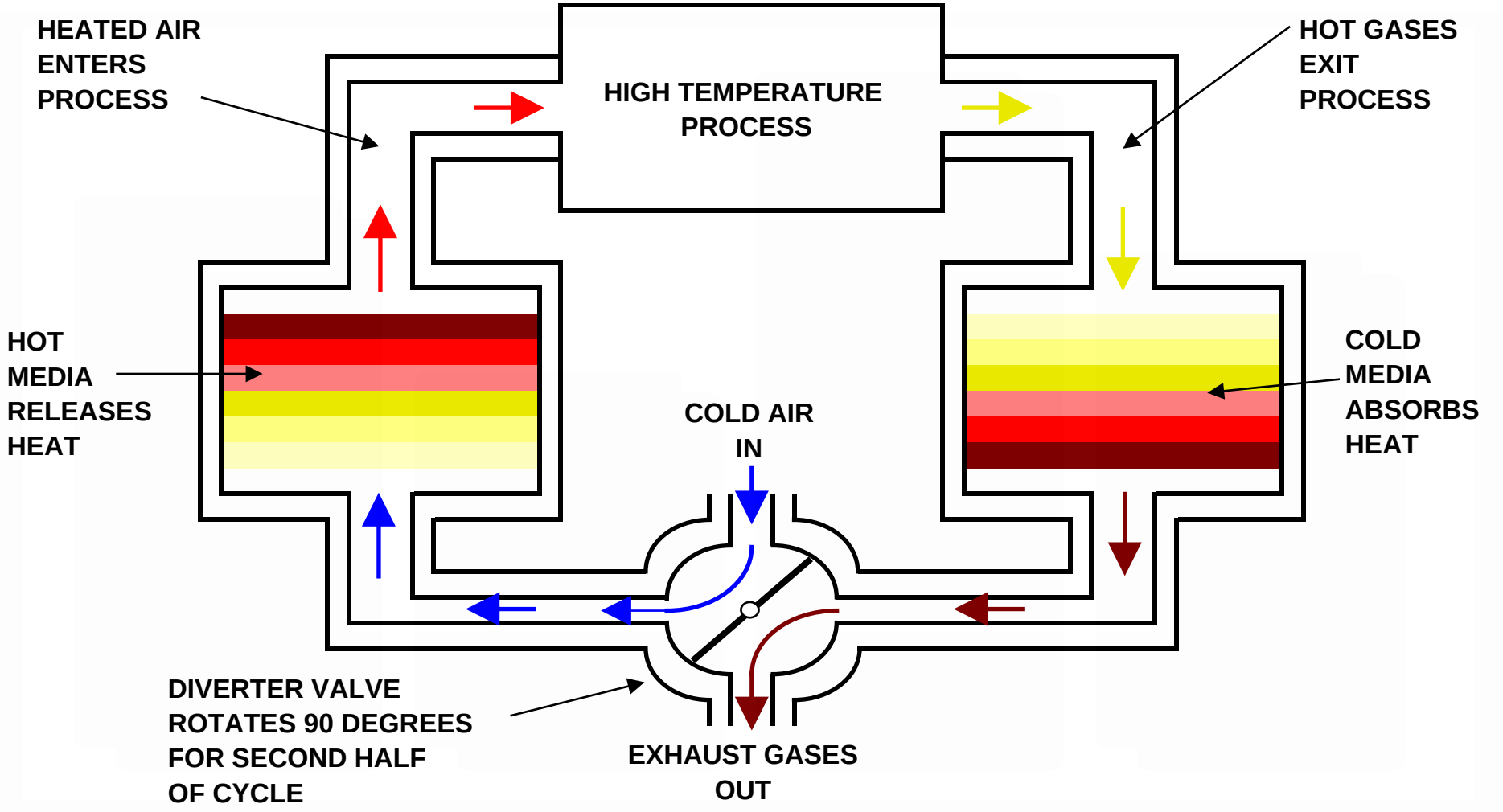
NOVELIS (Germany)

