

Waste Heat and Water Recovery from Industrial Flue Gases

By

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PhD, CEng, IntPE, FIMechE, FIEI, FCIBSE, MInstR, SFHEA



Innovate UK



EPSRC
Pioneering research
and skills



cultural

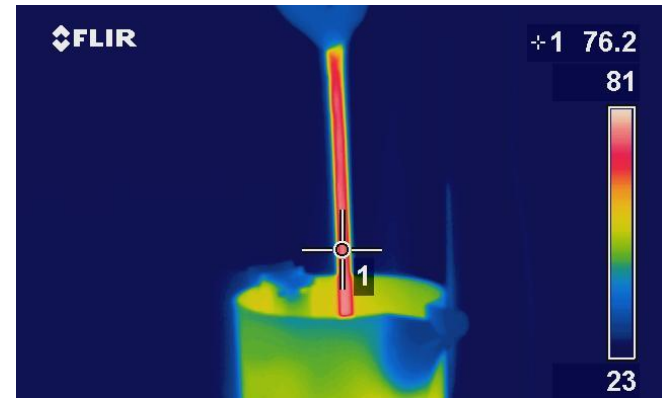
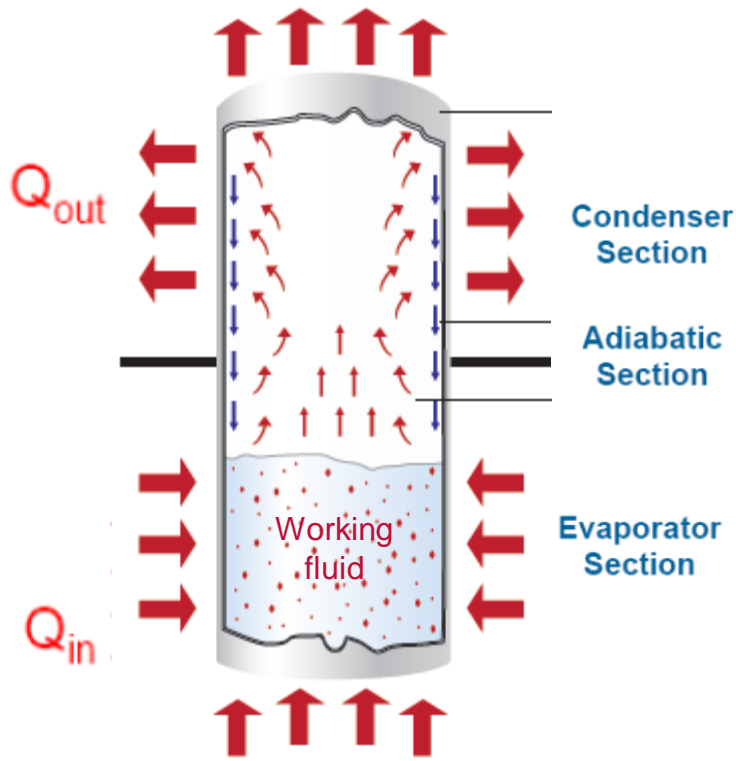


OVERVIEW

- **Heat pipes – What are they**
- **Waste heat recovery systems**
- **Waste heat and water recovery systems**

“Heat Pipes”

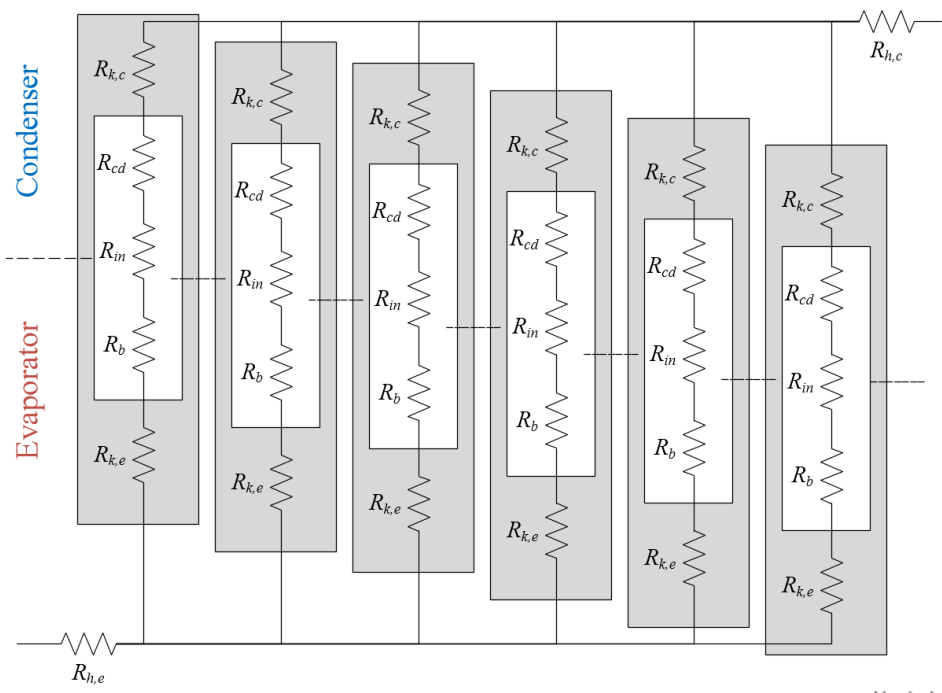
What are they?



Low temperature heat pipe

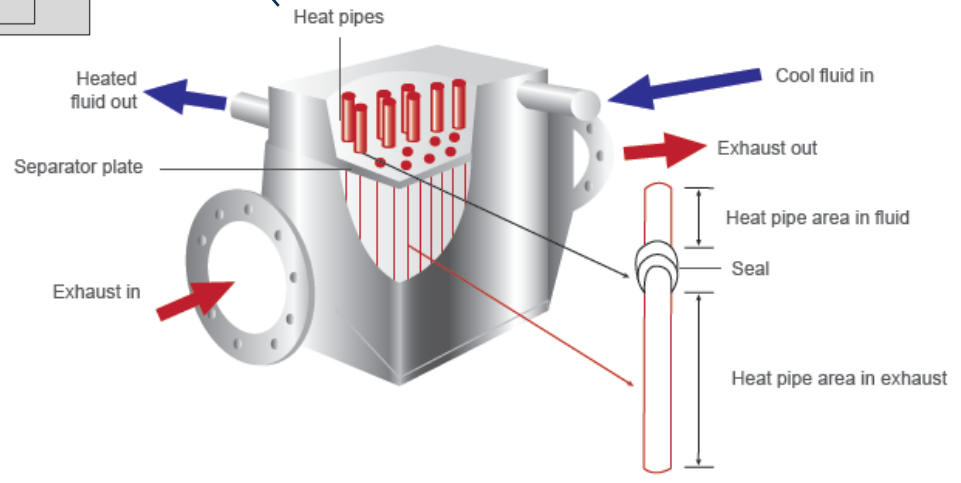


High temperature heat pipe



The heat pipe based system consists of n^* heat exchangers connected in parallel, from thermal point of view.

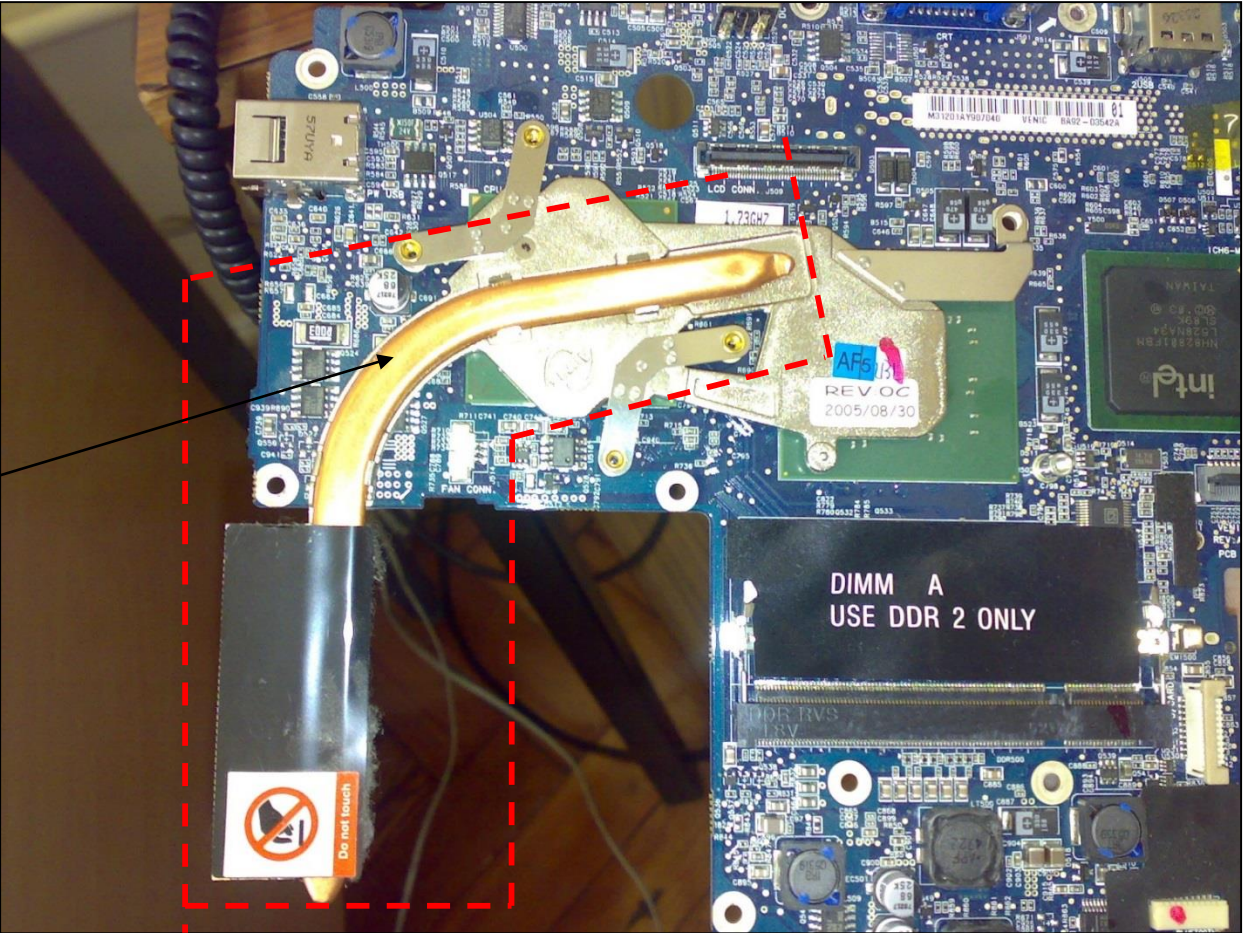
* n : the number of heat pipes in the system



Heat pipe heat exchanger construction

A schematic of a typical heat pipe unit

Heat Pipe





Innovative Waste Heat Recovery Systems

Challenging waste heat recovery scenarios

Many industrial processes generate highly difficult exhaust conditions that can be characterised as follows:

1. High temperatures / mass flows
2. High particulate content that is abrasive and / or can cause fouling
3. Highly corrosive, acidic content SO_2 , SO_3 , NO_2 , etc.





<http://smartrec.eu/>

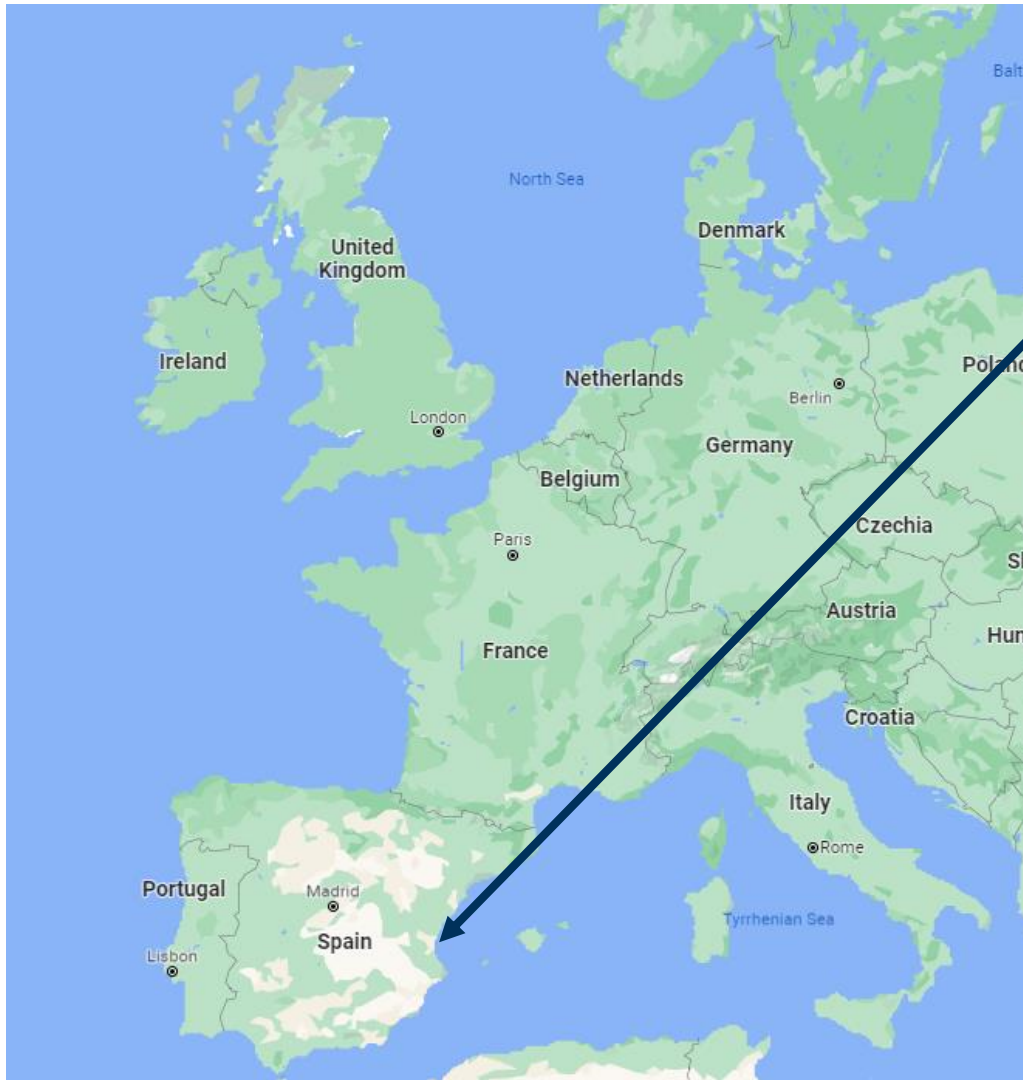
H2020 funding €4.6M
(Brunel's income: €700k)



