



# **sCO<sub>2</sub> applications for high grade heat to power conversion**

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ETN October Workshop 2019

Florence, 01/10/2019

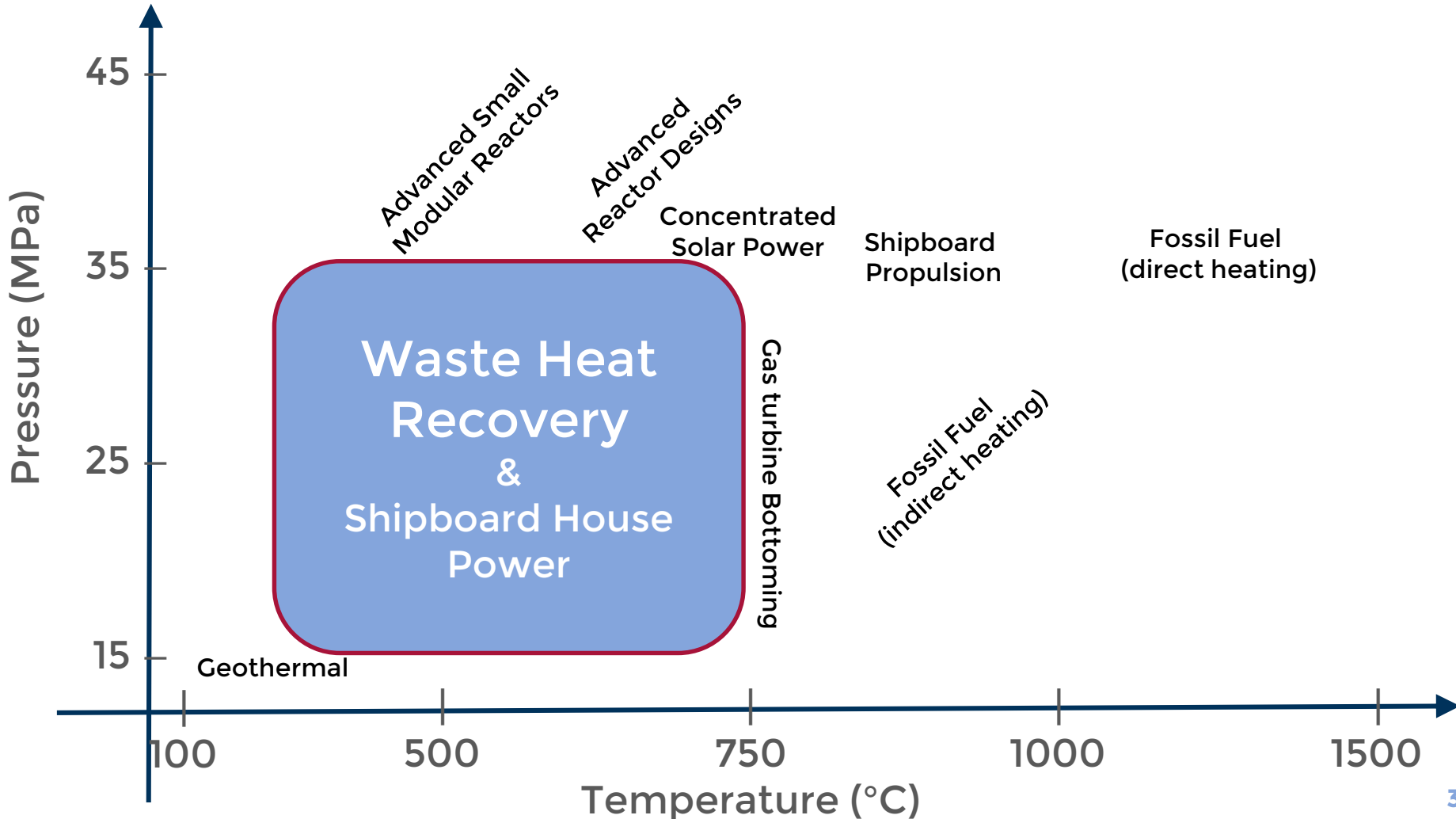
# Outline

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- ▣ Industrial waste heat potential in the EU
  - Iron & steel industry
  - Cement industry
  - Glass industry
- ▣ sCO<sub>2</sub> test rig at Brunel University
- ▣ European sCO<sub>2</sub> R&D Alliance

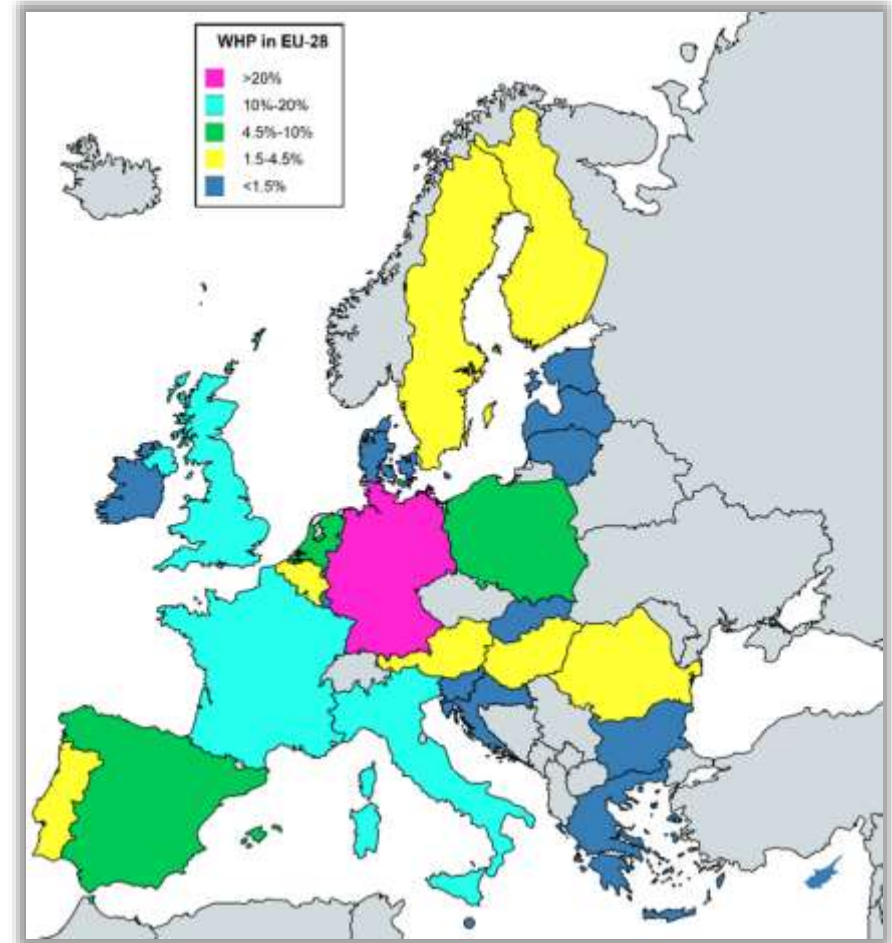
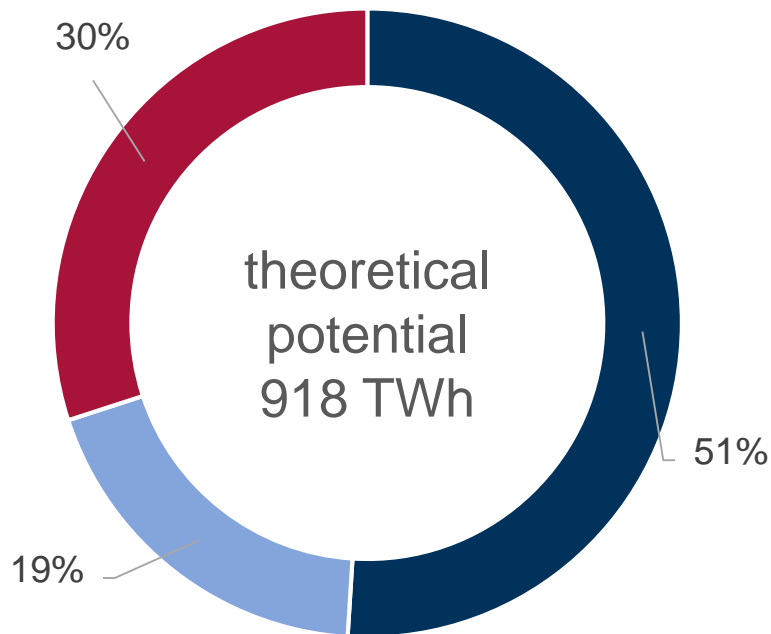
# sCO<sub>2</sub> Potential Applications and Configurations