RECUPERATIVE SYSTEMS – CENTRAL RECUPERATOR

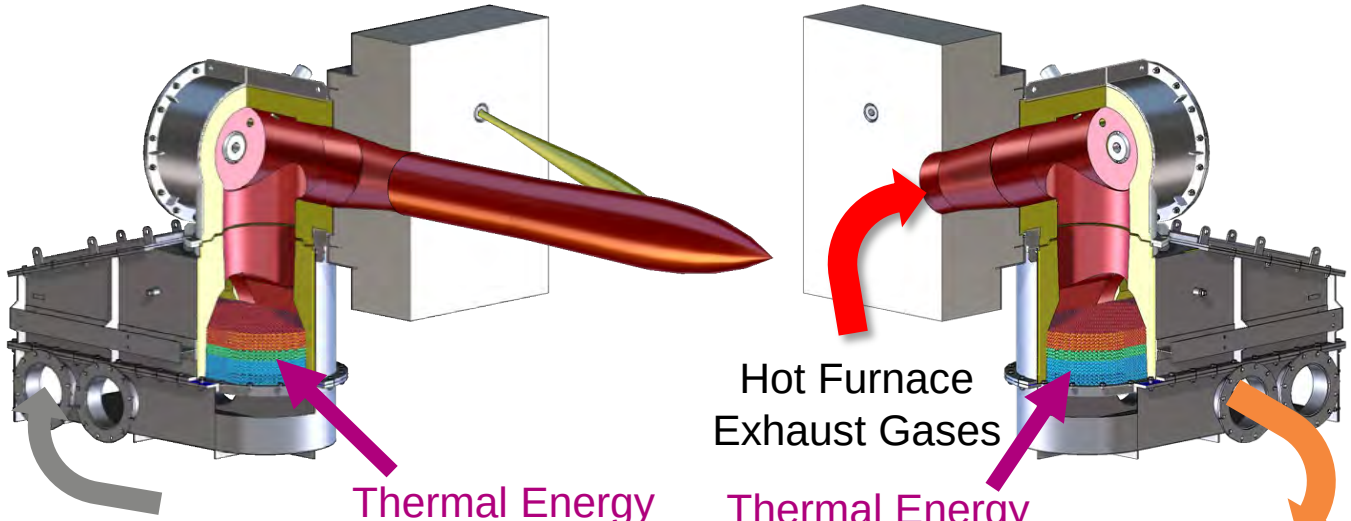
HEAT RECOVERY

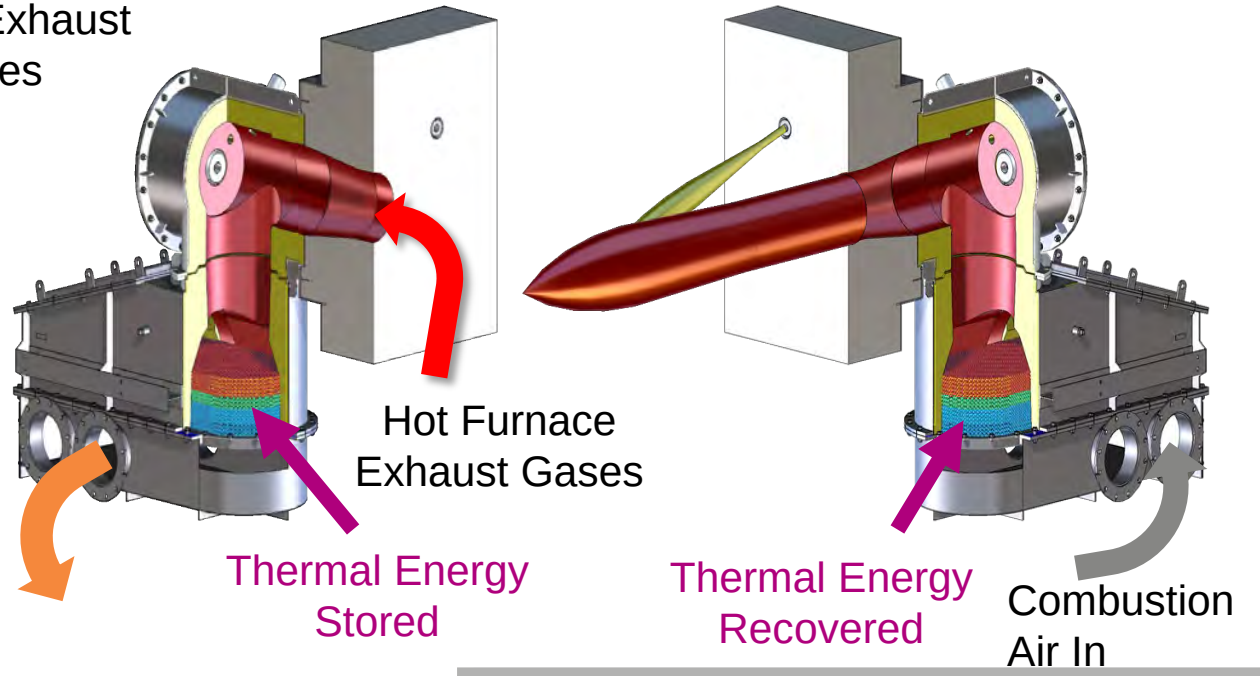


REGENERATIVE BURNERS: HIGHEST HEAT RECOVERY

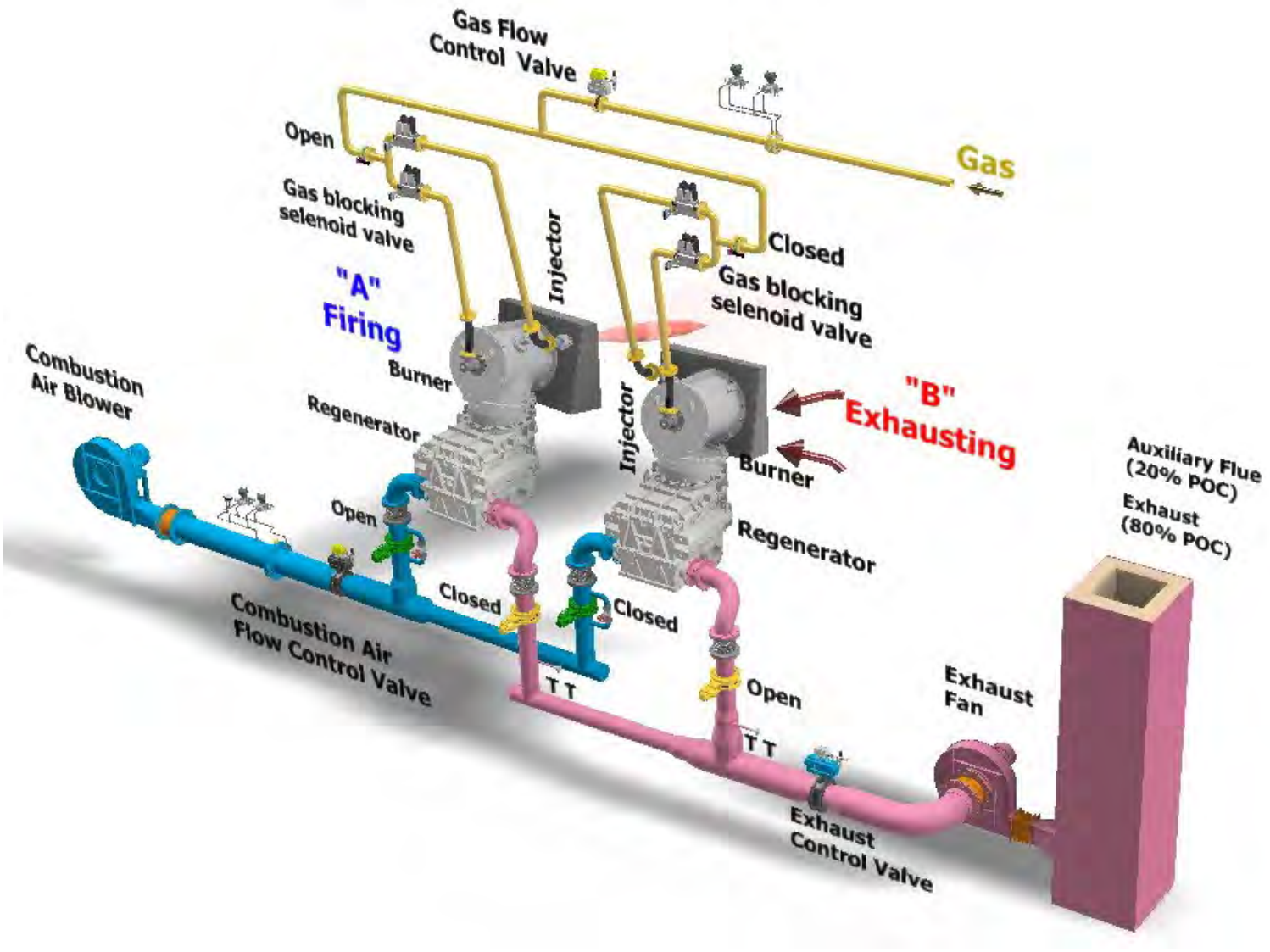


REGENERATIVE SYSTEMS





REGENERATIVE BURNERS

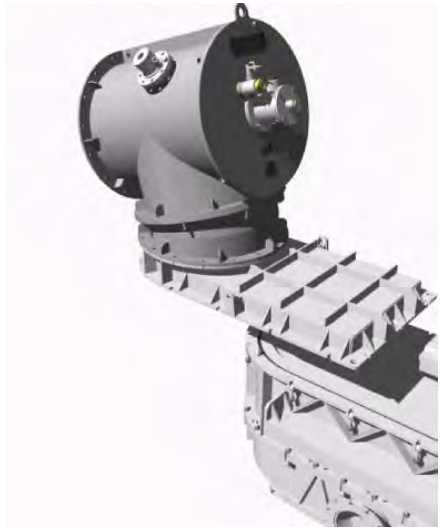


CASSETTE REGENERATORS

The North American TwinBed II cassette regenerators ease the change of the refractory media.

As the pieces to be moved are the minimum ones.