SMARTREC Waste heat recovery solution



Smartrec



AICE

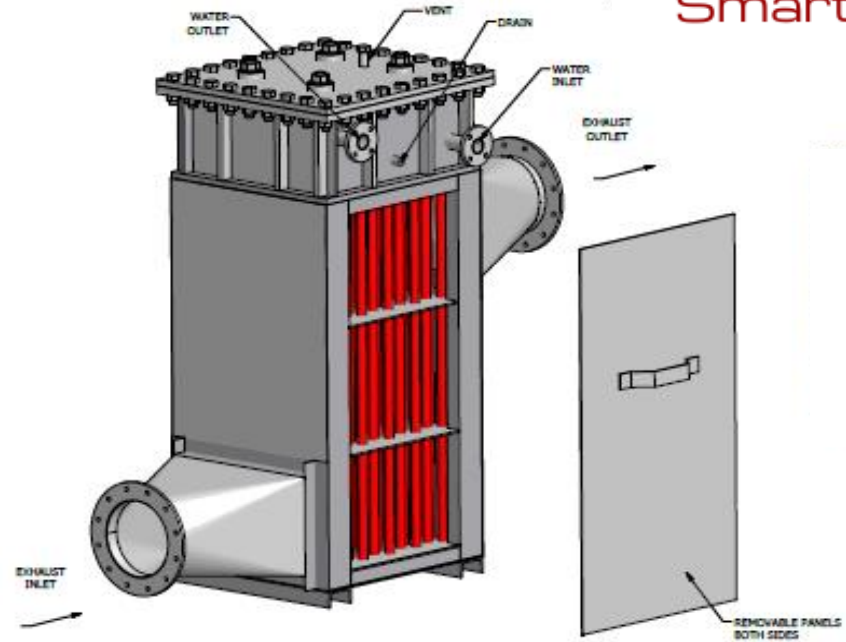


UNIVERSITAT
JAUME I

Ceramic Industry: Manufacture and Installation



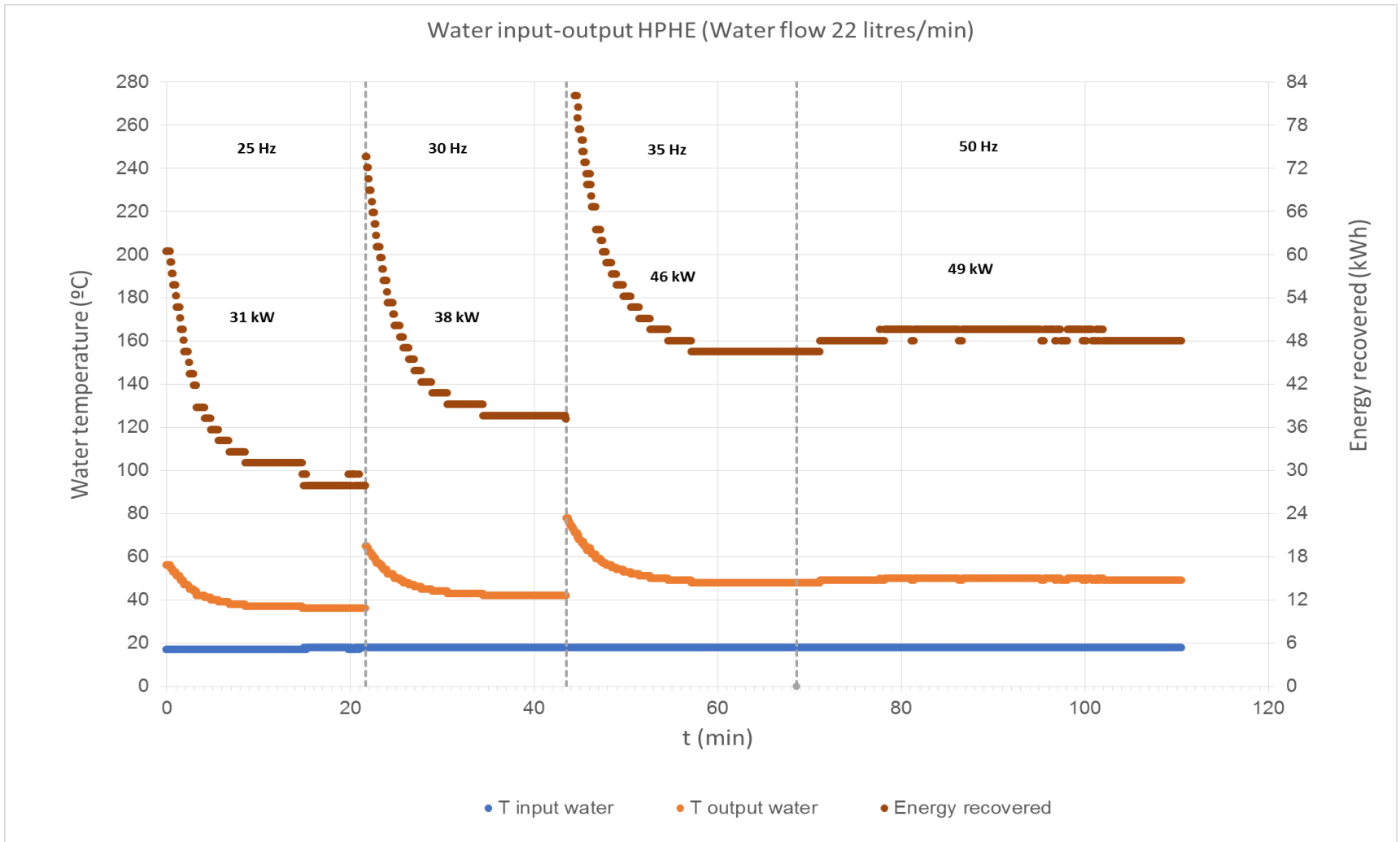
Smartrec



Ceramic Industry: Commissioning and Testing



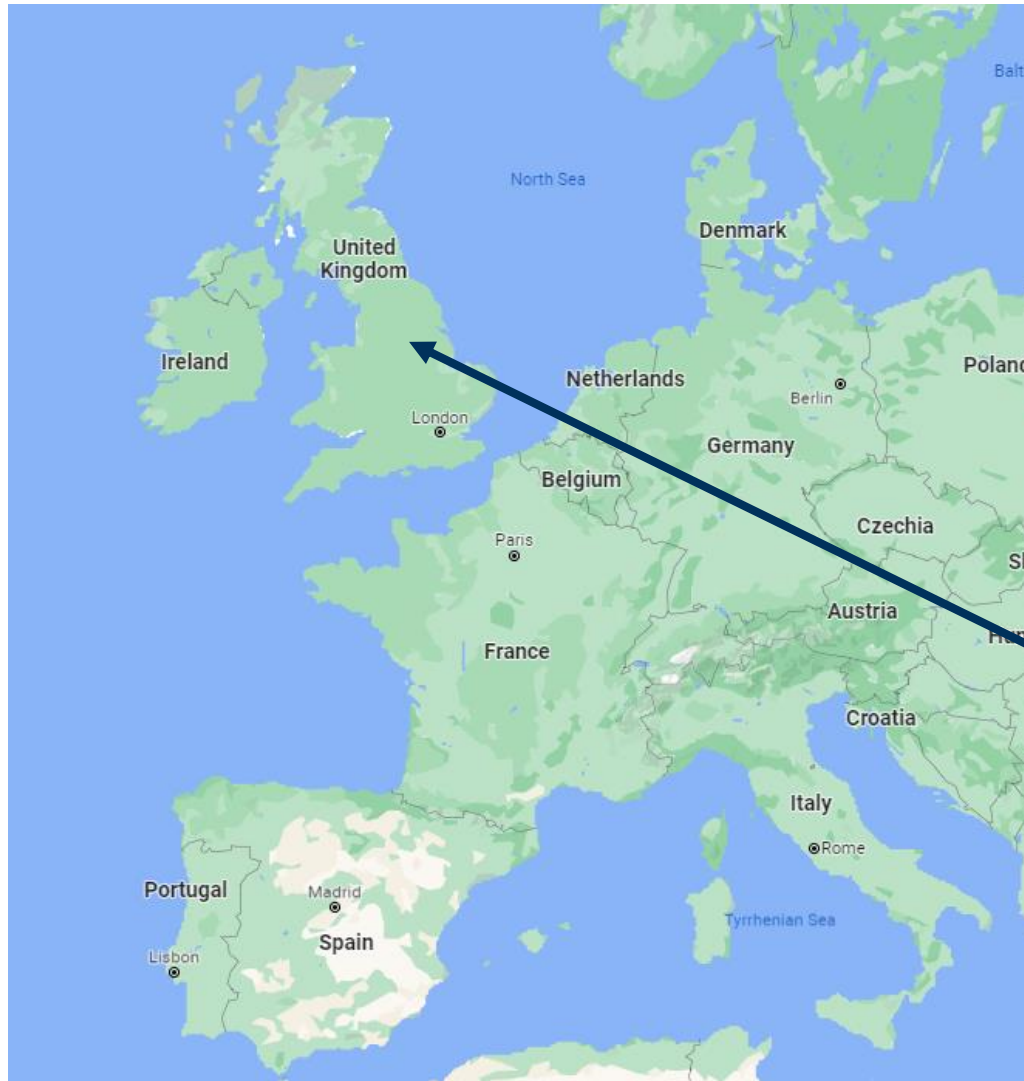
Ceramic Industry: Testing



SMARTREC Waste heat recovery solution



Smartrec

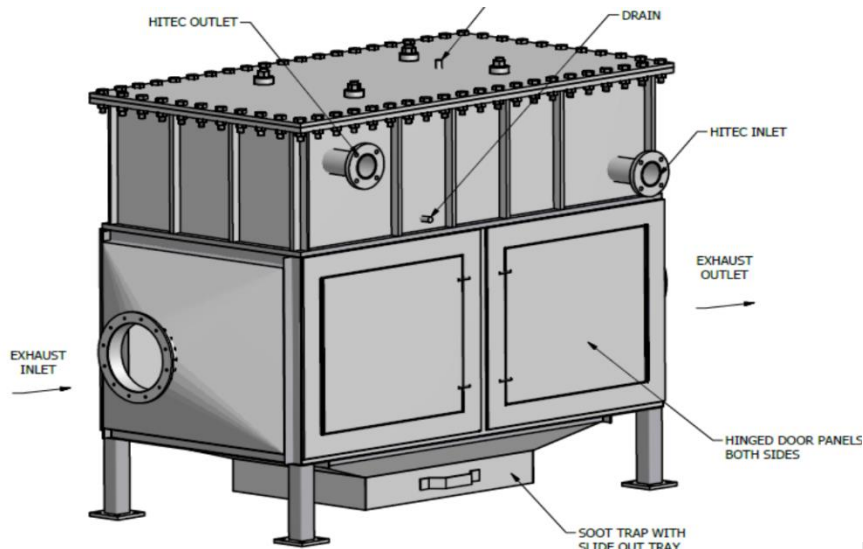


ALTEK
A HARSCO COMPANY

Aluminium Recycling Industry