Adapted from SAND2018-6187



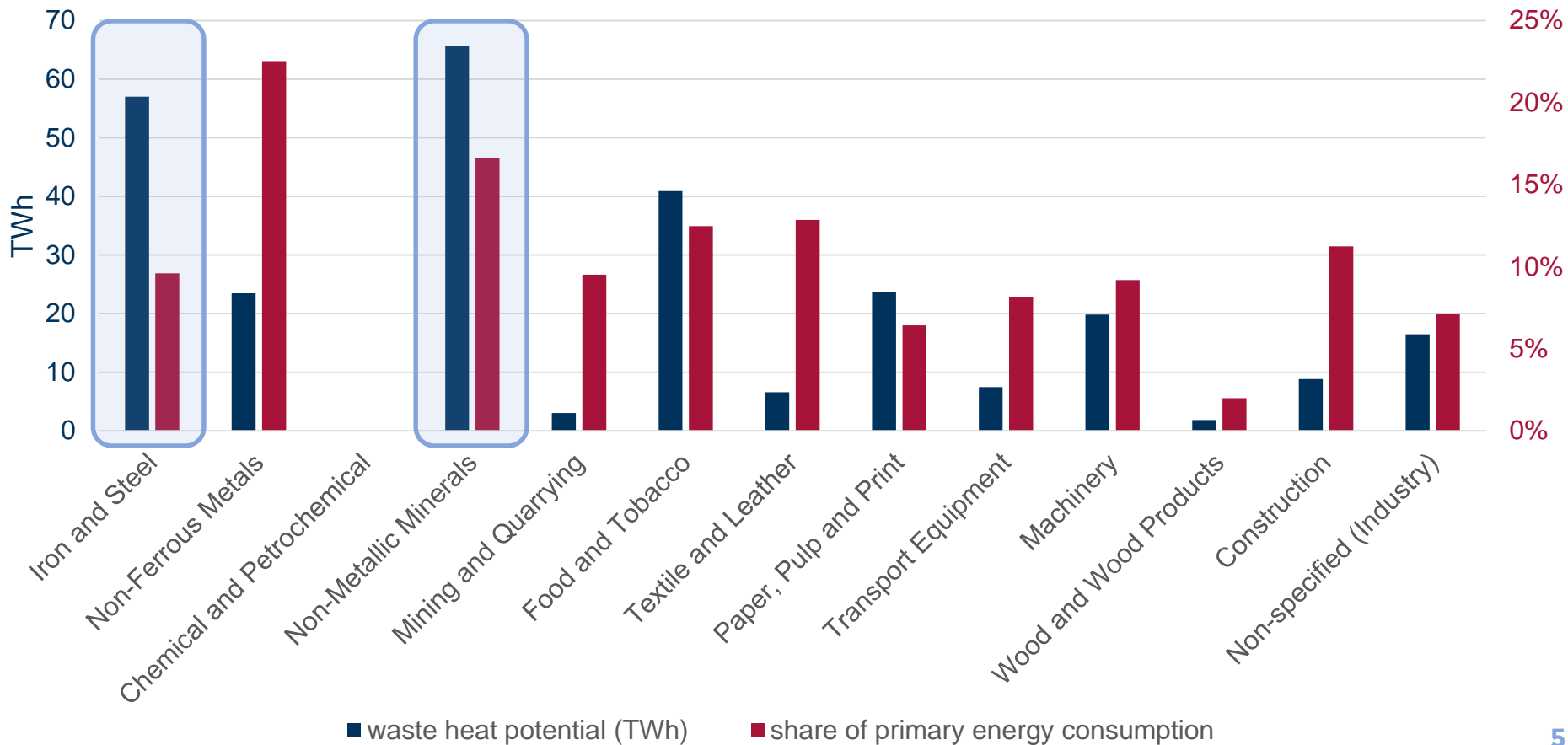
# EU Industrial waste heat potential

■ LT: <100°C ■ MT: 100-300°C ■ HT: >300°C



# High-grade Industrial waste heat

Total 275 TWh = 8.6% of primary energy consumption in EU industry



# 500+

Steel manufacturing plants in the EU

# 19.76 GJ

For each tonne of steel produced

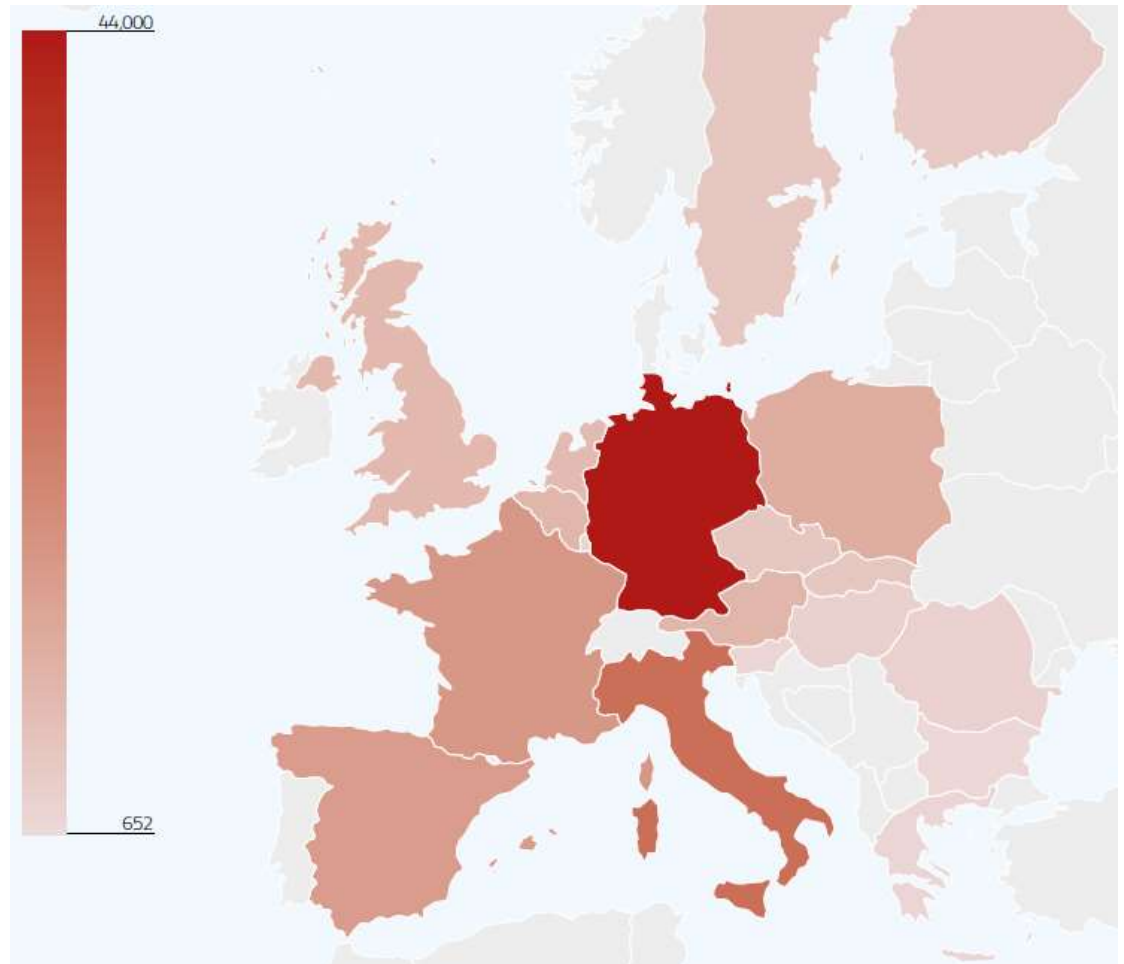