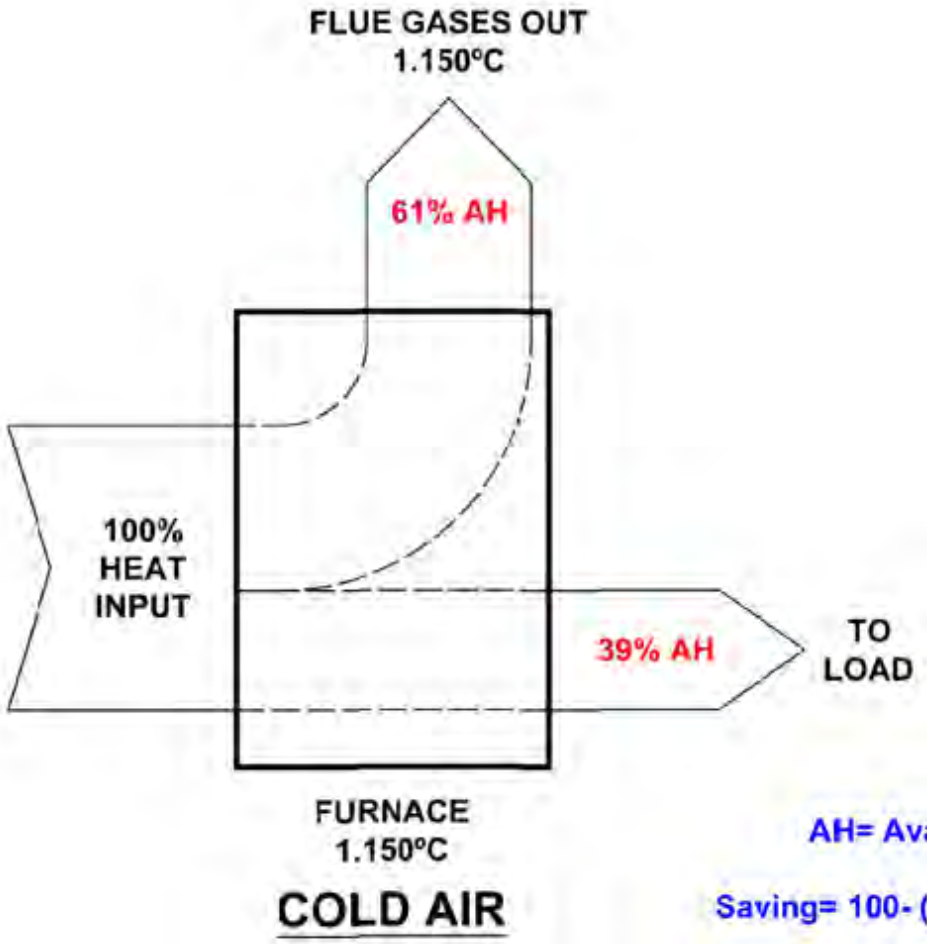






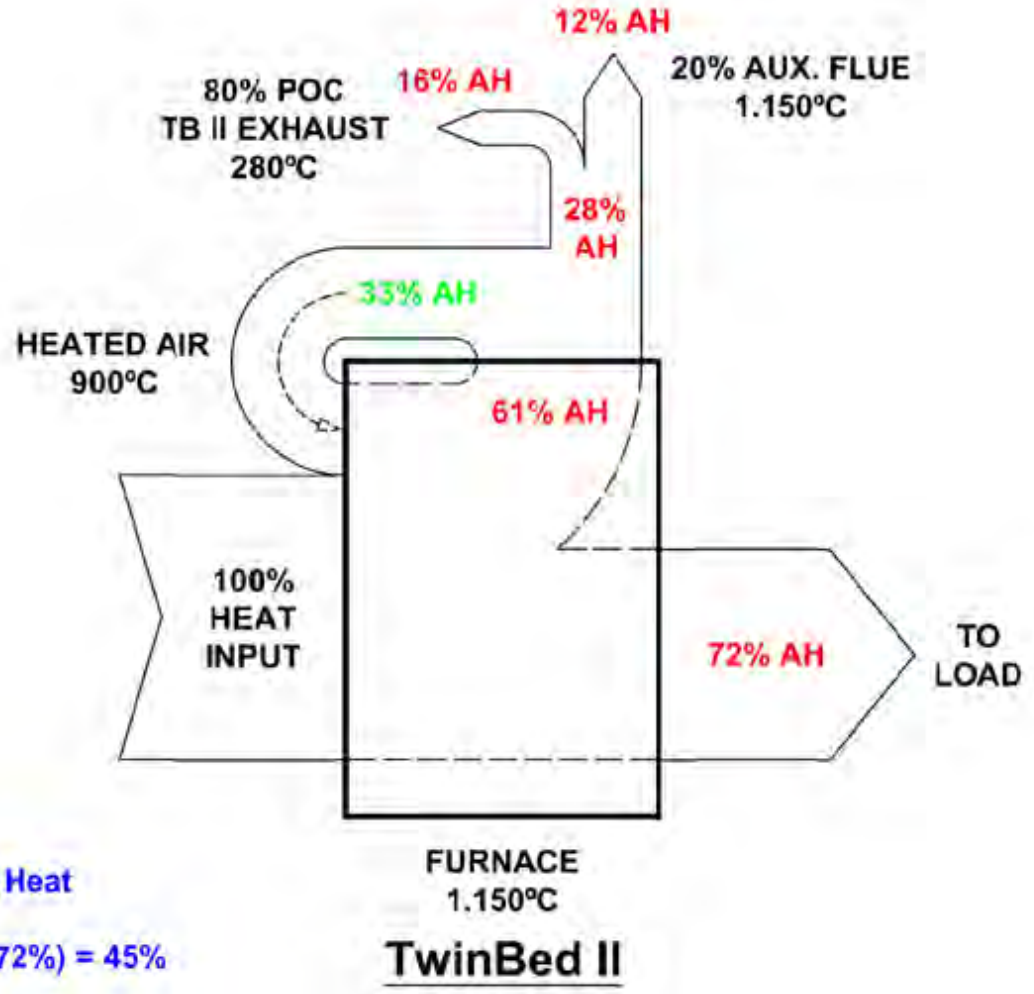


REGENERATIVE BURNERS AT ALUMINIUM CASTHOUSE



AH= Available Heat

Saving= 100- (39% / 72%) = 45%



REGENERATIVE BURNERS

COLD AIR VS NORTH AMERICAN TWINBED® II

So the use of Regenerative systems could drive to savings in the fuel consumption, compared with cold air burners use:

Saving = 100 - (39% / 72%) = 45%

Savings could be use for:

- Reducing the gas consumption

or

- Increasing the melting rate capability (if the furnace's dimensions allow it)

NOVELIS VOERDE

NOVELIS

- Leading sustainable aluminum solutions provider and the world leader in aluminum rolling and recycling
- Located in Germany (North from Düsseldorf)
- Integrated network of rolling and recycling facilities across North America, Europe, Asia and South America
- Part of the ADITYA BIRLA Group
- Former ALERIS and TRIMET plant

PROJECT OVERVIEW

- Revamping of 3 furnaces
- Heat recovery technology (North American TwinBed® II regenerative burner)
- 40% reduction in CO_2 | 40% energy



IN THE MEDIA

Aluminium International Today



ALUMINIUM INTERNATIONAL TODAY

GLAMA

ELDAN RECYCLING

Novelis and Fives complete German furnaces upgrade

Published 12th November, 2025 by Greg Morris

Novelis has upgraded three melting furnaces at its plant in Voerde, Germany using regenerative technology from Fives.

The North American TwinBed II burners, manufactured by Fives, are recognised for their energy efficiency, low emissions and robust design.

From engineering and design to commissioning, the project was managed by Fives' North American Combustion's teams based in Bilbao, Spain.

The final furnace was recently commissioned, resulting in a more than 40% reduction in carbon footprint, based on gas consumption, compared to pre-upgrade levels measured in mid-2023 at the Voerde casthouse.

Emilio Braghi, Executive Vice President and President Novelis Europe, said the company had set ambitious goals to advance circularity and decarbonisation by 2030.

"The upgrade of our three melting furnaces represents a practical advancement in reducing our environmental footprint and improving operational efficiency", he said.

Paolo Arrobazaga, Managing Director for Europe at Fives North American Combustion, said the project represents a milestone in the long-standing collaboration with Novelis, which began nearly two decades ago.

"We are proud to support Novelis' sustainability journey with high-performance, low-emission combustion solutions tailored to their operations."

Mining.com.au



MINING COM.AU

COMMODITIES | DEALS | REGIONS | EVENTS

13 NOVEMBER, 2025 | NEWS

High Fives as Novelis partnership slashes emissions

Aluminium recycling company Novelis and global industrial combustion firm Fives have completed a large-scale upgrade of three aluminium melting furnaces at Novelis' Voerde facility in Germany.

The project, completed in November 2025 and achieved a more than 40% reduction in carbon footprint and significantly lowered natural gas consumption.

The upgrade introduced Fives' North American regenerative technology, featuring the TwinBed II burner, a high-efficiency combustion system known for cutting emissions while delivering consistent thermal performance.

From design and engineering to commissioning, the project was managed by Fives' North American Combustion team in Bilbao, Spain.

"Sustainability is at the core of Novelis' business model," says Emilio Braghi, Executive Vice President and President of Novelis Europe.

"With our company vision, Novelis 3×30, we've set ambitious goals to advance circularity and decarbonisation by 2030. The upgrade of our three melting furnaces represents a practical advancement in reducing our environmental footprint and improving operational efficiency."

The Novelis 3×30 vision focuses on tripling the company's recycled content, slashing carbon emissions by 30%, and achieving full circularity in aluminium by the end of the decade.

Novelis had net sales of $17.1 billion in Fiscal year 2025. It is a subsidiary of Hindalco Industries, and part of Aditya Birla Group, a multinational conglomerate based in Mumbai.