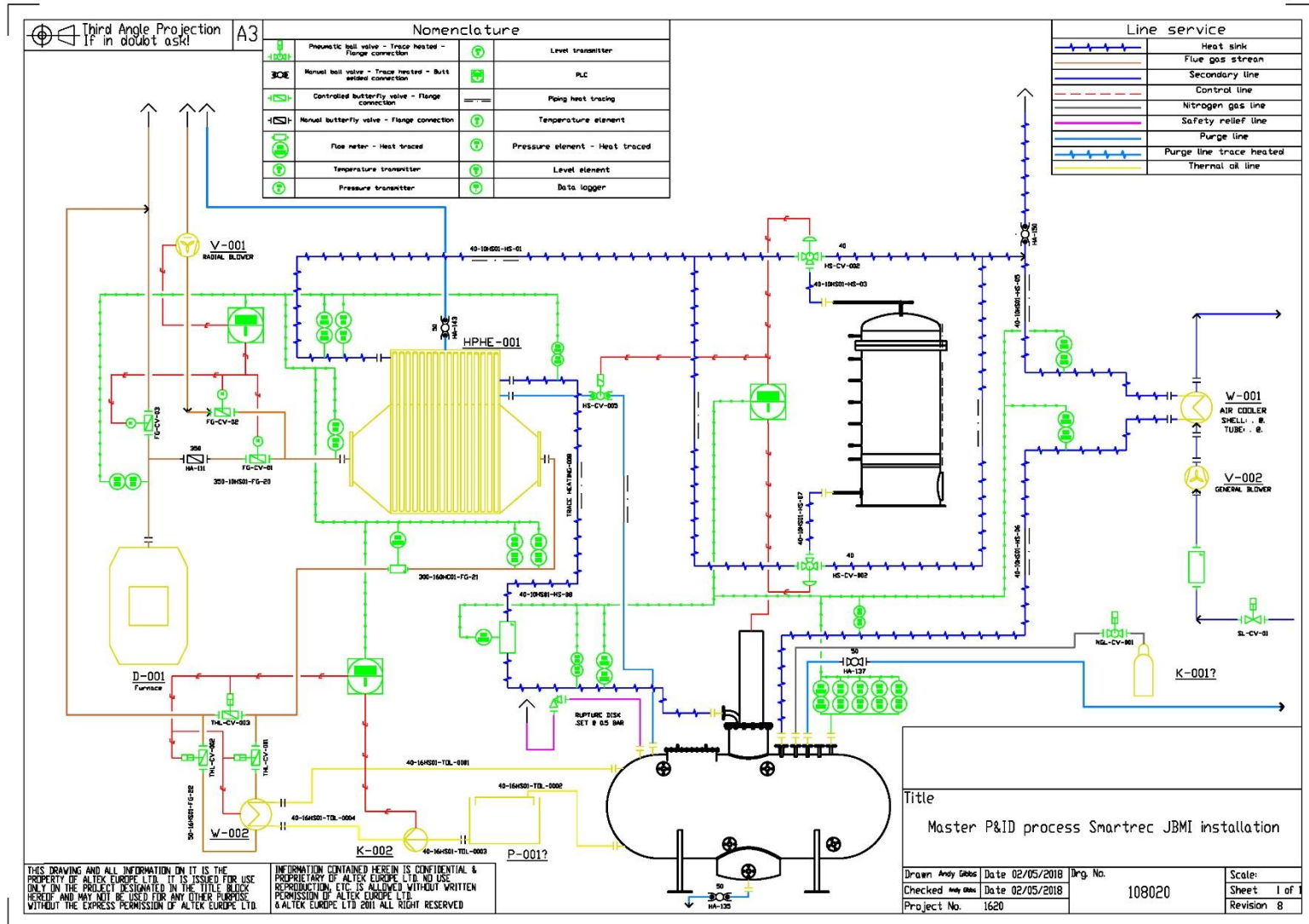
Smartrec



Balance of plant design Process



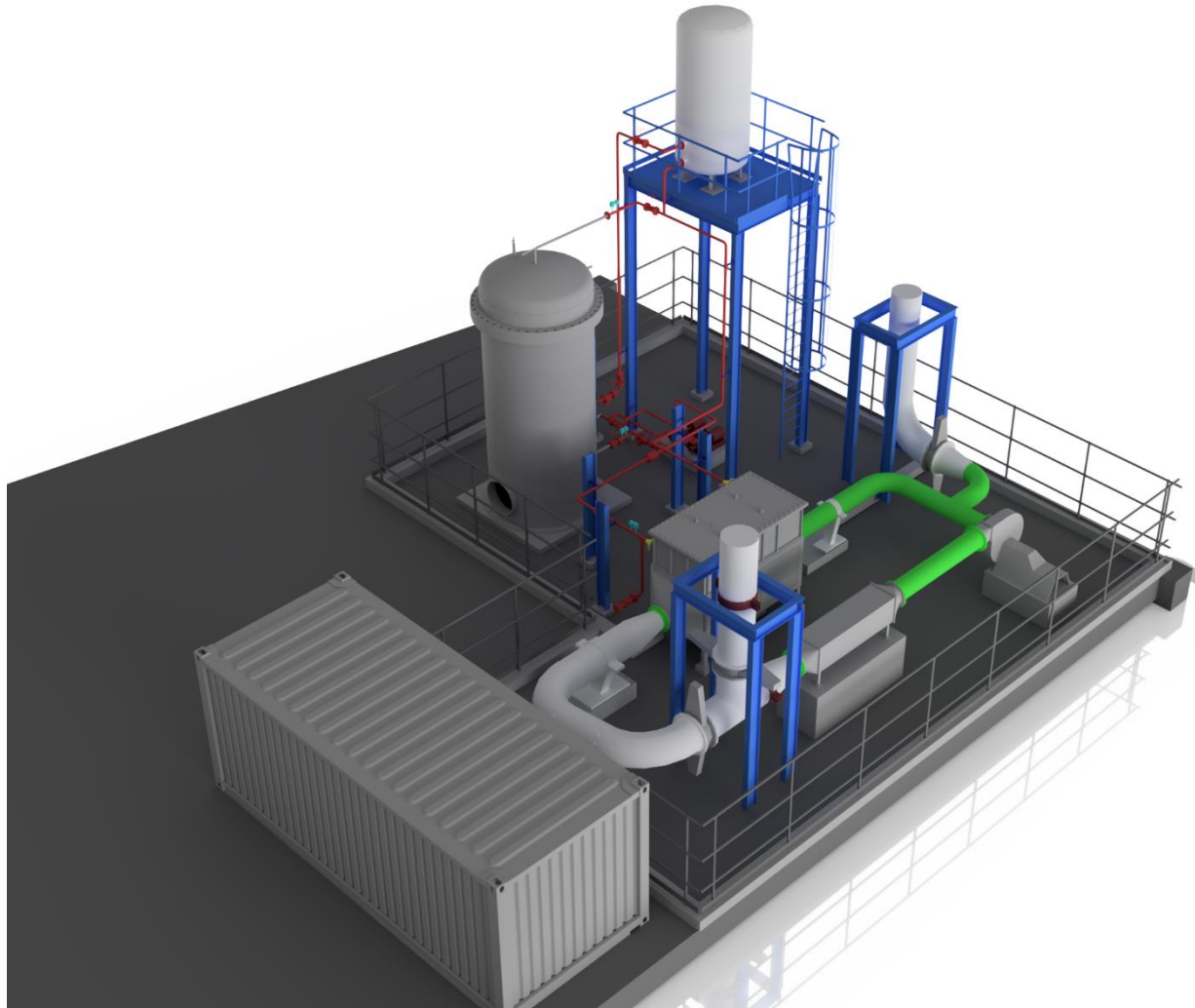
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Smartrec

3D Design option 3, Final



HPHE Installation



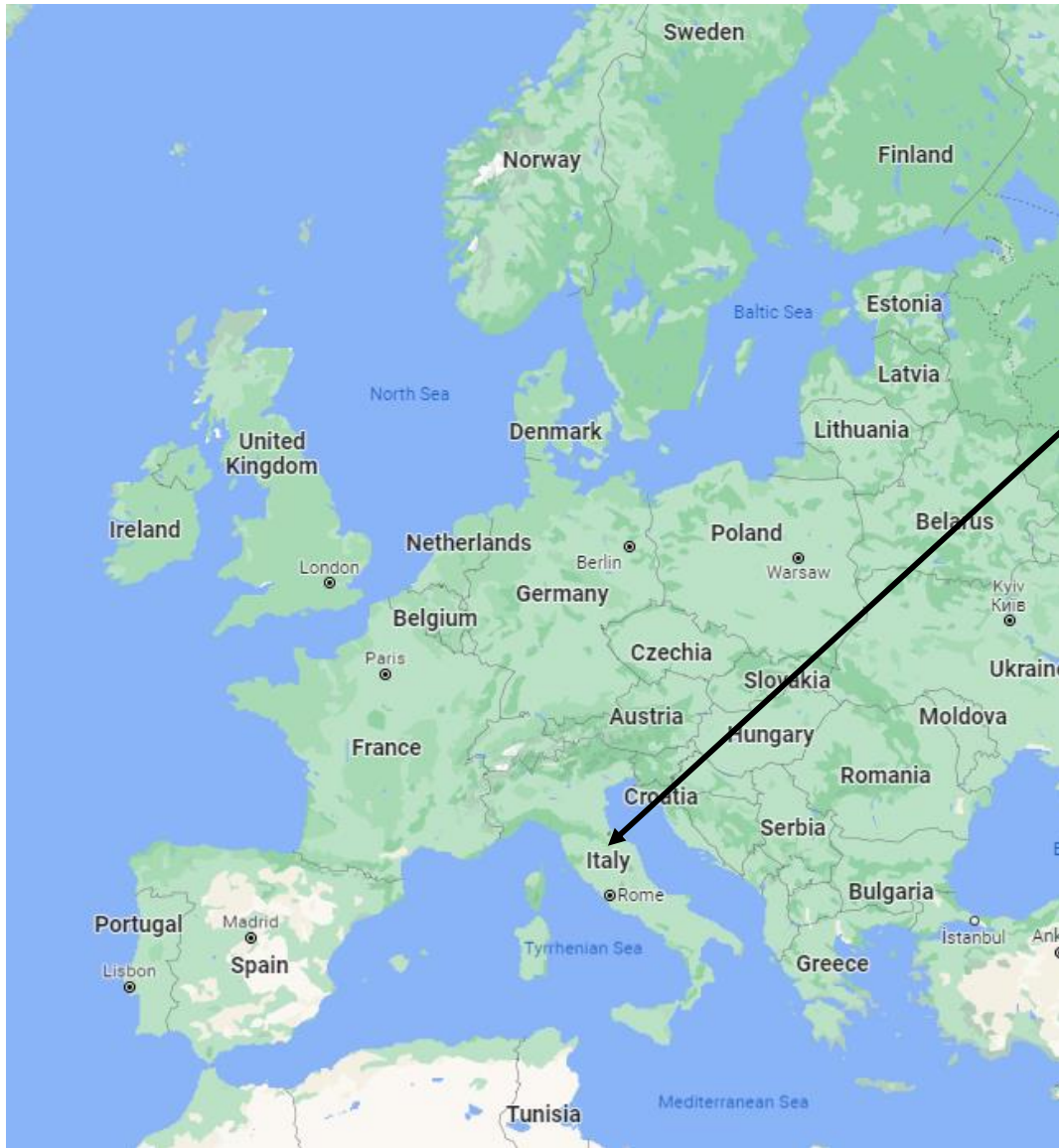


<https://www.spire2030.eu/dream>

H2020 funding €5.1M
Brunel's income: €490k



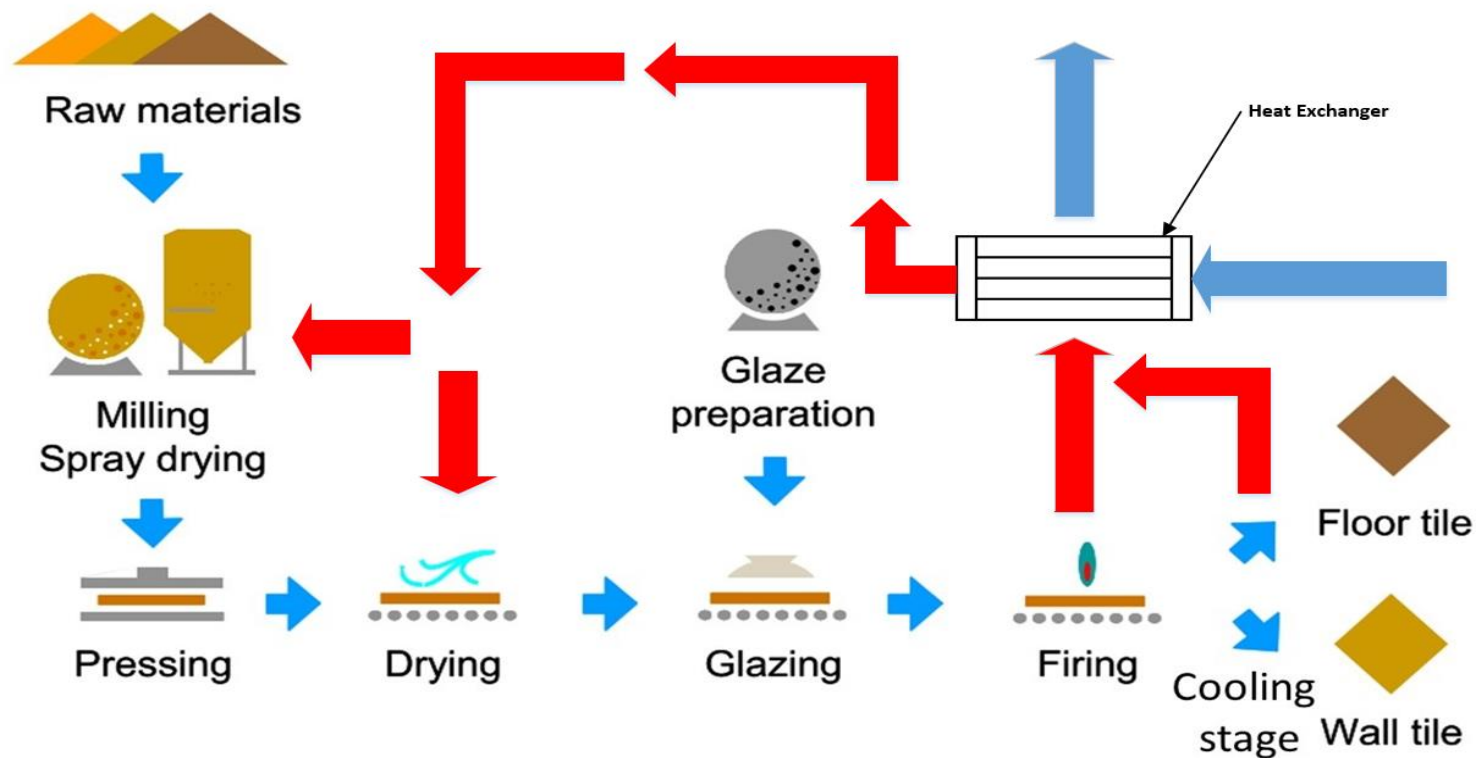
DREAM: Design for Resource and Efficiency in cerAMic kilns