# Up to 40%

Share of total product cost due to energy

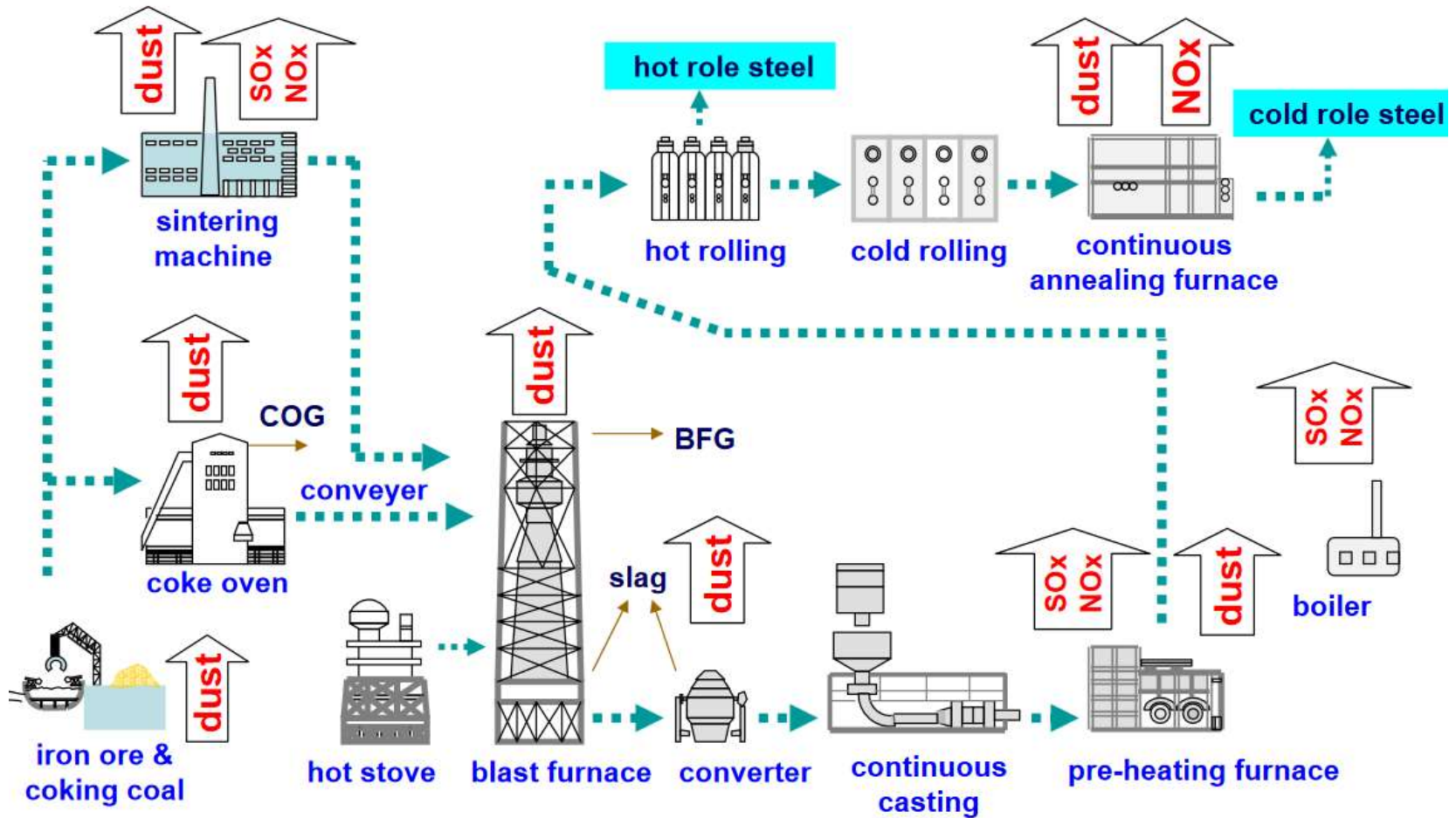
# EU Steel Industry

**The EU steel industry supports nearly 2.5 million jobs**

**The EU steel industry creates around €128 billion of Gross Value Added**

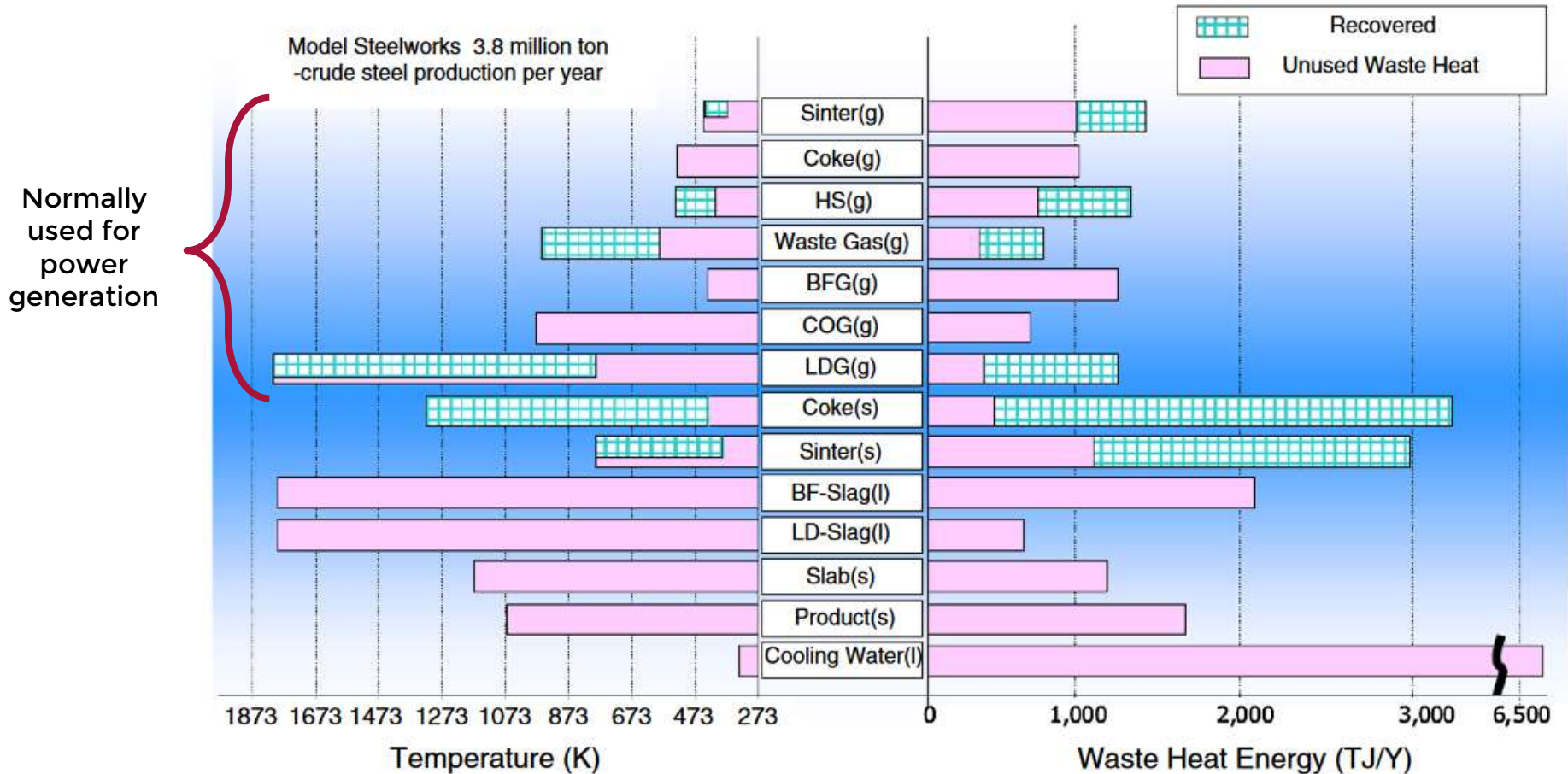


# Overview of steel manufacturing



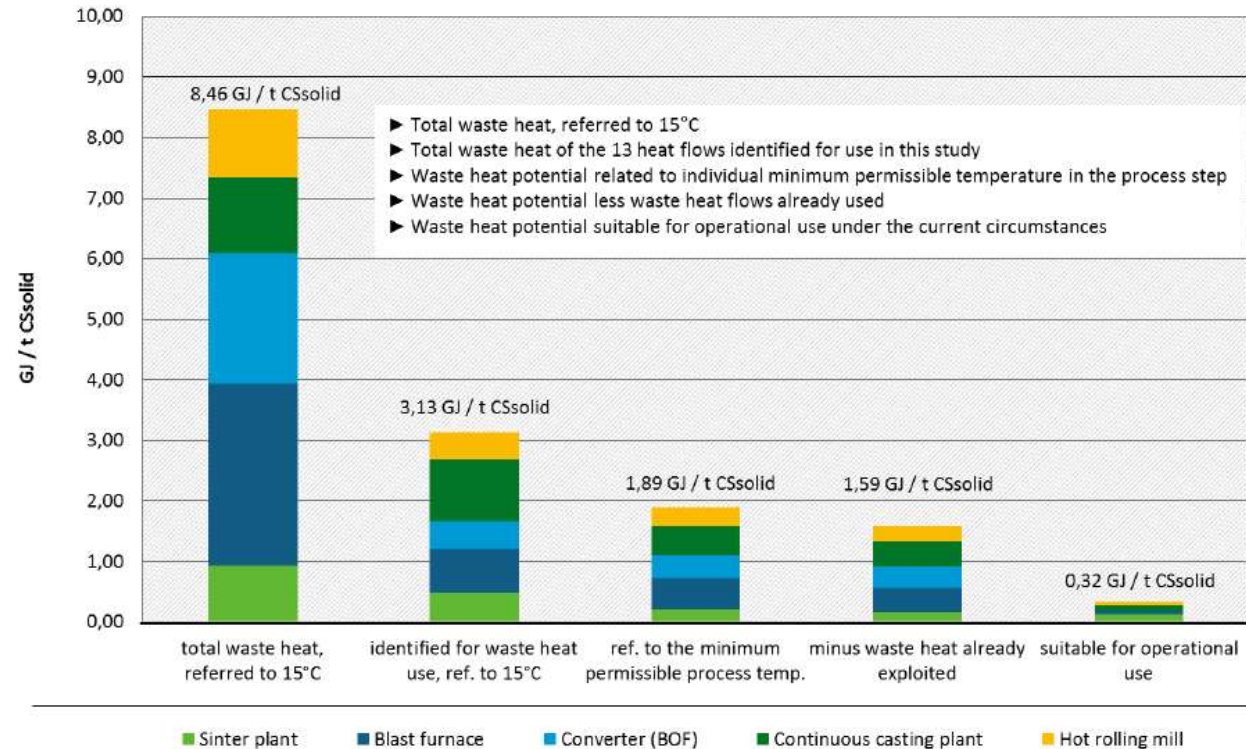