Industry EMEA



industry EMEA

13 NOV 25

FIVES NEWS

NOVELIS AND FIVES PARTNER TO ADVANCE ENERGY EFFICIENCY IN ALUMINIUM RECYCLING

www.fivesgroup.com

©Novelis

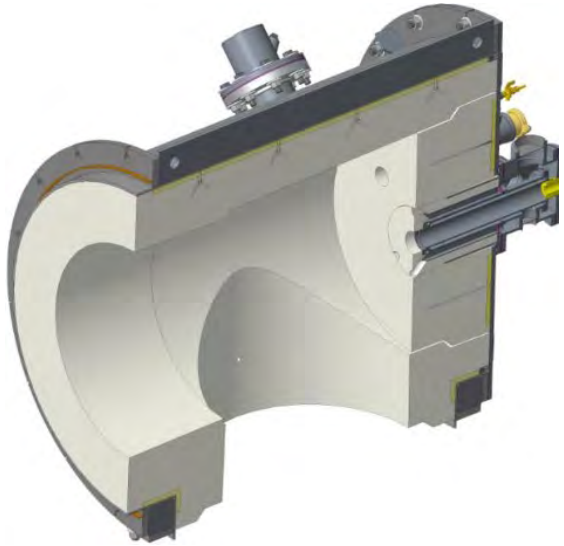
03 DECARBONIZATION BY H_2 USE

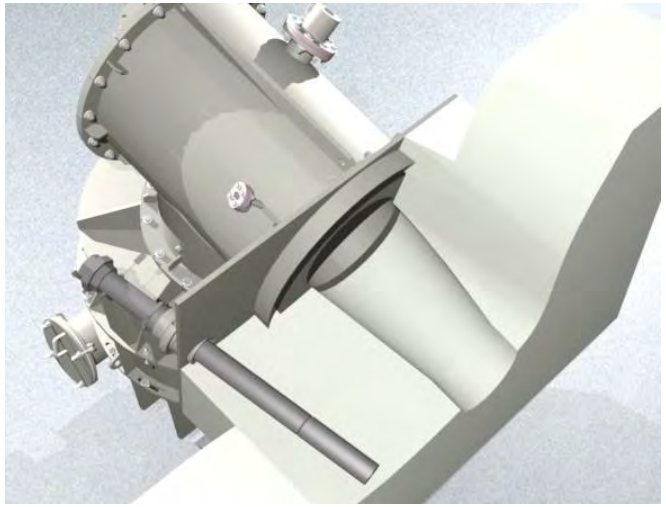
FURNACE AND REGENERATIVE COMBUSTION SYSTEM WITH H_2

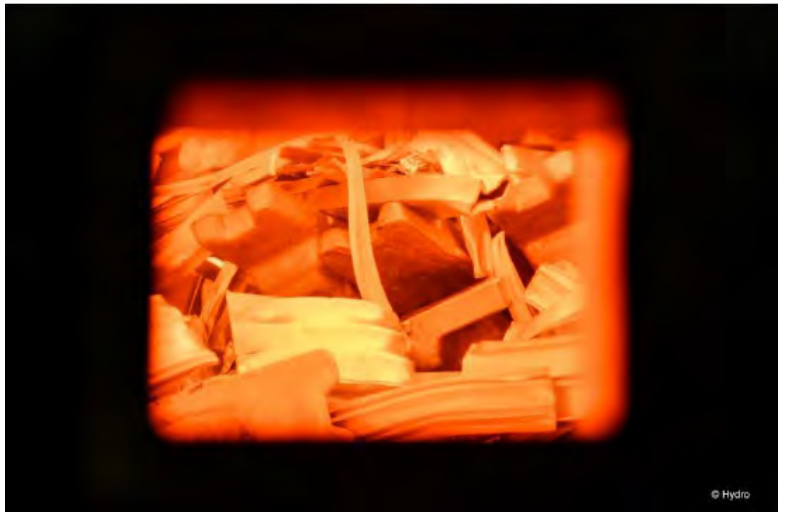
- 28 MT direct charge melter
- Single pair North American TwinBed II regenerative burners
- 3.6 MW (LHV) burner capacity



WORLD'S FIRST BATCH OF ALUMINIUM USING GREEN HYDROGEN 2023





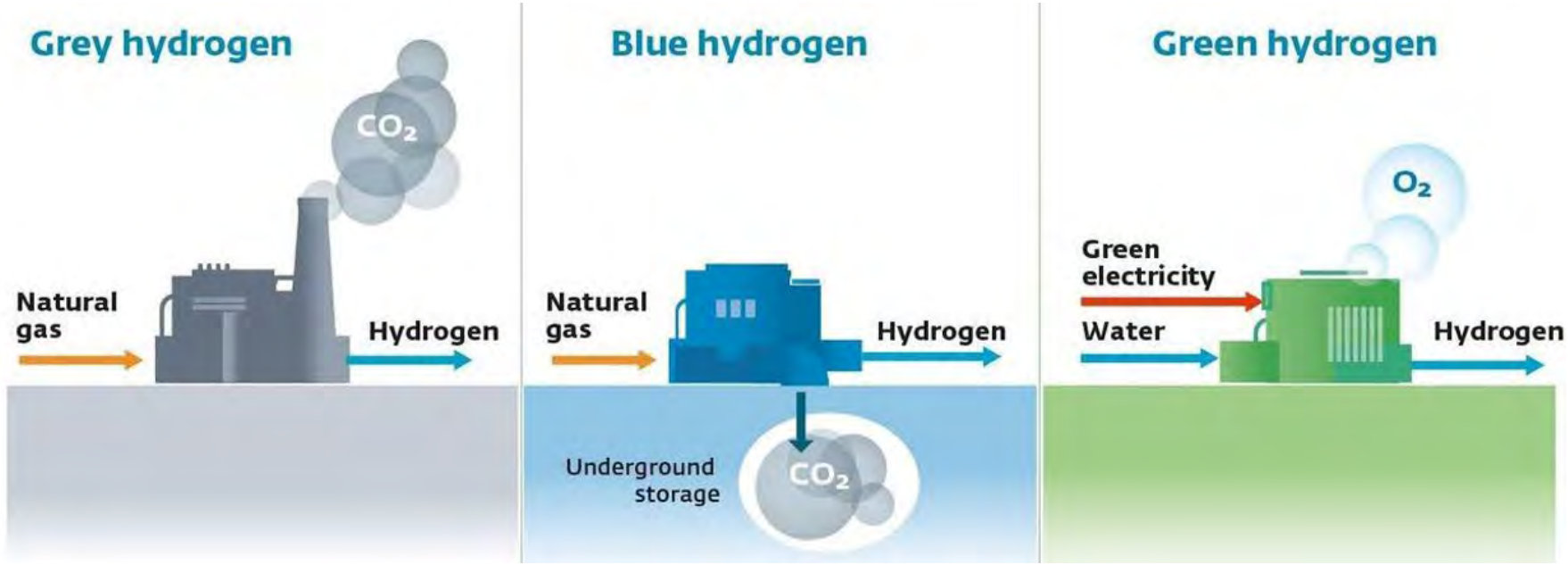


H_2 DECARBONIZATION TECHNOLOGY

Using 100% of H_2 as fuel, drives to 0% of CO_2 emissions in the combustion process:

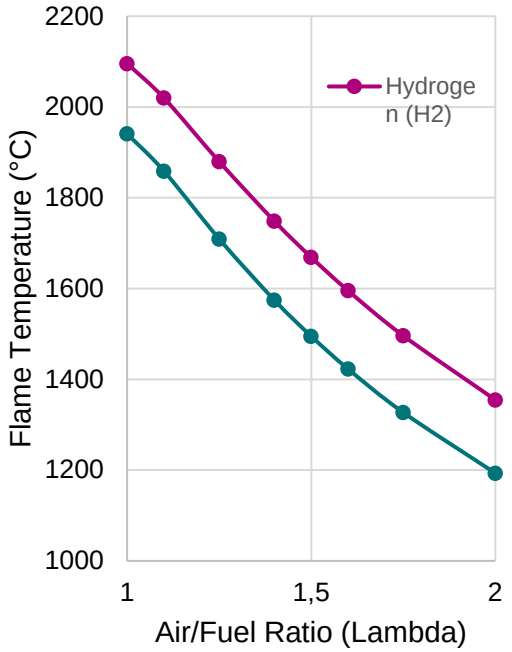
$$H_2 + ½\ O_2 \rightarrow H_2O$$

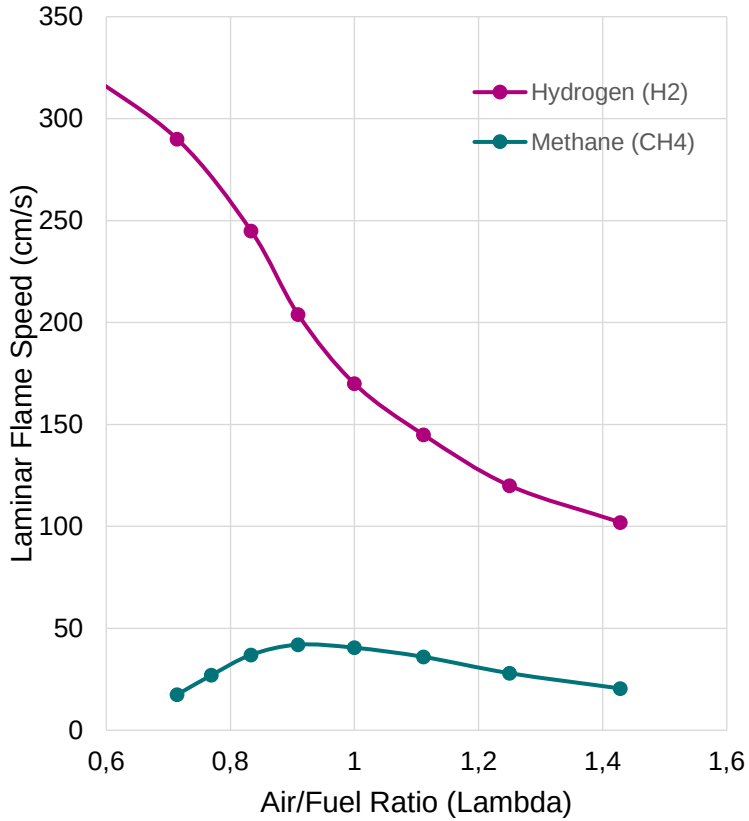




CHALLENGES OF FIRING HYDROGEN

- Higher flame temperatures
- Faster flame speed
- Wider flammability limits
- Lower autoignition temperature
- Smaller quenching distances
- Smaller molecule size





TRANSITIONING TO HYDROGEN

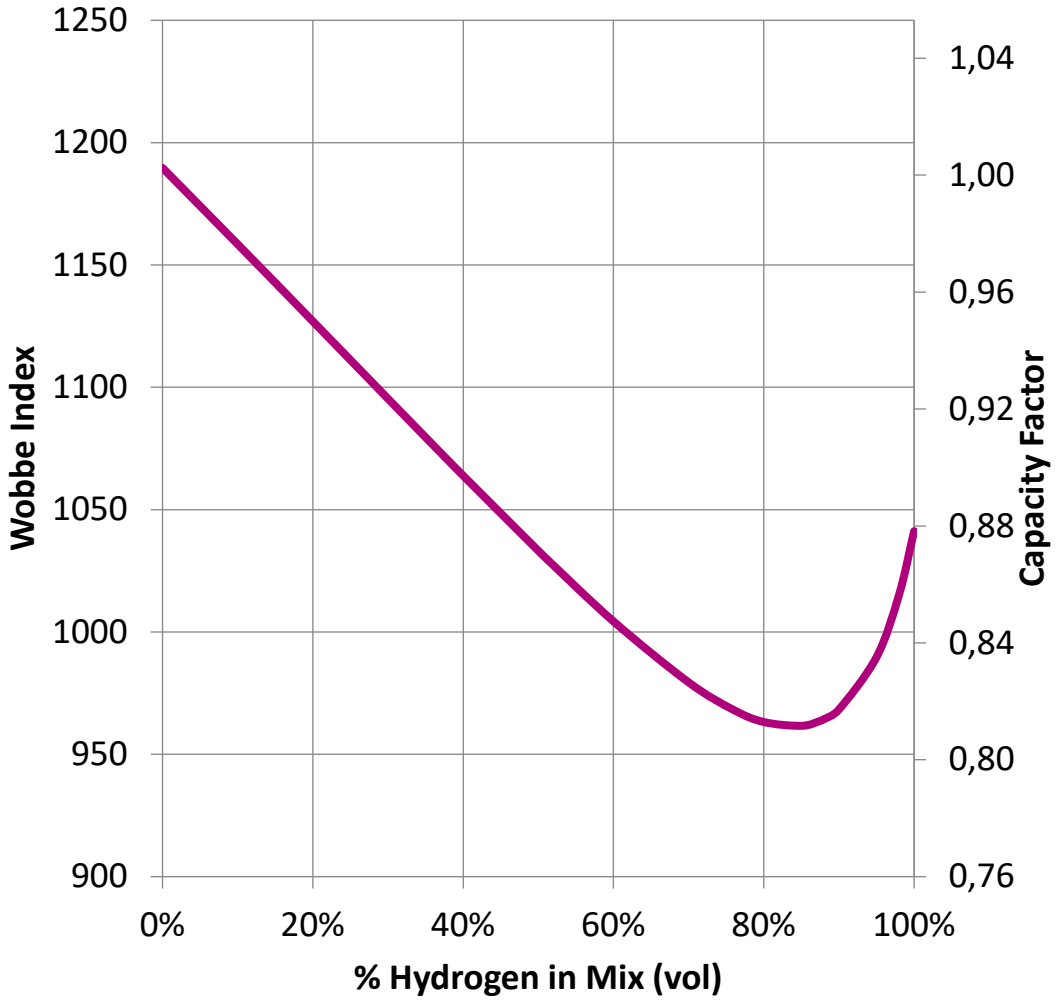
SIZING FOR HYDROGEN

For component and piping sizing, pure hydrogen is nearly directly interchangable with natural gas.

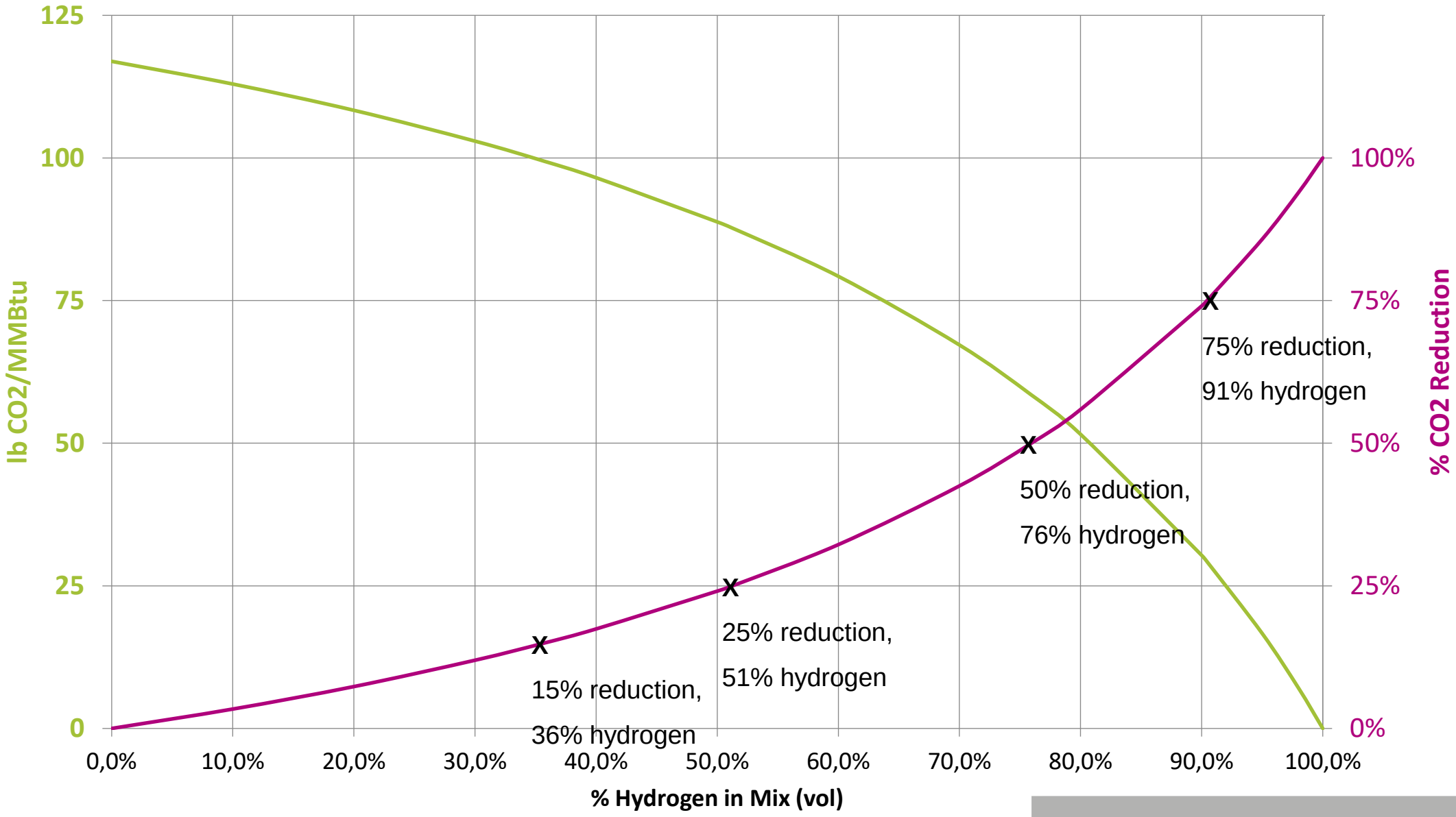
Wobbe Index (lhv)