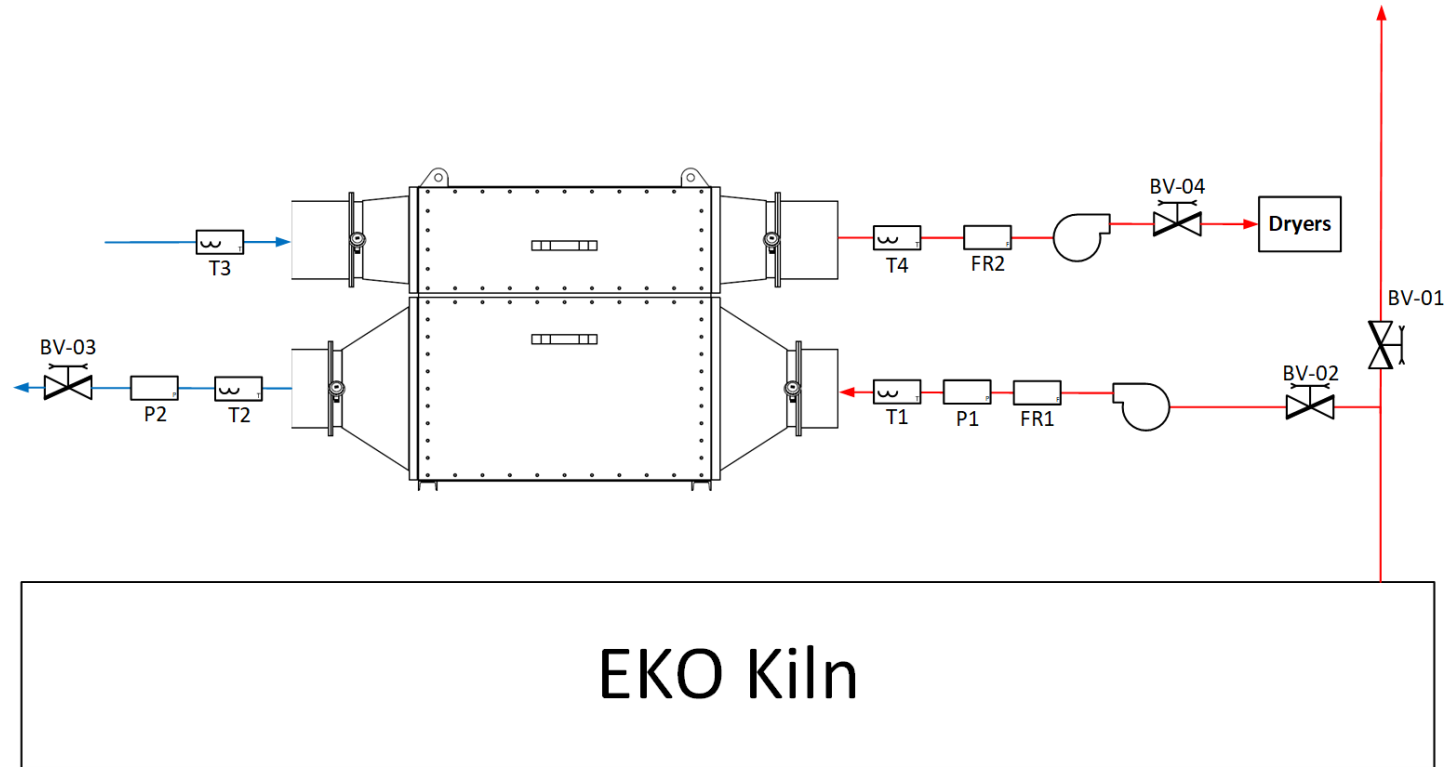
atlas concorde



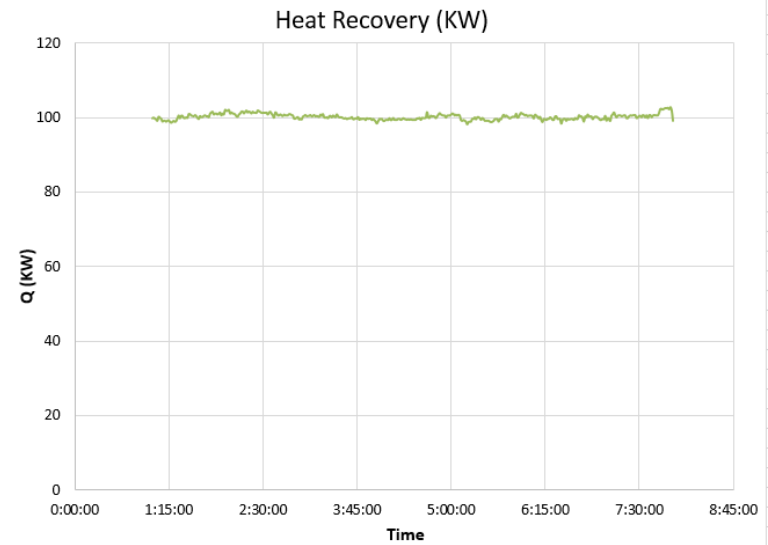
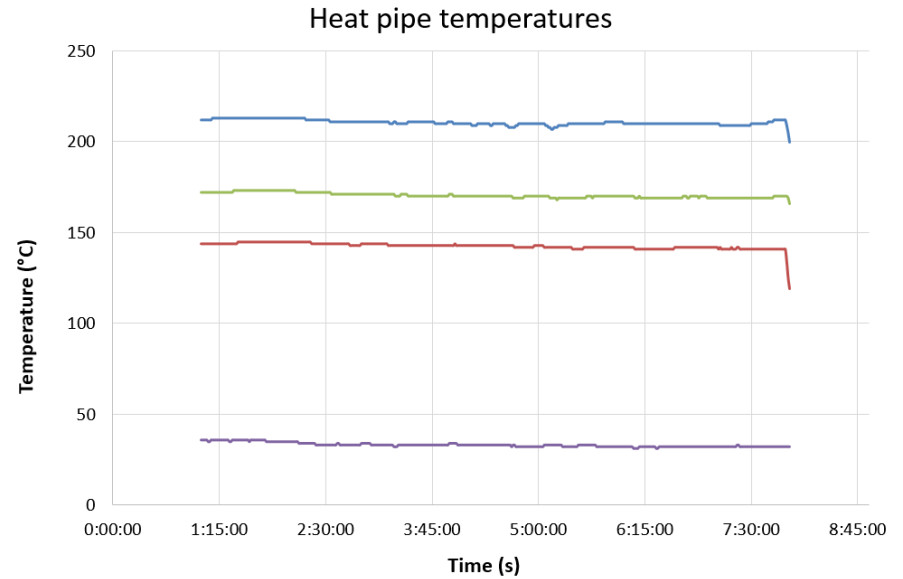
DREAM: Design for Resource and Efficiency in cerAMic kilns