# Waste heat sources in the I&S industry



# Limitations and Barriers

- ❑ Limited space for installation of heat recovery technology
- ❑ Safety concerns
- ❑ Mismatching between demand and supply of the energy recovered
- ❑ Lack of stability in political decision-making make it difficult to calculate the economic efficiency of large-scale production plants.



# 2950

Cement manufacturing plants all over the world  
(257 in EU27)

95 kg of fuel + 110 kWh<sub>el</sub>

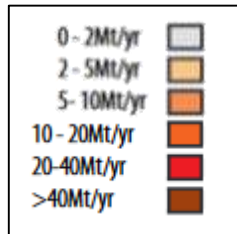
1.25 tonnes of CO<sub>2eq</sub>

For each tonne of cement produced

# 56%

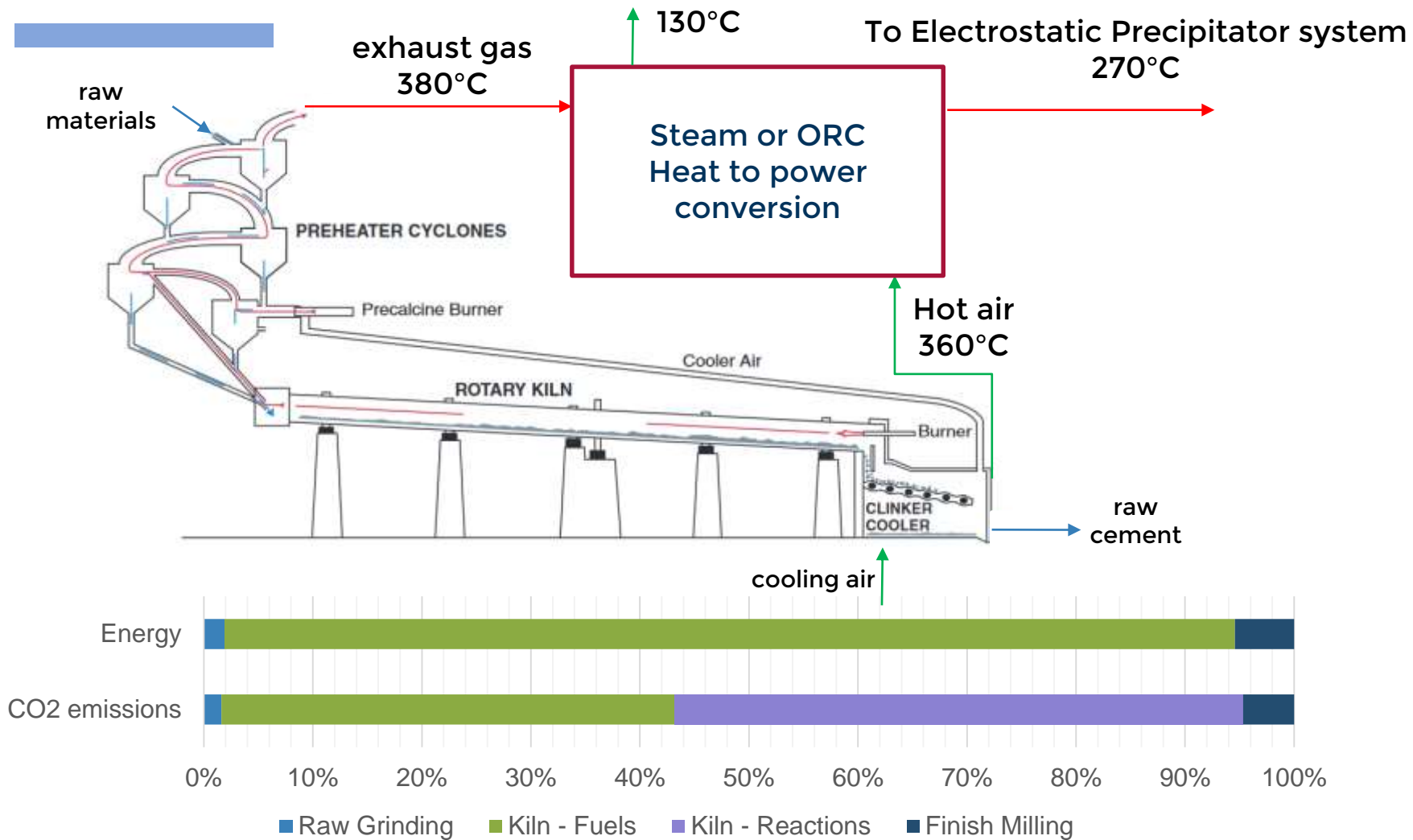
Of the cement fuel mix is still of fossil type

# EU Cement Industry



**The European Cement Industry contributes 1.9% of the annual EU GDP**

# Cement manufacturing



Adapted from: (US DOE, 2003) (Karellas et al. 2013)