- 100% natural gas: 1,190
- 100% hydrogen: 1,041

Worst case, increase by one pipe size



DECARBONIZATION CURVE (NG)



PRODUCING THE FIRST WORLDWIDE GREEN ALUMINIUM AT INDUSTRIAL SCALE

Cooperation between Hydro Group and Fives Group at Hydro's plant in Navarra, Spain.

Special feeding:

- Each day two trucks
- Each one with 4,000 m^3 of H_2 at 200 bar





Reducing station from 200 bar to 8 bar

HYDROGEN CONTROL

Pressure reduction from 8 bar to our standard operating pressures.
Safety devices and flow measurement device.
Redundant equipment.

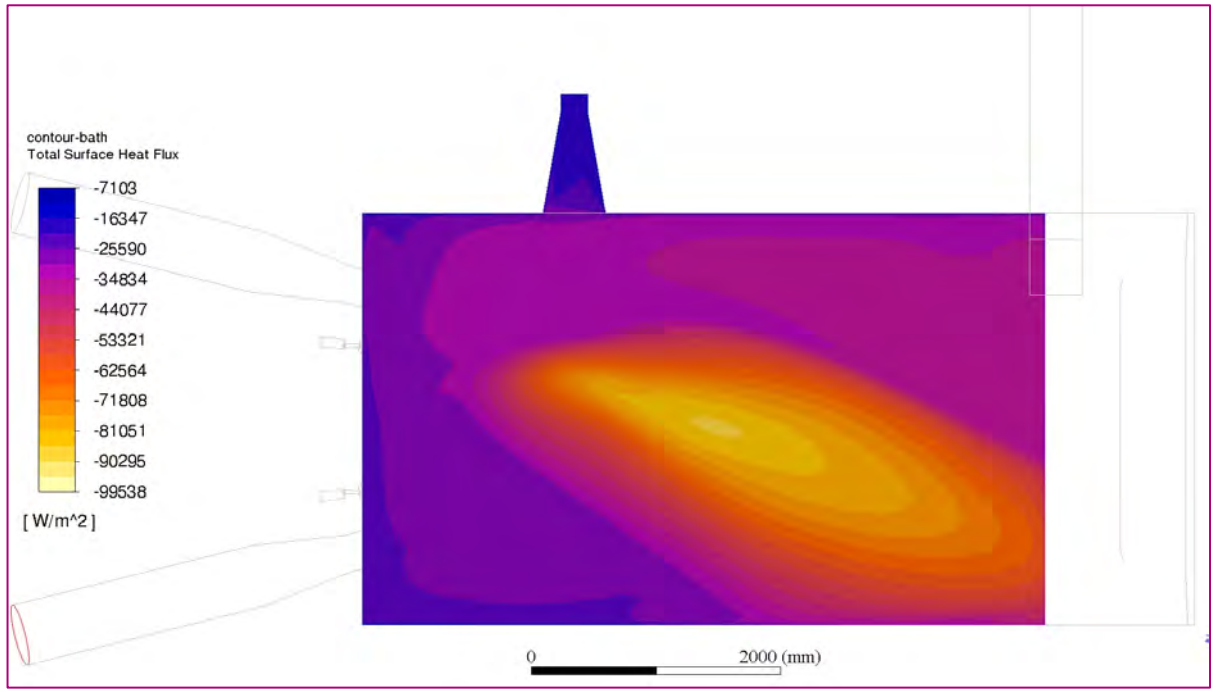




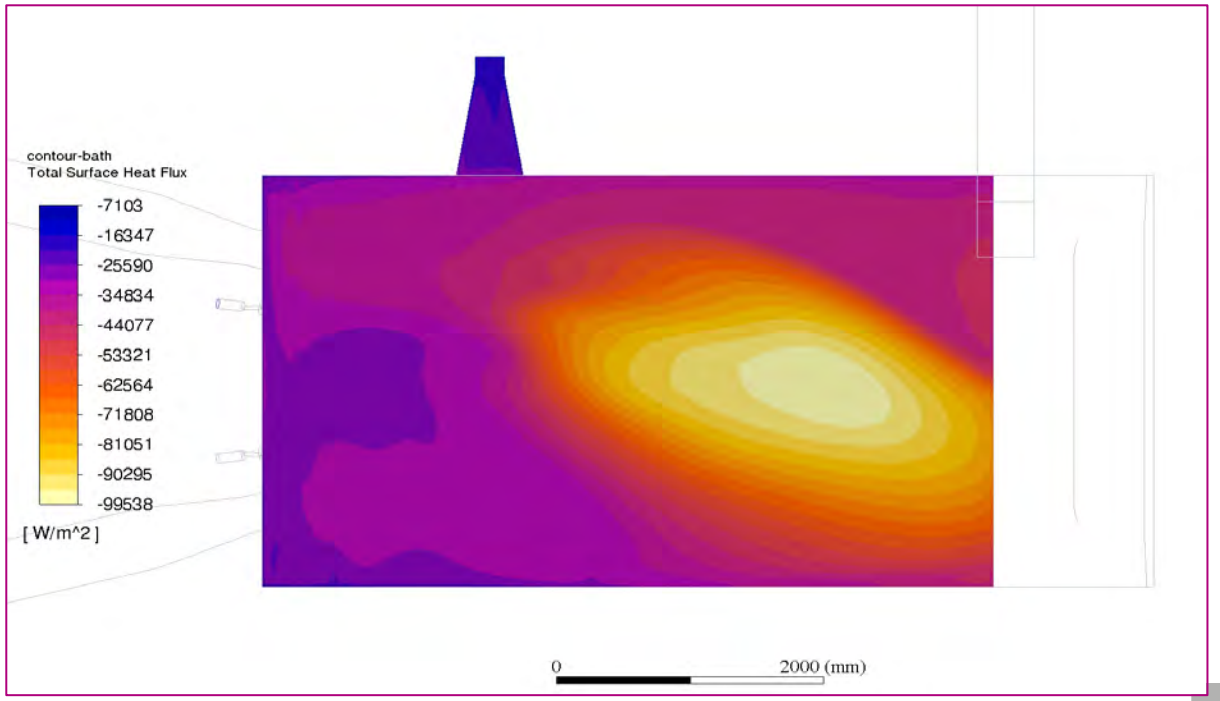
Mixer device for natural gas and hydrogen. Flow control valve.