DREAM: Design for Resource and Efficiency in cerAMic kilns



DREAM: Heat Pipe Heat Exchanger installation





ETEKINA

Thermal energy recovery

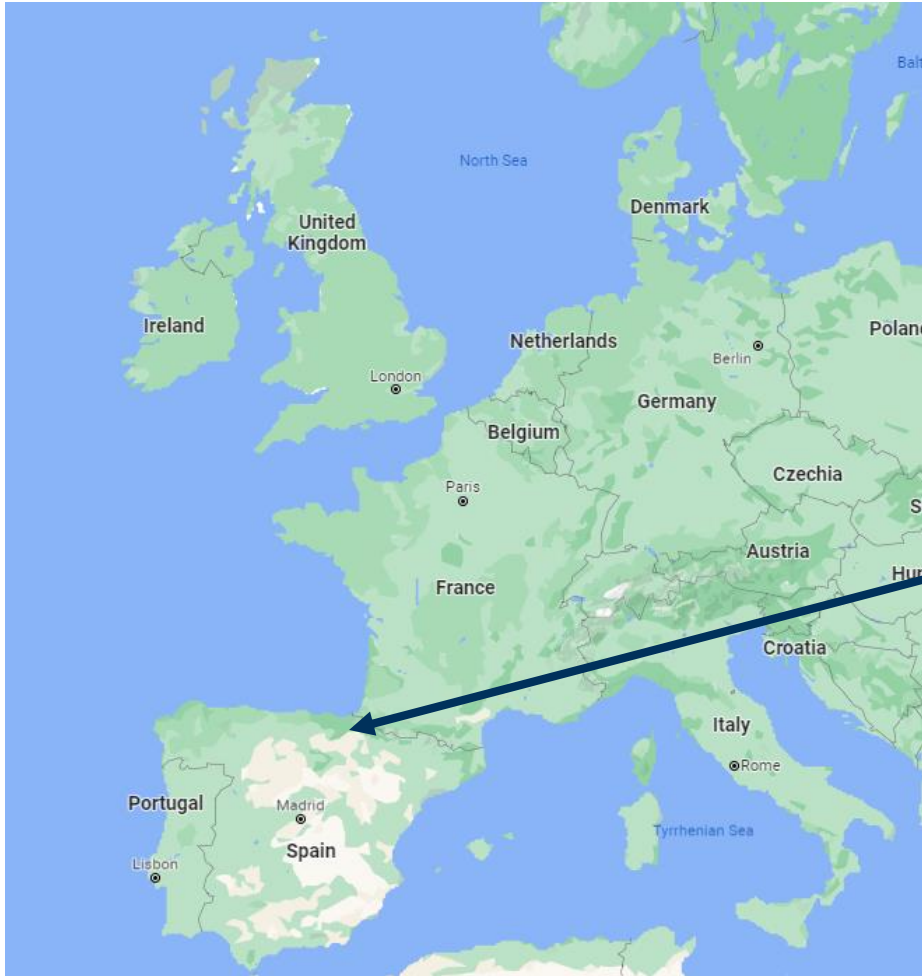
<https://www.etekina.eu/>

H2020 funding €4.6M

Brunel's income: €700k

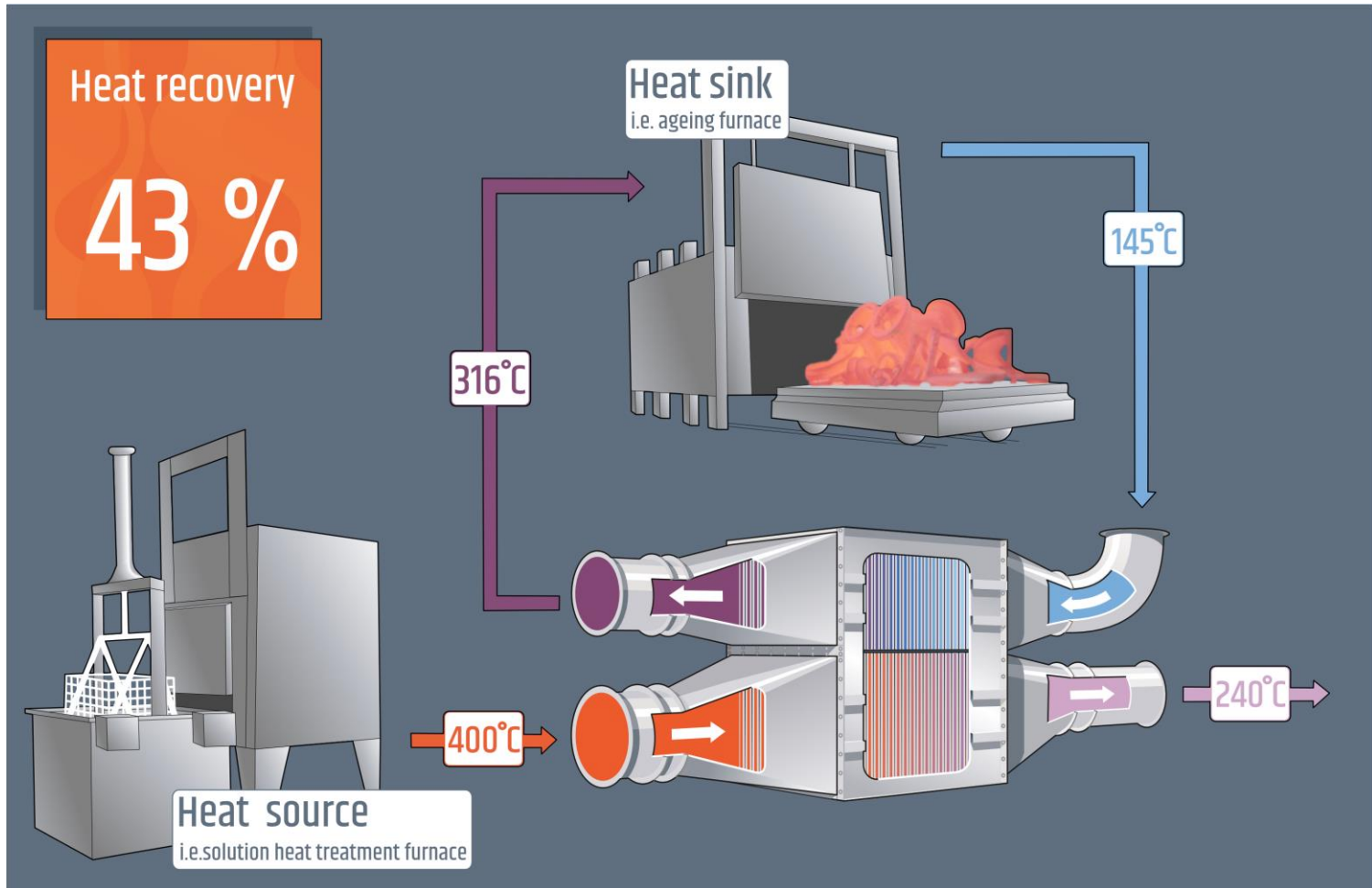


Aluminium industrial installation

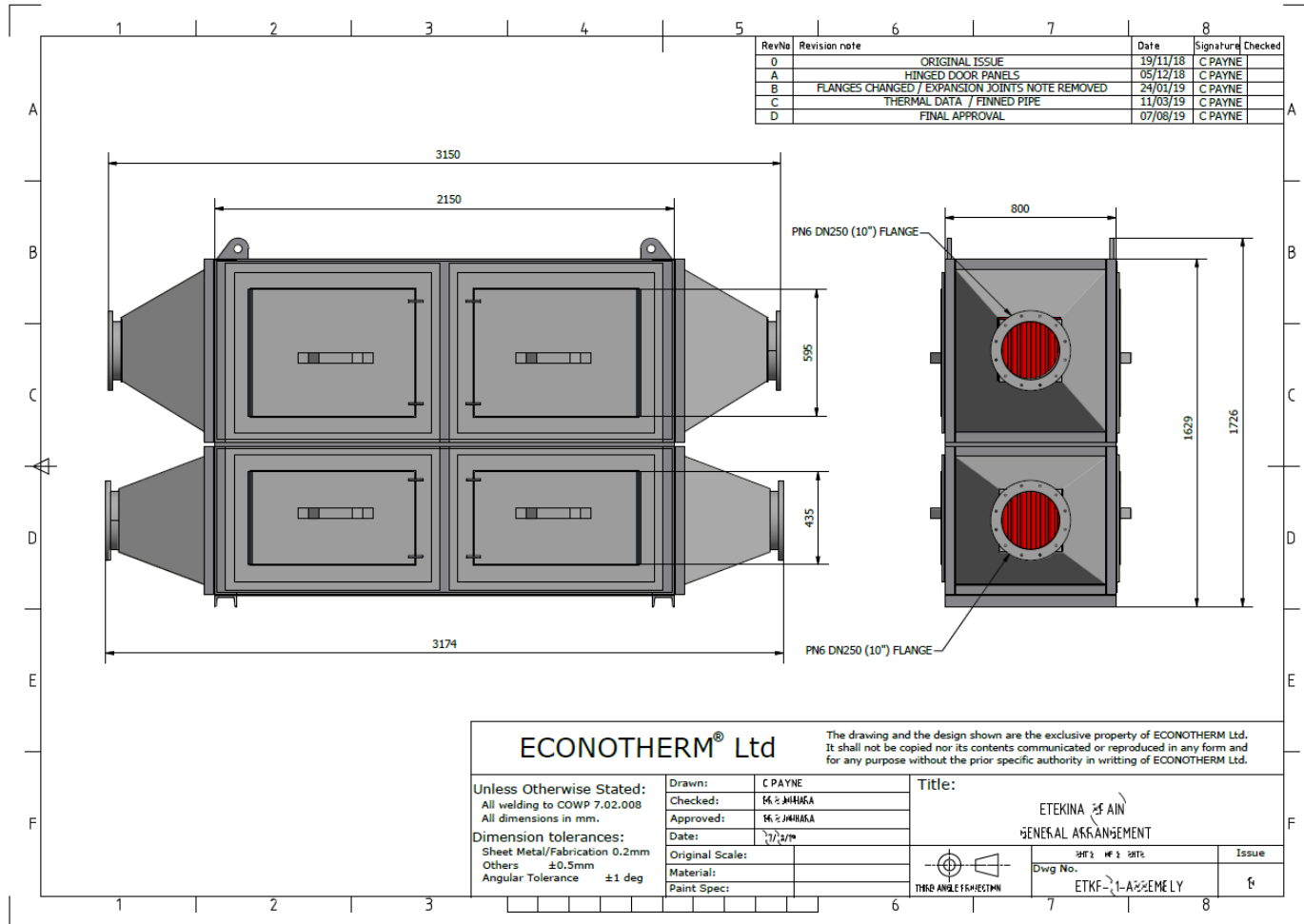


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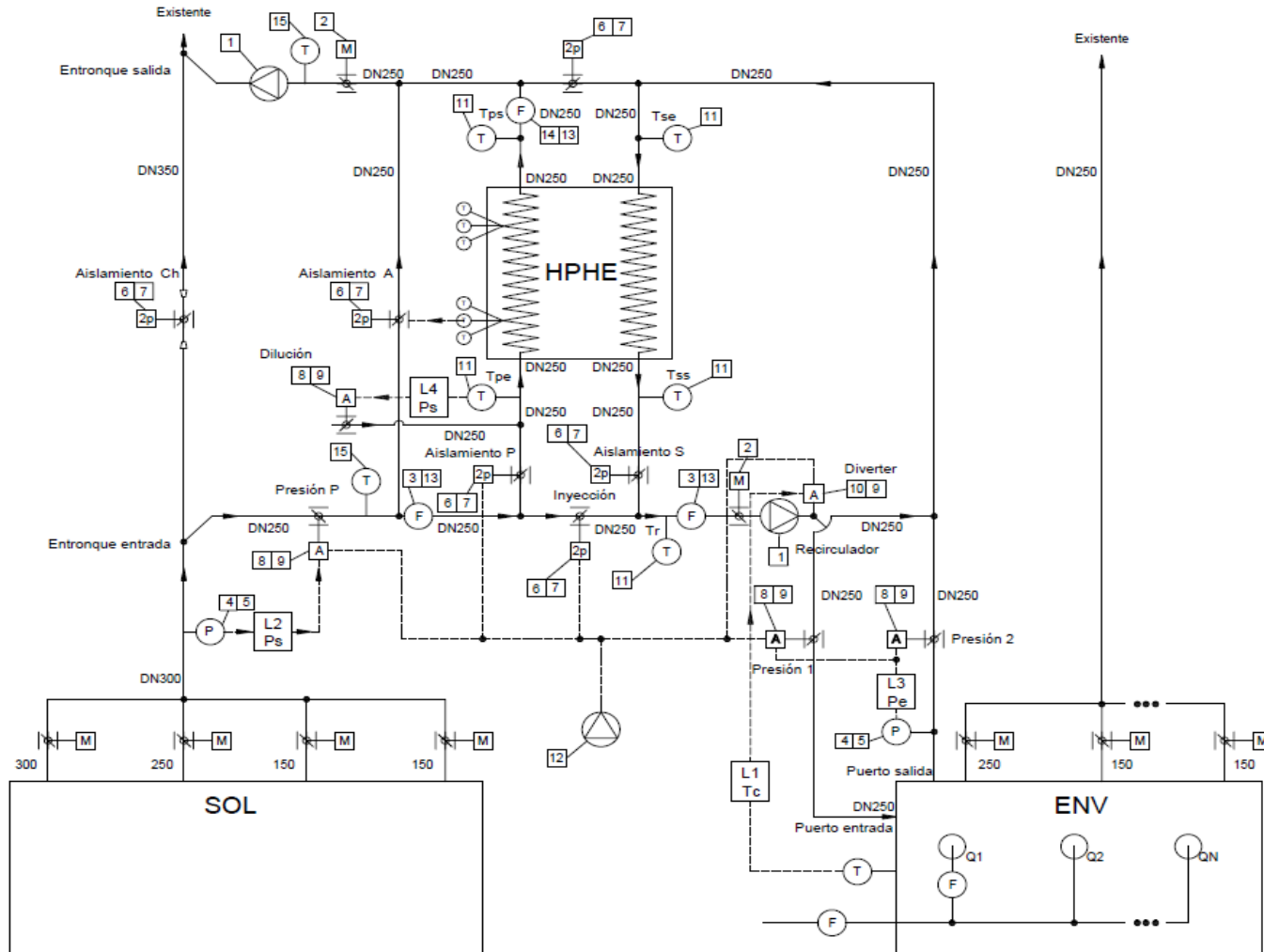
Aluminium Industrial installation



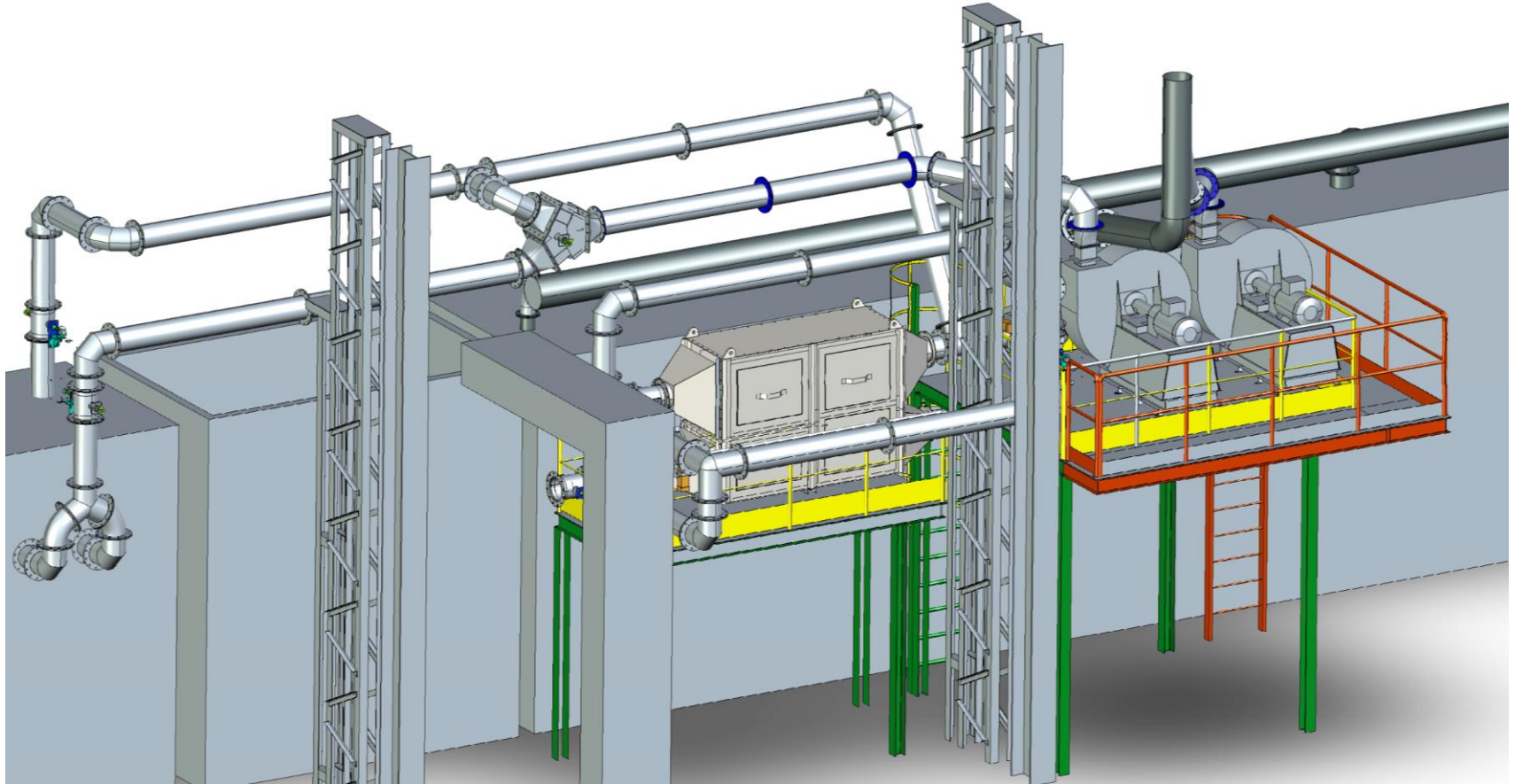
Aluminium Industry Thermal and Mechanical Design