# 1500

Class manufacturing plants all over the world

# 24/7 operation

5-12 years between shut-downs

# Up to 15%

Share of total product cost due to energy

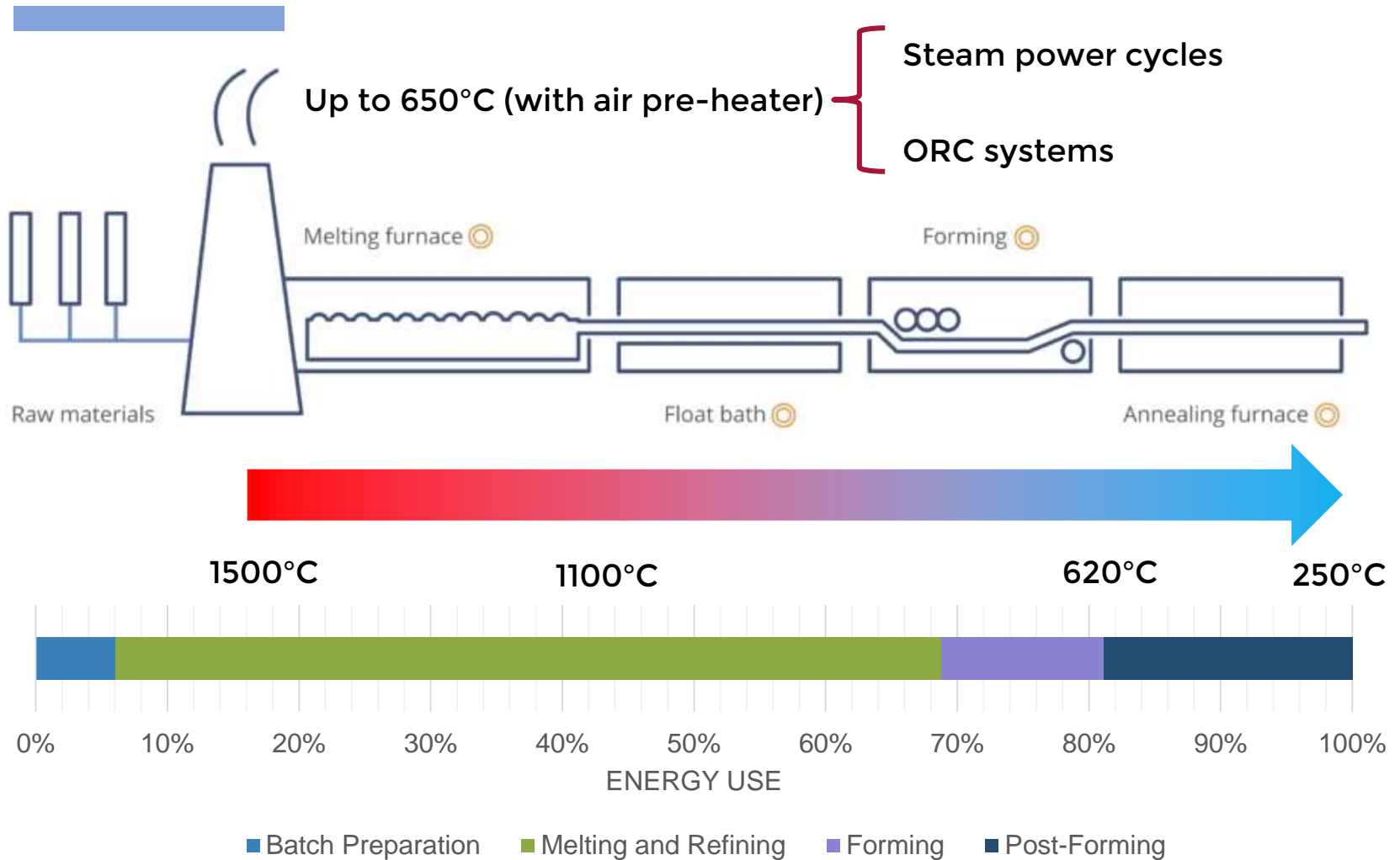
# EU Glass Industry



**The European Glass Industry contributes €9.5 billion to the EU annual GDP**



# Flat glass manufacturing



Adapted from: mptv, US DOE



# The I-ThERM project

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*The Industrial Thermal Energy Recovery Conversion and Management project aims to*

*investigate, design, build and demonstrate innovative plug and play waste heat recovery solutions to facilitate optimum utilisation of energy in selected applications with high replicability and energy recovery potential in the temperature range 70°C - 1000°C*

[www.itherm-project.eu](http://www.itherm-project.eu)

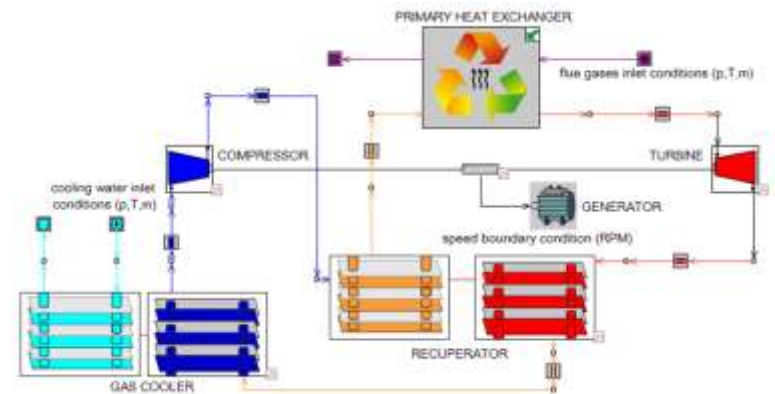
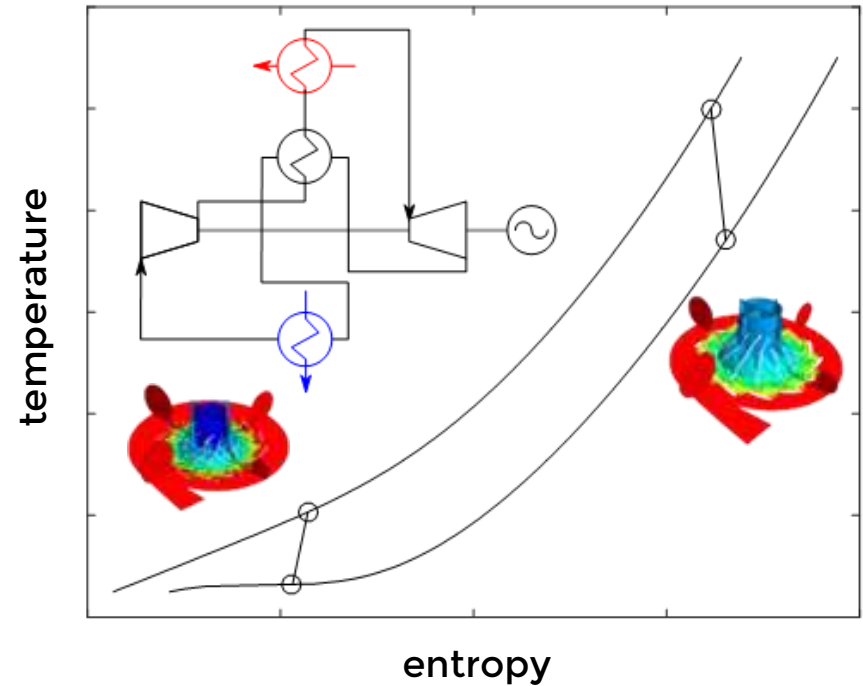