CFD MODEL

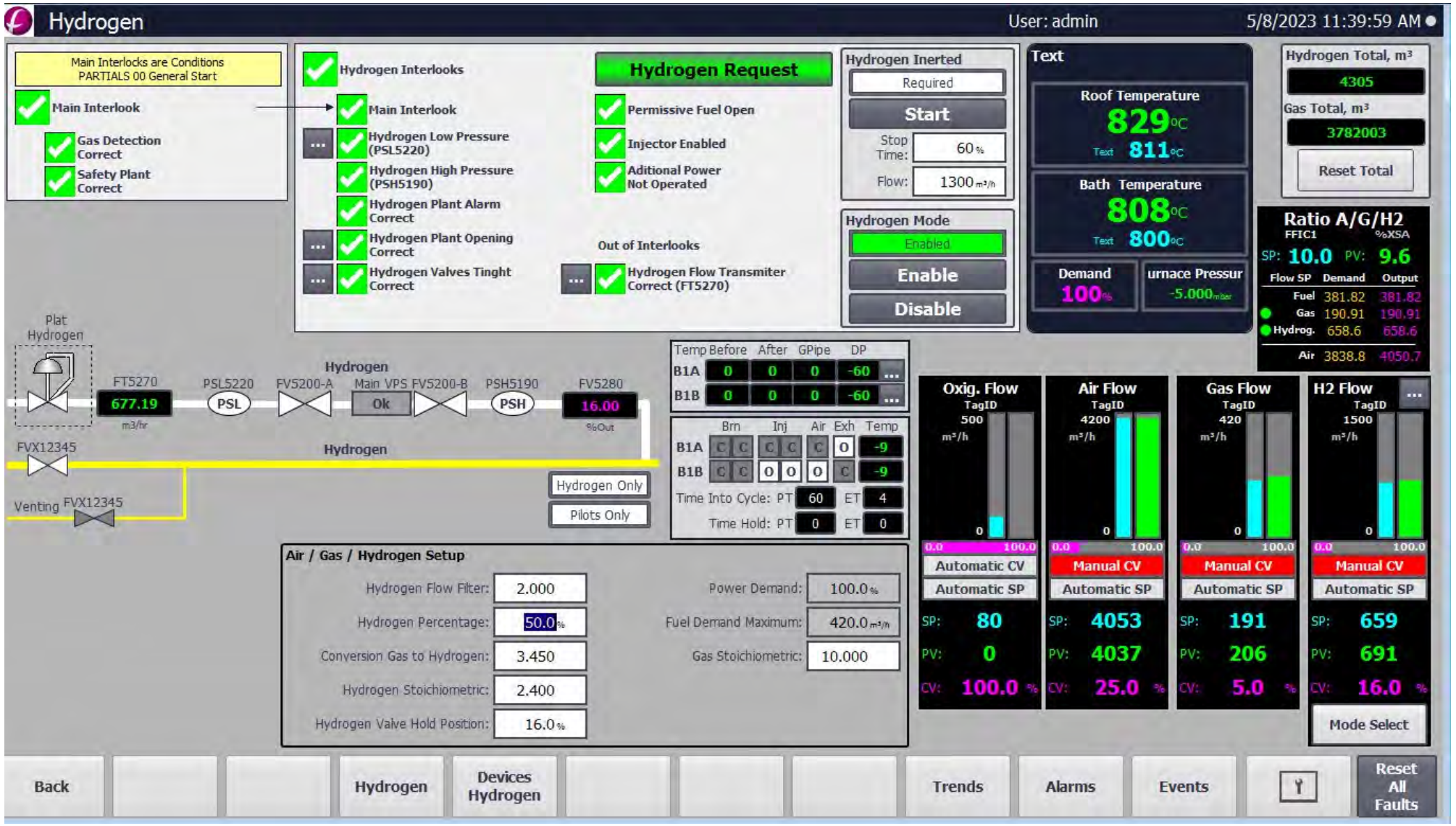
Bath Heat Flux - CH_4 Case



Bath Heat Flux – H_2 Case



CONTROL SYSTEM FOR HYDROGEN TESTS

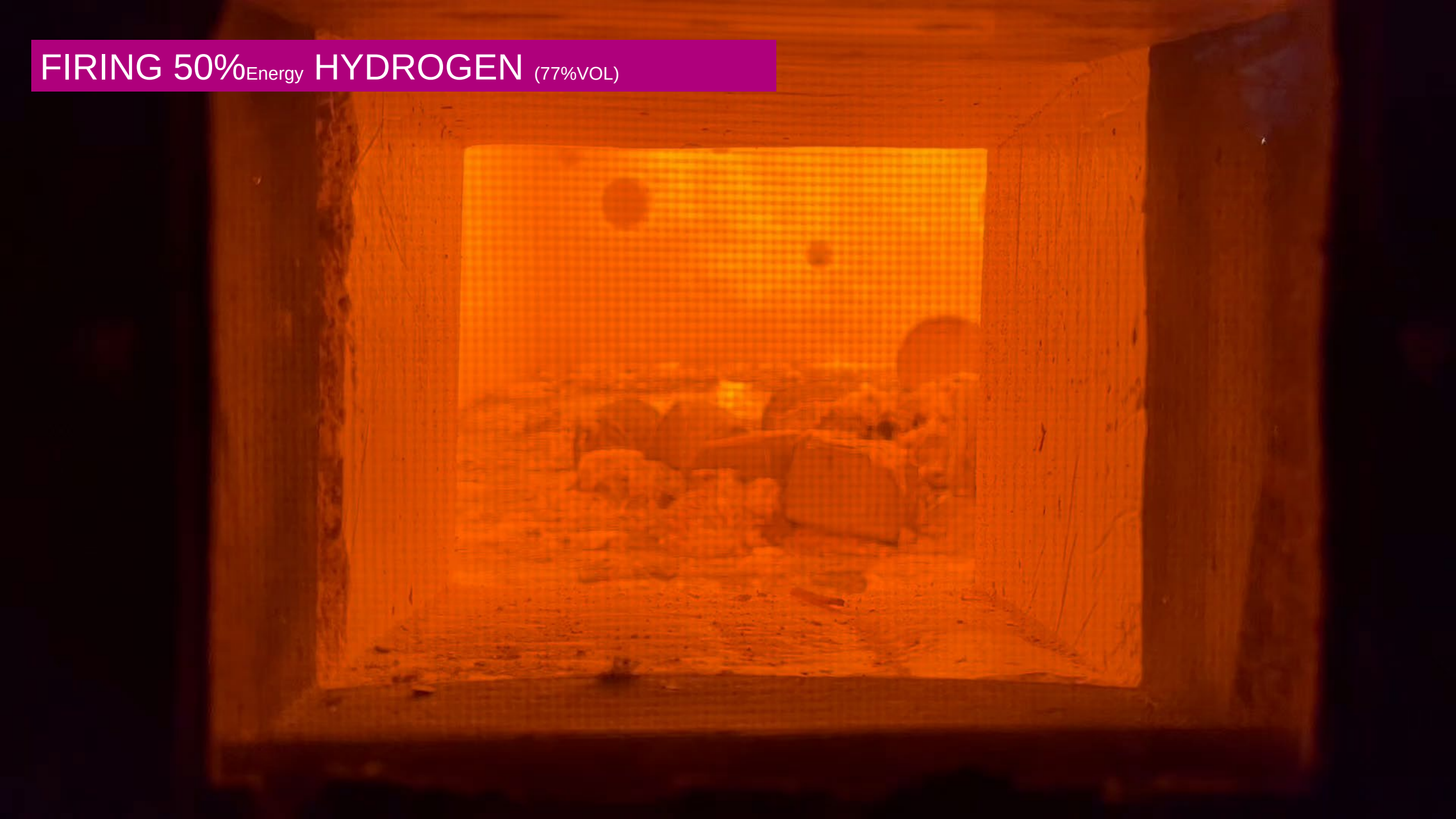


PRODUCTION



- Charges of 26 – 27 tons each test
- Clean scrap, mixed profiles, internal cut ends, and primary ingot
- Scrap to ingot ratio ranging from 50 to 85 percent

FIRING 50%Energy HYDROGEN (77%VOL)