Aluminium Industry Piping and Instrumentation Diagram



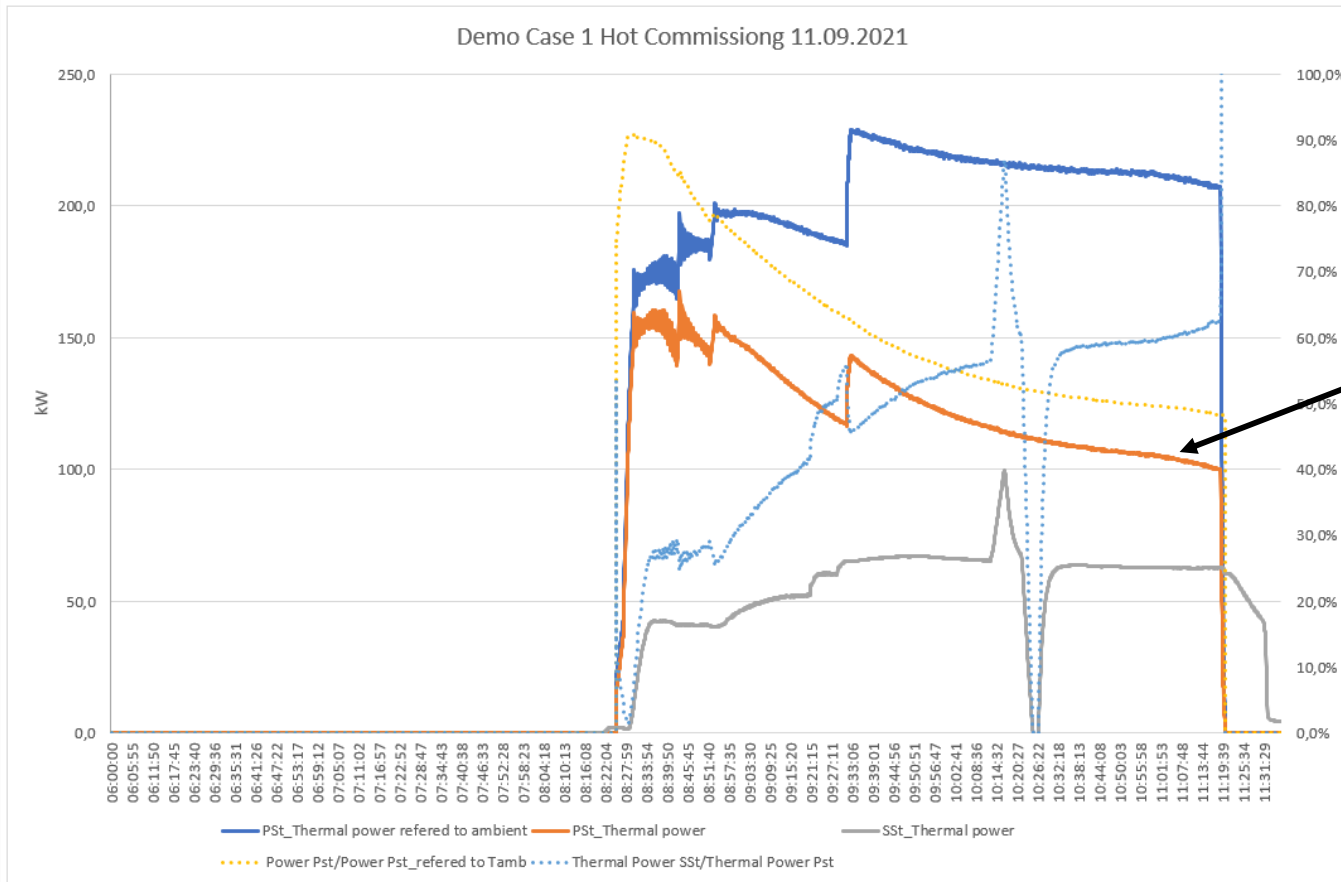
Aluminium Industry 3D Representation



Aluminium Industry, Commissioning



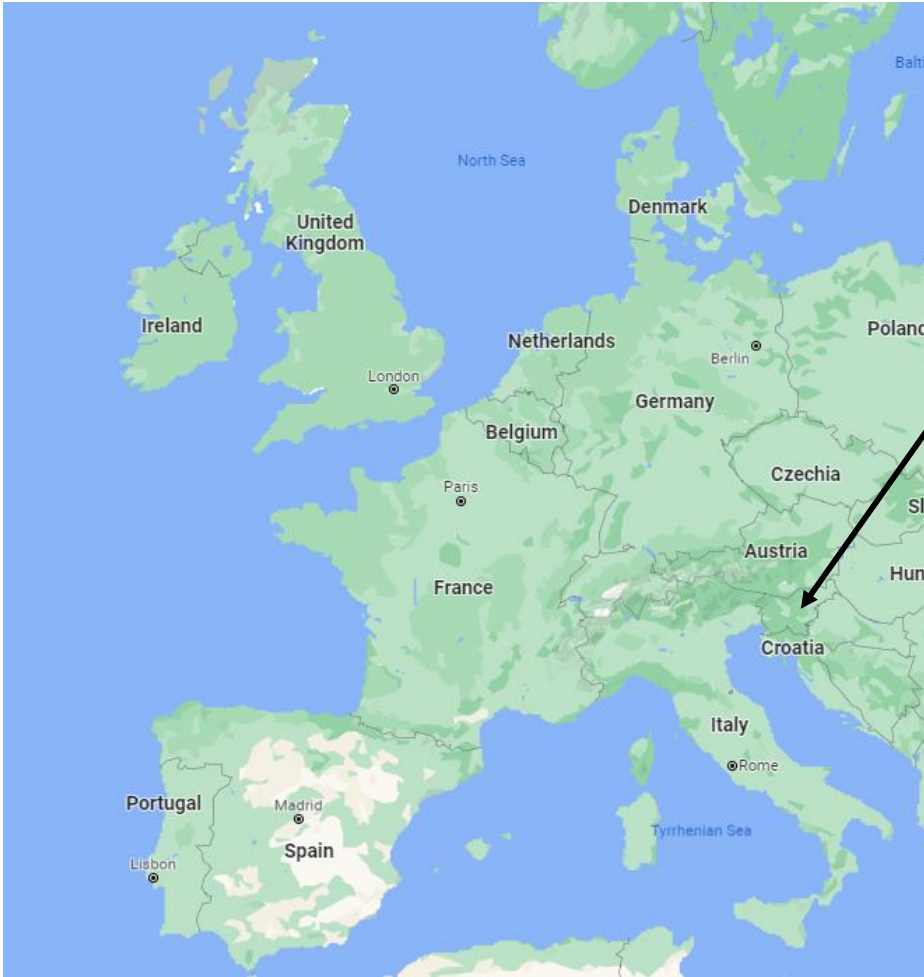
Aluminium Industry Results



100 kW heat recovery

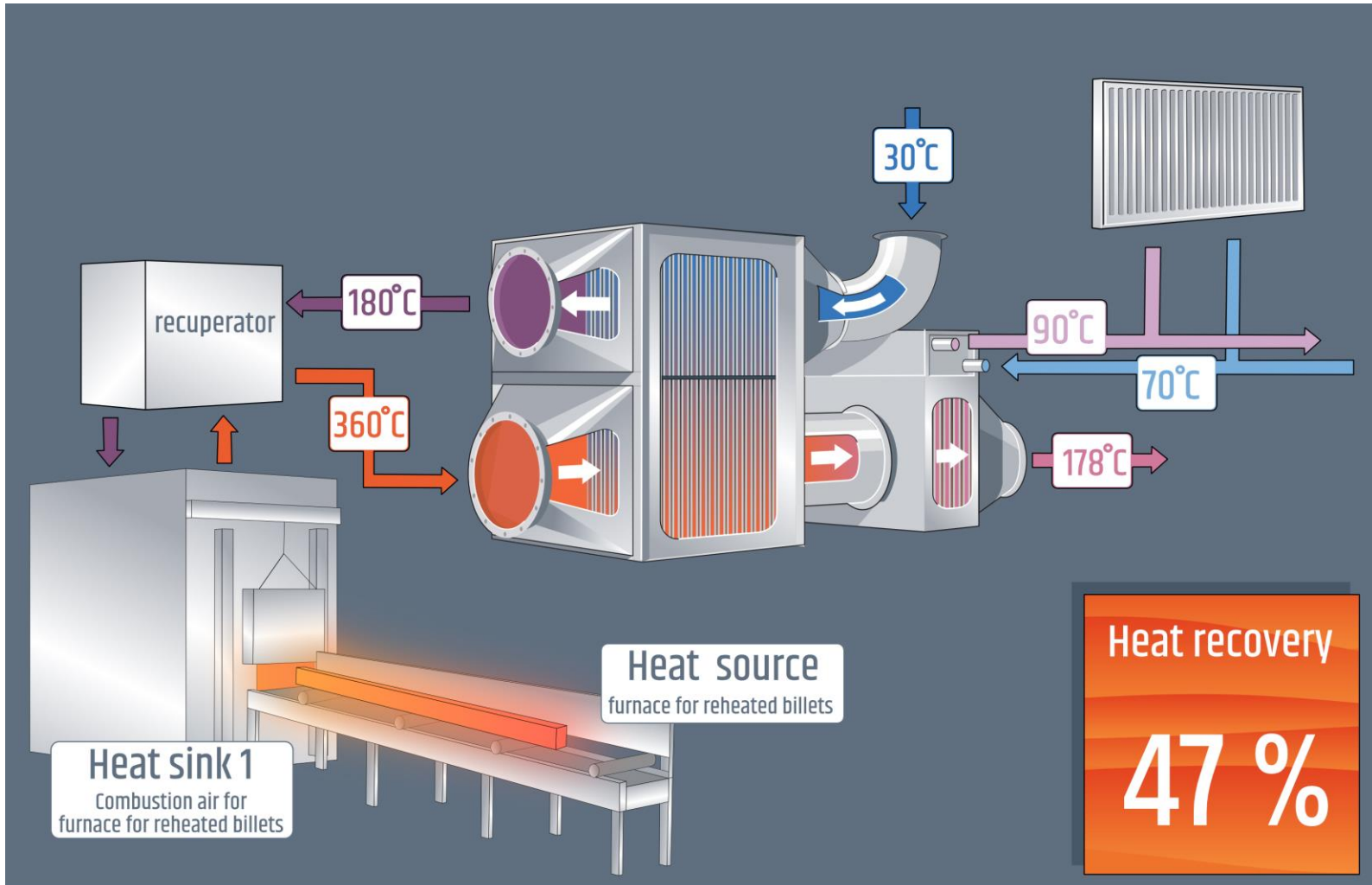
Return On Investment of less than 24 months, 88 kW