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 680599

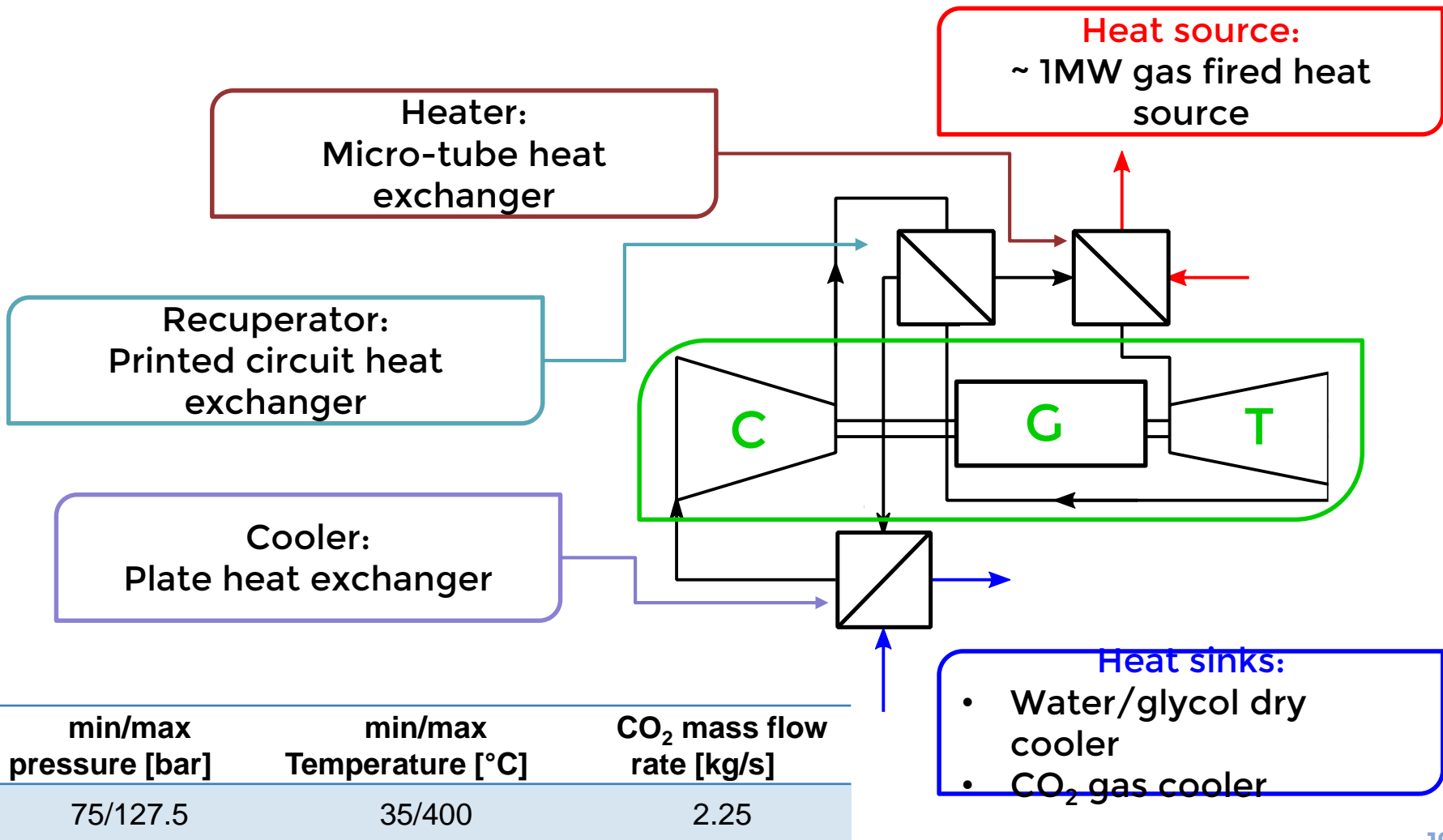


# I-ThERM sCO<sub>2</sub> demonstrator

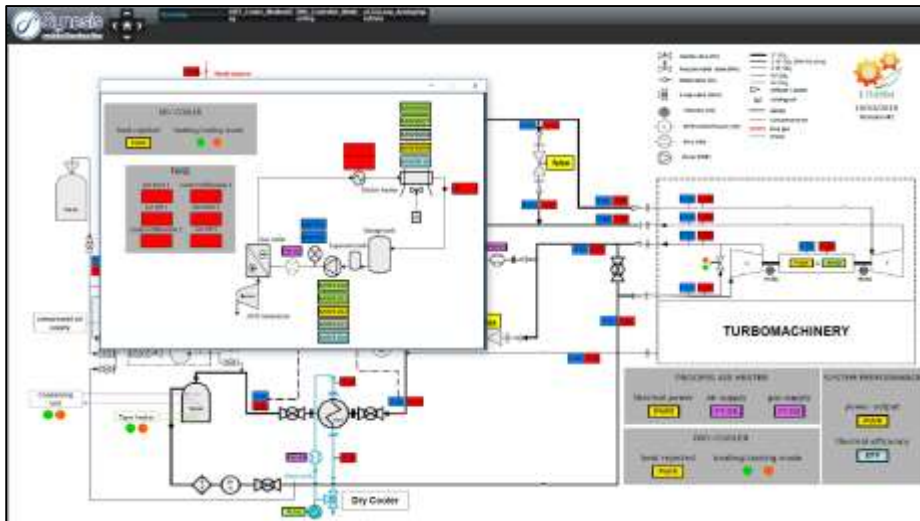
- 1<sup>st</sup> experimental facility in EU academia
- 50 kWe design power output at 20% efficiency
- Simple regenerative layout
- Developed through multi-scale (0D-1D-3D) modelling and control