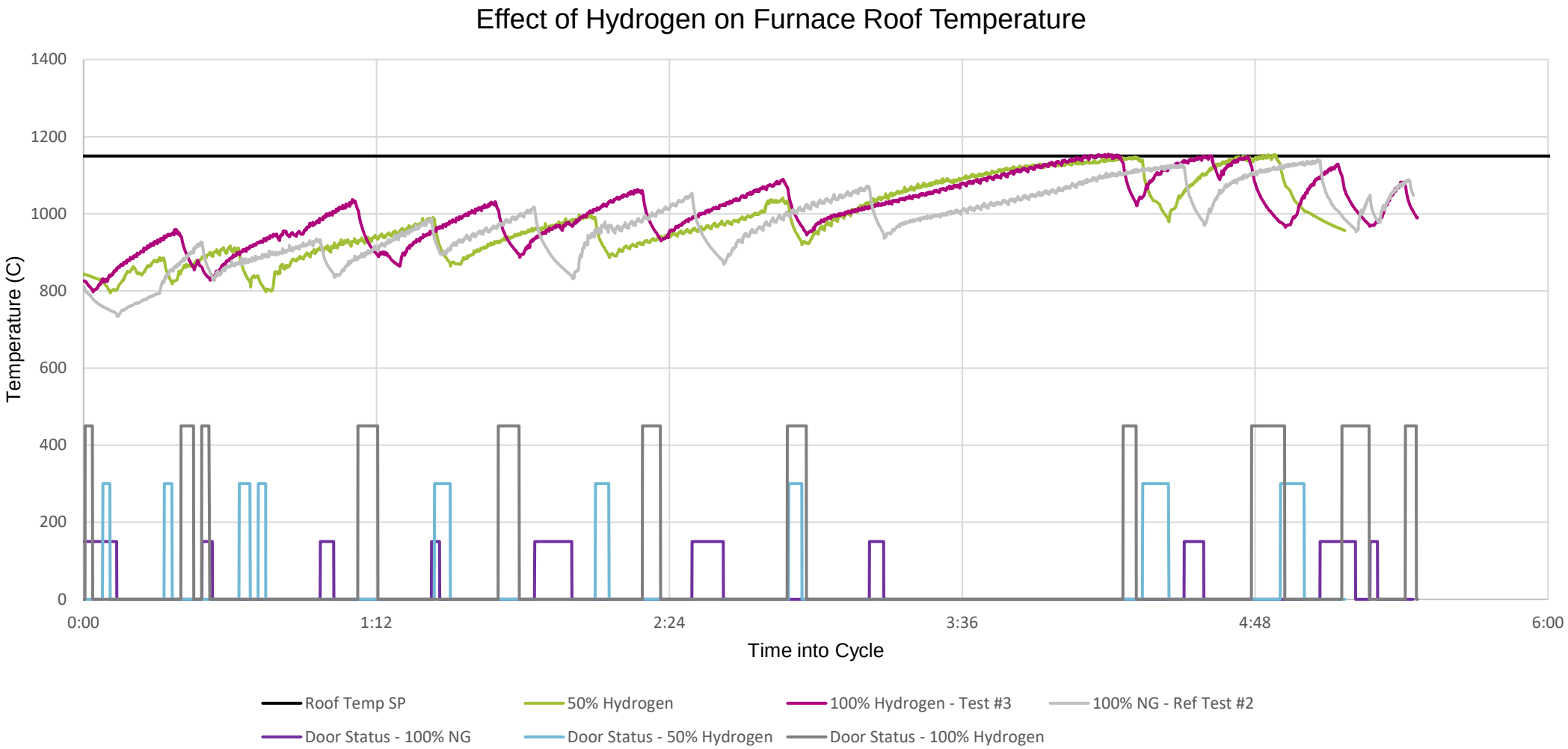


FIRING 100% HYDROGEN



TRANSITION FROM 100% H_2 TO 100% NATURAL GAS

FURNACE TEMPERATURE



SUMMARY OF RESULTS

- Total of 11 tests
  - 2 tests with natural gas
  - 3 tests with various hydrogen / natural gas blends
  - 6 tests with hydrogen
- Combustion system modifications included the hydrogen fuel piping and control system
  - No modifications were made to the burners, regenerators, LNI injectors, or other system components

Parameter	100% Natural Gas	100% Hydrogen
Average Melt Rate (t/h)	5.2	5.7
Average Energy Consumption (kWh/t)	598	571

IN THE MEDIA

Al Circle

Recycled Aluminium News - Technology

Norsk Hydro produces world's first batch of recycled aluminium using green hydrogen

15-Jun-2023 | AlCircle



During a recent test conducted at Hydro's extrusion plant in Navarra, Spain, carbon-free green hydrogen was successfully used as a replacement for natural gas in the recycling of aluminium.

This test, which hydrogen experts from Hydro Havrand led in partnership with Fives, marks the world's first known industrial-scale test of using hydrogen as an energy source in aluminium production.

Hydro Havrand is Hydro's flagship green hydrogen firm, whereas Fives is an industrial engineering organisation with special prowess in aluminium industry solutions and hydrogen burner technology.

The Executive Vice President for Hydro Extrusions, Paul Warton, remarked: "We are excited to be conducting this test, and it demonstrates Hydro's commitment to decarbonisation. By removing the carbon emissions from the energy source, we will be able to produce carbon-free aluminium from recycling post-consumer scrap."

Green hydrogen is a potent emission-free fuel that can replace fossil fuels used in high-temperature heating processes in industries such as aluminium, glass, steel, and cement. The Hydro and Fives collaboration is currently cataloguing and deciphering the test results to gain insights into the effects of fuel switching from natural gas to hydrogen on metal quality and the aluminium melting process. The final report is expected to be ready in the fall.

The Head of Hydro Havrand, Per Christian Eriksen, quoted: "This test is part of developing commercial fuel switch solutions and of demonstrating that hydrogen can be used in aluminium production. Green hydrogen can remove hard-to-abate emissions from fossil fuels in processes where electricity is not an alternative, both in the aluminium industry and in other heavy industries."

Related News

- Aluminium use in North American EVs will grow to 550 PPV by 2...
- Rosatom commissions the creation of aluminium robots to be u...
- LME aluminium benchmark price closes the week with a hike of...

Most Viewed News

- Top 10 aluminium alloy wheel manufacturers in the world
- Top 10 Aluminium Companies in India
- Top five aluminium can manufacturers in the U.S.
- Top five aluminium windows and doors manufacturers in the wo...
- Top Five Aluminium Can Manufacturers in the World

Aluminium International Today

ALUMINIUM INTERNATIONAL TODAY

World's first batch of recycled aluminium using hydrogen fueled production

Published: 15th June, 2023 by Zahra Kazan



Hydro has produced the world's first successful batch of aluminium using green hydrogen as an energy source. The test is another step towards carbon-free aluminium.

Aluminium Insider

Aluminium INSIDER

TECHNOLOGY SUSTAINABILITY FEATURES MARKET SELECTION EXPERTS PARTNERS

BUSINESS / NEWS / EUROPE

Norsk Hydro Smelts First Recycled Aluminium Using Carbon-Free Hydrogen



Source: Norsk Hydro

- Norwegian aluminium producer Norsk Hydro ASA announced this week the smelting of the first batch of recycled aluminium using green hydrogen in history.
- The test, which was carried out at Hydro's plant in Navarra, Spain, utilized carbon-free green hydrogen instead of natural gas to power the experiment. Hydro Havrand, partnered with industrial engineering group Fives to design and conduct the test.
- Paul Warton, Executive Vice President for Hydro Extrusions said in a press release that his firm is highly encouraged at the positive results.

> "We are excited to be conducting this test and it demonstrates Hydro's commitment to decarbonization. By removing the carbon emissions from the energy source, we will be able to produce carbon-free aluminium from recycling post-consumer scrap."

- The test at Navarra this week is the first such test at an industrial scale. Hydro says the test offered valuable data regarding switching from natural gas to hydrogen. Hydro Havrand will continue building out infrastructure for converting its operations to hydrogen, while Hydro and Fives analyze the data and prepare a report due out in the

04 Q&A



fives

Industry can do it

fnac.combustioneu@fivesgroup.com