Steel industrial installation, Slovenia

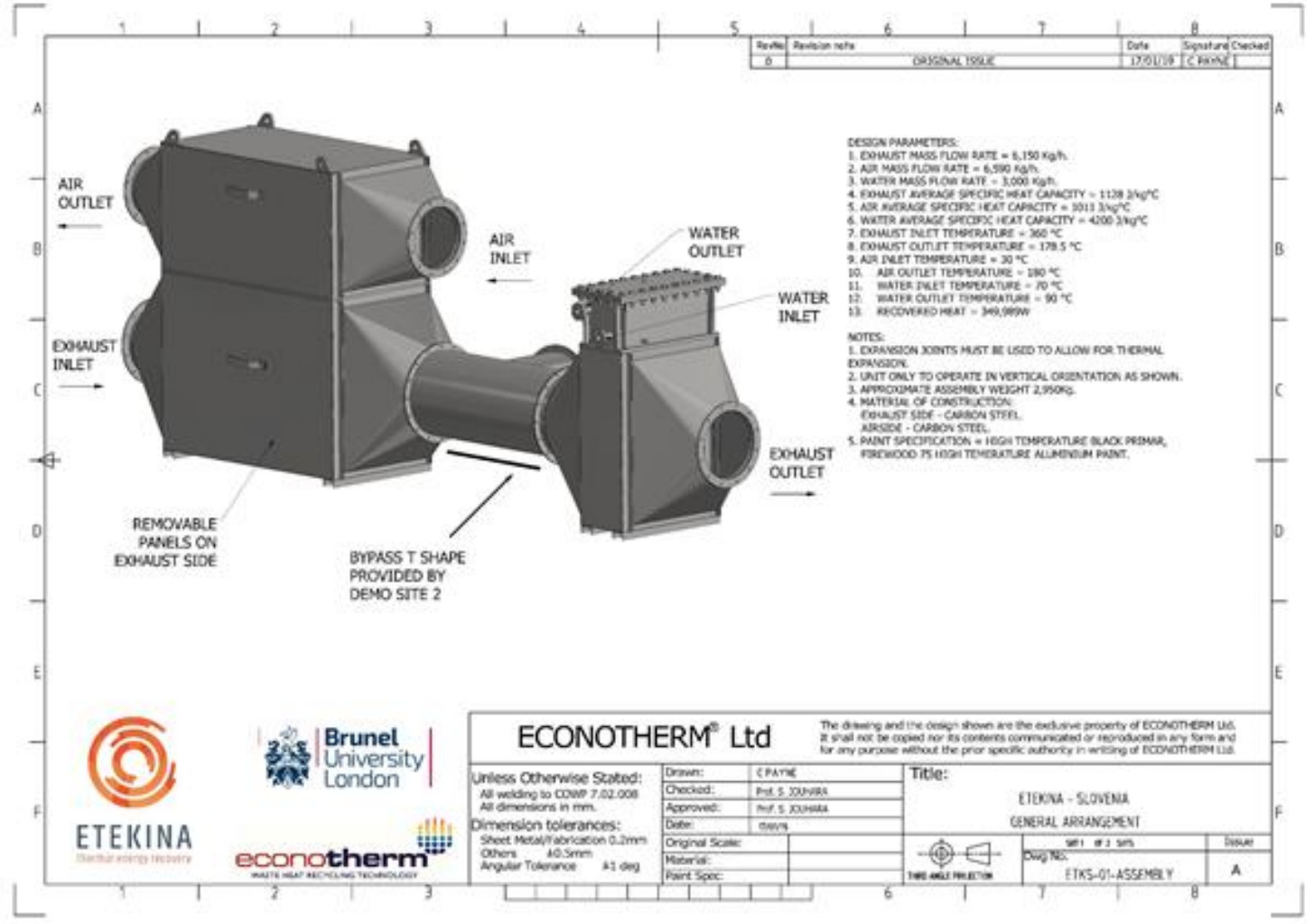


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systems

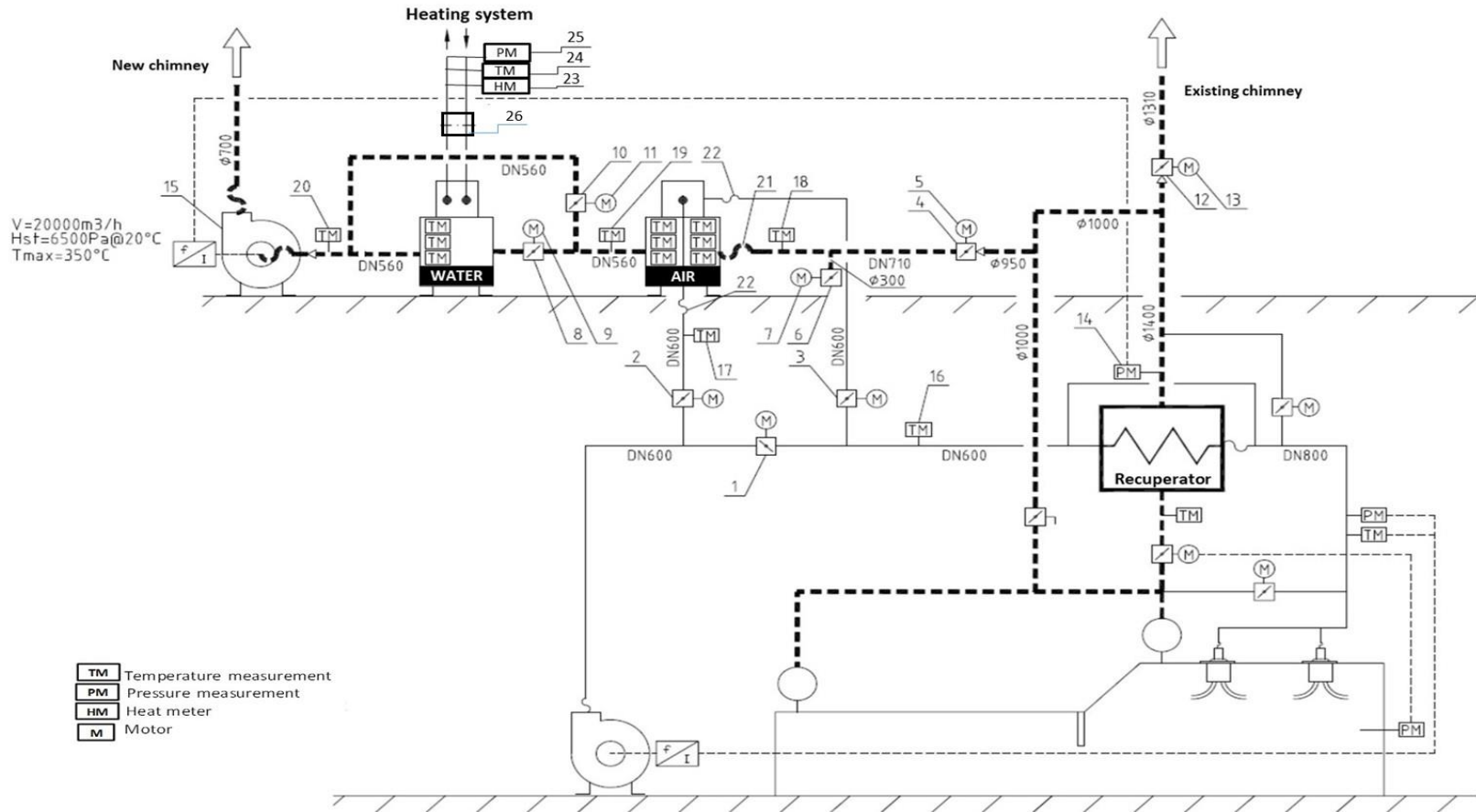
Steel Industrial installation, Concept



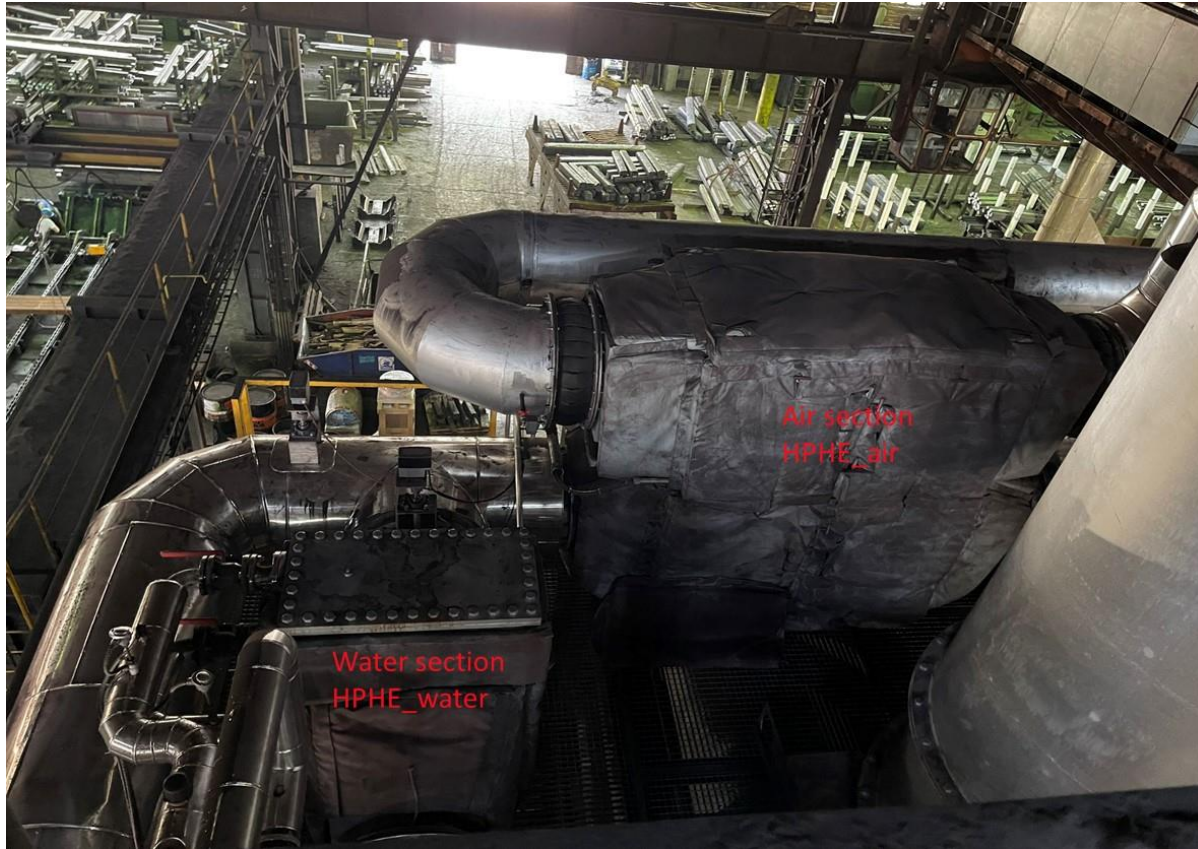
Steel Industry Thermal and Mechanical Design



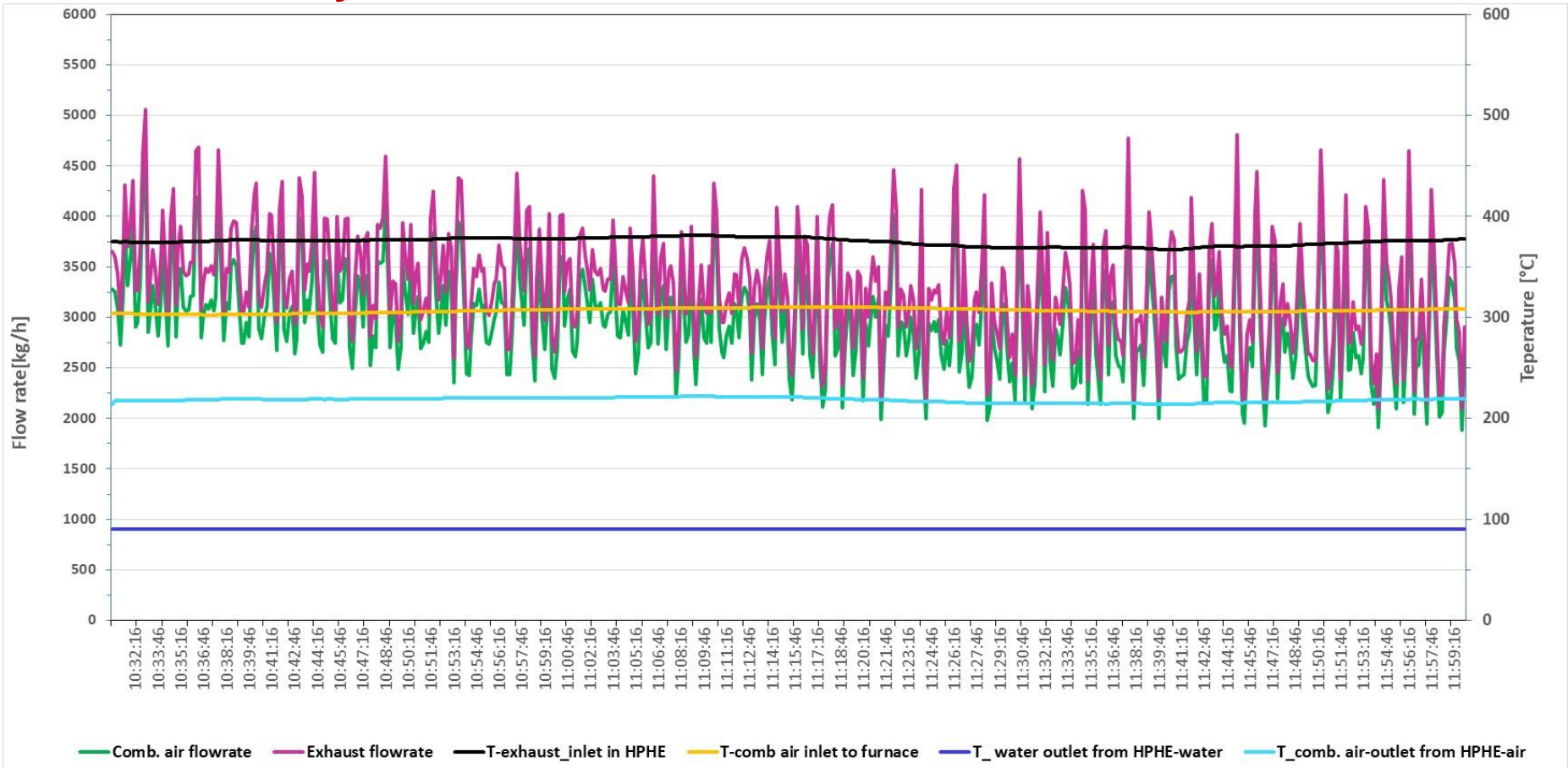
Steel Industry Piping and Instrumentation Diagram