# I-ThERM sCO<sub>2</sub> demonstrator



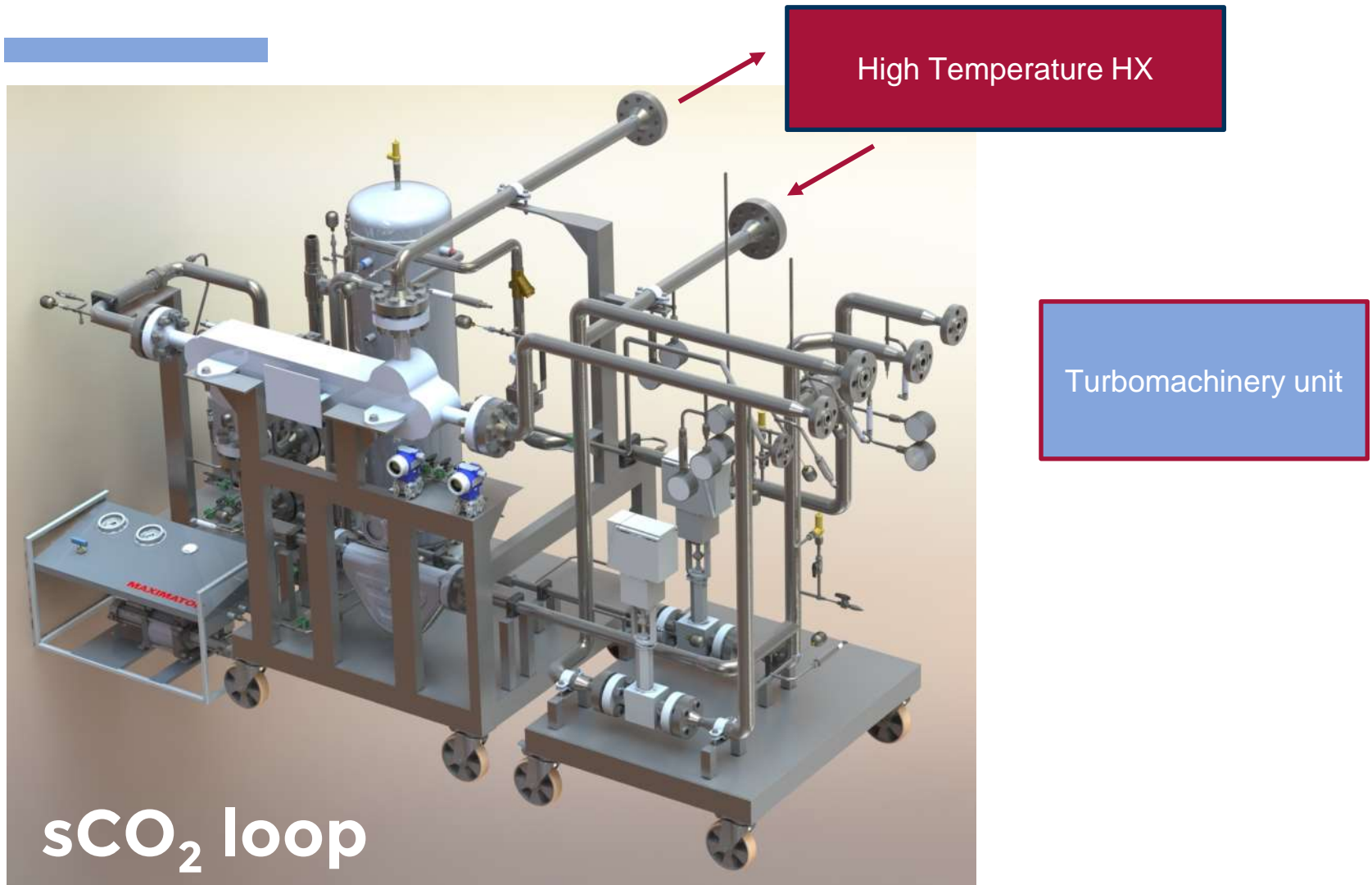
# I-ThERM sCO<sub>2</sub> demonstrator



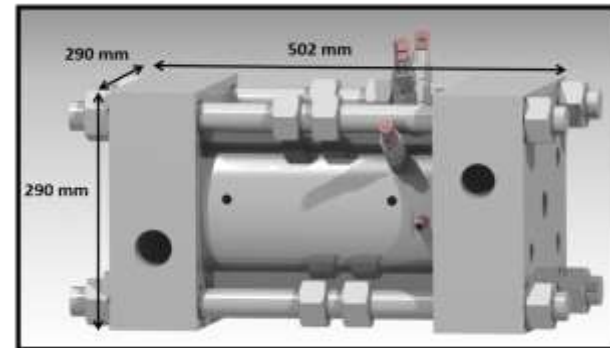
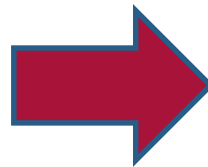
Supervisory system to monitor and control the whole heat to power conversion facility (developed by Synesis Consortium)



# I-ThERM sCO<sub>2</sub> demonstrator



# I-ThERM sCO<sub>2</sub> demonstrator



Single-shaft Compressor-Generator-Turbine unit & ancillaries  
(developed by Enogia SAS)

# sCO<sub>2</sub> Facility Highlights

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- ❑ Pilot-scale test capabilities
- ❑ PED compliant
- ❑ High-accuracy measurement chain
- ❑ Exhaust gas control up to 800°C at 70mbar<sub>g</sub>
- ❑ Power export up to 100kWe
- ❑ Plug&play connections for turbomachinery units and flue gas/sCO<sub>2</sub> heat exchangers

# The European sCO<sub>2</sub> Research & Development Alliance



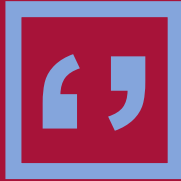
## **Aims and ambitions**

To provide a platform for exchanging knowledge on sCO<sub>2</sub> technologies in the energy sector for academia and industry, as well as to promote this topic in society.

## **Key Objective**

To break the ground to design, build and operate a European sCO<sub>2</sub> research cycle on MW scale. The alliance joins European key actors on sCO<sub>2</sub> technology interested to operate a power cycle in Europe by 2030.





...it is clear that the benefits of transport electrification on climate change mitigation will be greater if EV deployment takes place in parallel with the decarbonisation of power systems.

IEA, Global Electric Vehicle Outlook 2019

# Thanks!

## Any questions?

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