Steel Industry, Commissioning

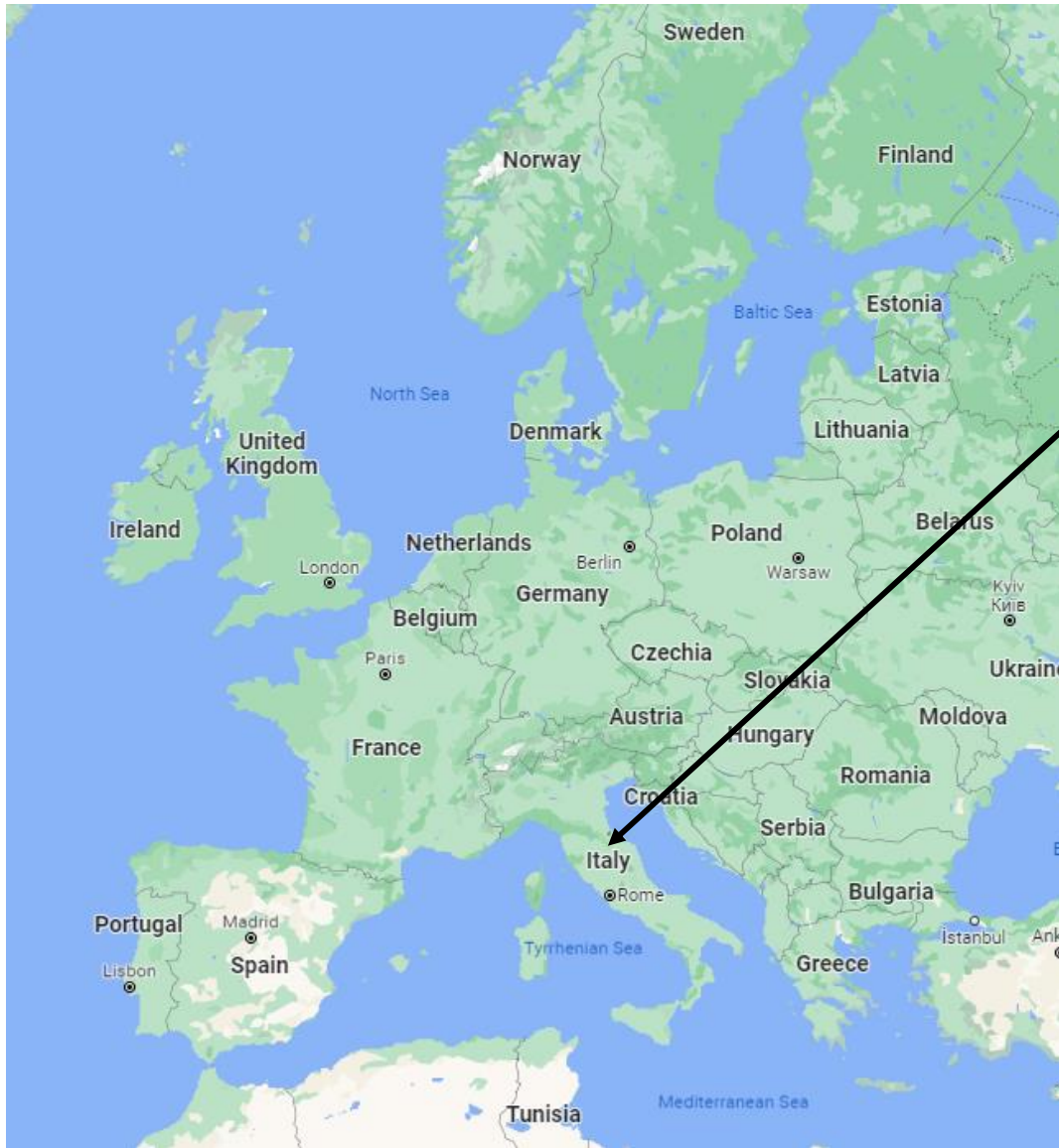


Steel Industry Results



Return On Investment of less than 9 months, 350 kW

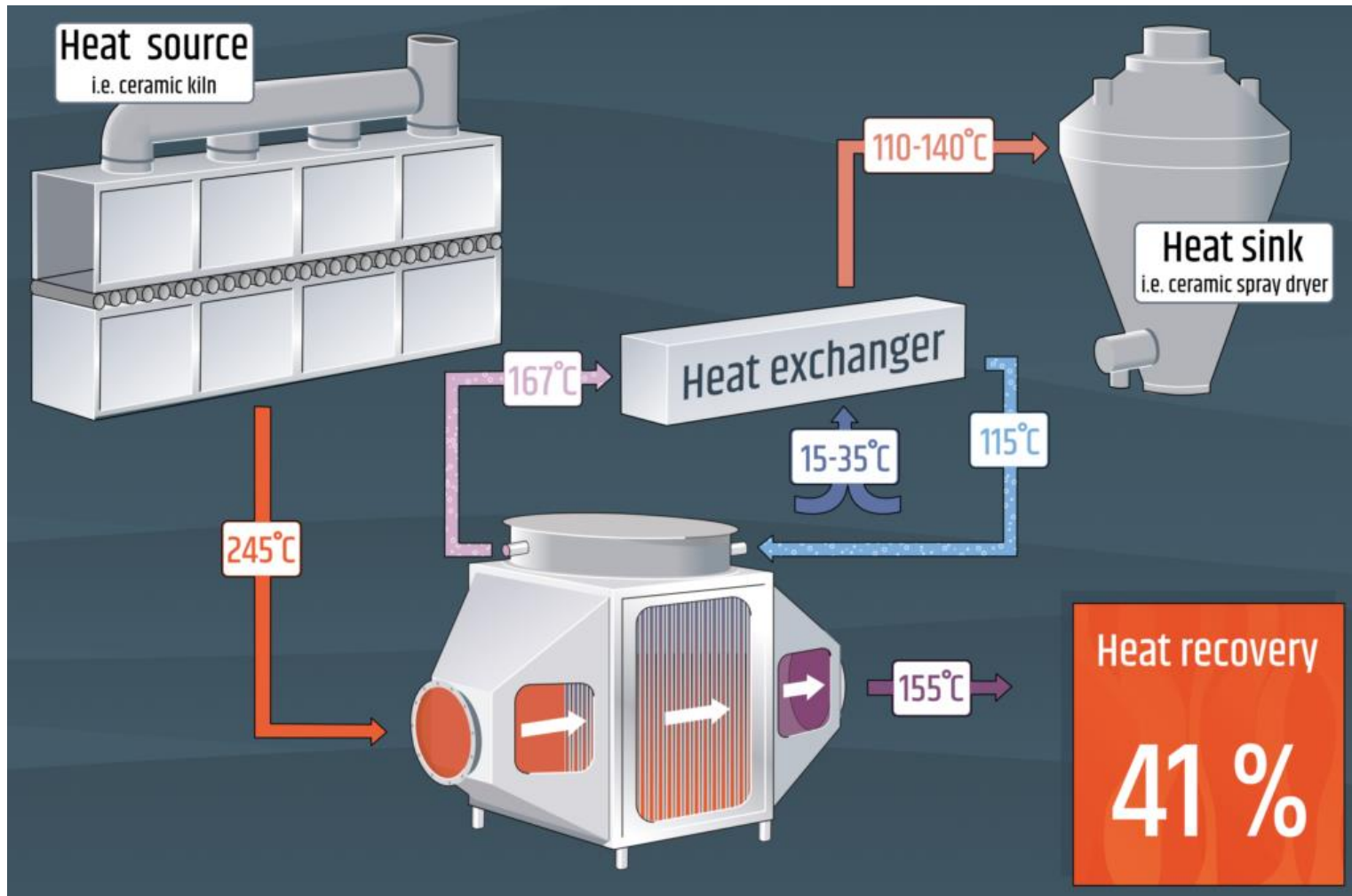
Ceramic Industrial installation, Concept



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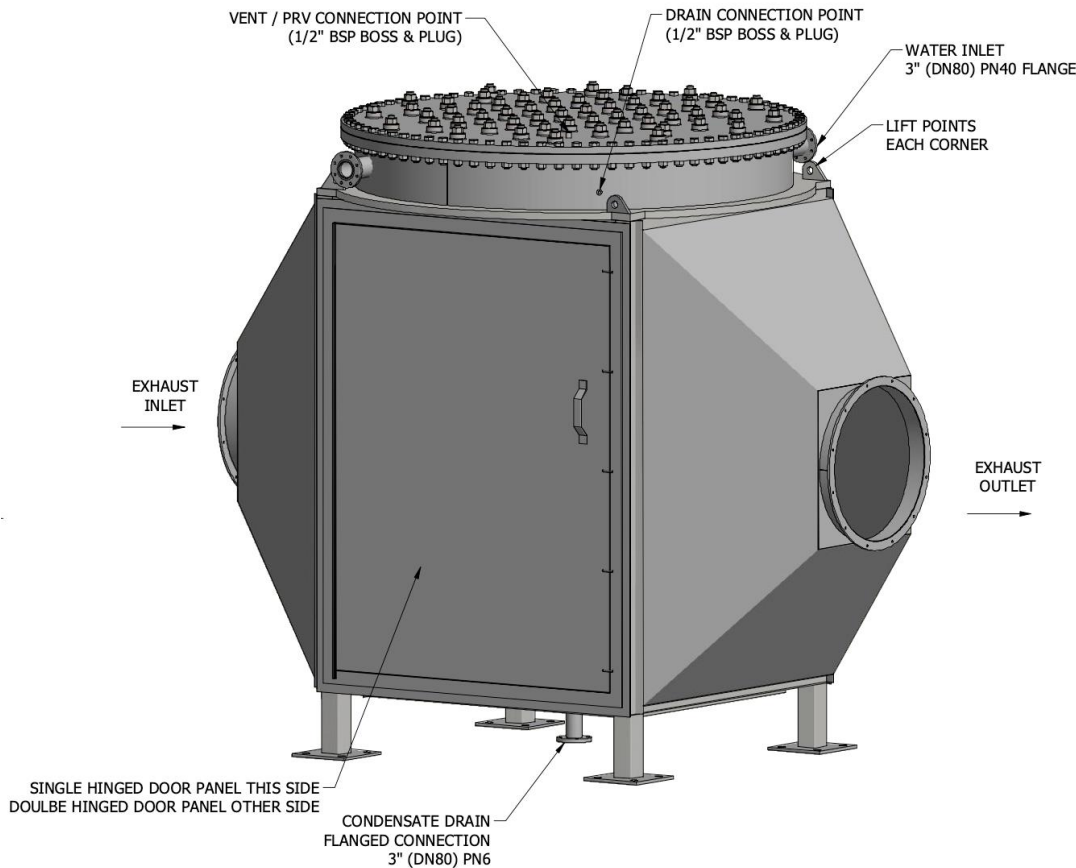


Ceramic Industrial installation, Concept



Ceramic Industry Thermal and Mechanical Design

RevNo	Revision note	Date	Signature	Checked
0	ORIGINAL ISSUE	20/02/20	C PAYNE	



DESIGN PARAMETERS:

1. EXHAUST MASS FLOW RATE = 26,000 Kg/h.
2. WATER MASS FLOW RATE = 11,280 Kg/h.
3. EXHAUST AVERAGE SPECIFIC HEAT CAPACITY = 0.257 Kcal/Kg°C
4. WATER AVERAGE SPECIFIC HEAT CAPACITY = 1.000Kcal/Kg°C
5. EXHAUST INLET TEMPERATURE = 245 °C
6. EXHAUST OUTLET TEMPERATURE = 155 °C
7. WATER INLET TEMPERATURE = 115 °C
8. WATER OUTLET TEMPERATURE = 167 °C
9. RECOVERED HEAT = 699,279W
10. UNIT DESIGNED IN ACCORDANCE WITH ASME VIII DIV 1 (2017).
11. DESIGN PRESSURE STEAMSIDE 16 BAR(G).
12. CORROSION ALLOWANCE ON STEAMSIDE = 1mm.
13. IMPACT TESTING EXEMPT AS PER UG20(f).
14. NO RADIOGRAPHY REQUIRED (JOINT EFFICIENCY FACTOR 0.7 USED).
15. WATER CHAMBER TO BE HYDROTESTED AT 23BAR (1.43 TIMES OPERATING).
16. GRAPHOIL GASKET USED, m = 2, Y=10MPa

NOTES:

1. EXPANSION JOINTS MUST BE USED TO ALLOW FOR THERMAL EXPANSION.
2. UNIT TO OPERATE IN VERTICAL ORIENTATION AS SHOWN.
3. DRY ASSEMBLY WEIGHT 12,050Kg.
4. MATERIAL OF CONSTRUCTION:
EXHAUST SIDE - STAINLESS STEEL.
WATERSIDE - CARBON STEEL.
HEAT PIPES - CARBON STEEL
5. PAINT SPECIFICATION = HIGH TEMPERATURE BLACK PRIMAR
FIREWOOD 75 HIGH TEMPERATURE ALUMINIUM PAINT.

263-01-ASSEMBLY BILL OF MATERIALS

ITEM	DRAWING NUMBER	DESCRIPTION	QTY	REVISION
1	263-01-1000	HEAT PIPE ASSEMBLY	896	0
2	263-01-2000	STEAMSIDE ASSEMBLY	1	0
3	263-01-3000	SEPARATION PLATE	1	0
4	263-01-4000	EXHAUST ASSEMBLY	1	0
5	263-01-5000	NAME PLATE	1	0

Ceramic Industry Thermal and Mechanical Design



Document no:	O-36808
Issue Number:	0
Page 1 of 2	

Inspection Services Design Appraisal Document

Lloyd's Register EMEA
Inspection Services
04 Park Square,
Thorncliffe Park Estate,
Chapelton,
Sheffield, S35 2PH

Date
11 March 2020
Quote this reference on all future communications
PRJ11100254977 O-36808/PS

Client : Econotherm (UK) Limited
Manufacturer : Econotherm (UK) Limited
Subject : Gas to Water Economiser
Design Pressure : 16.0 Barg
Volume : 1373 Litres
PED Category : IV
Module : G

- The documents listed below have been examined for compliance with the design requirements of ASME VIII Division 1:2017, in support of the Essential Safety Requirements of the Pressure Equipment Directive (2014/68/EU) for the design conditions stated on the documents and are assigned an appraisal status as indicated:
- The following points are advised for information:
 - It is concluded that Code stamping is neither intended nor applied.
 - It is noted that non-ASME listed materials are proposed and the requirements of UG-10 apply.

Name : P. Swanston
Senior Specialist

Office Details : Sheffield
Phone : +44 (0)114 2468137
Email : paul.swanston@lr.org



Document no:	O-36808
Issue Number:	0
Page 2 of 2	

Inspection Services Design Appraisal Document

Lloyd's Register EMEA
Inspection Services
04 Park Square,
Thorncliffe Park Estate,
Chapelton,
Sheffield, S35 2PH

Date
11 March 2020
Quote this reference on all future communications
PRJ11100254977 O-36808/PS

Document No.	Rev	Title	Status	Date
263-01-Assembly Sht 1 of 2	0	General Arrangement	A	11 Mar'20
263-01-Assembly Sht 2 of 2	0	General Arrangement	A	11 Mar'20
263-01-1000	0	Heat Pipe Assembly	A	11 Mar'20
263-01-3000	0	Separation Plate	A	11 Mar'20
263-01-2000 Sht 1 of 2	A	Waterside Assembly	A	11 Mar'20
263-01-2000 Sht 2 of 2	A	Waterside Assembly	A	11 Mar'20
263-01-2500	0	Staybar Assembly	A	11 Mar'20
263-01-2001	0	Outer Shell	A	11 Mar'20
263-012002	0	Outer Flange	A	11 Mar'20
263-01-2003	0	Top Cover	A	11 Mar'20
263-01-2004	0	Top Cover Gasket	A	11 Mar'20
263-01-5000	0	Nameplate	A	11 Mar'20
PMA-02-516	0	Particular Material Appraisal	A	11 Mar'20
PMA-02-105	0	Particular Material Appraisal	A	11 Mar'20
		Design Calculations	SI	11 Mar'20
		Hazard Checklist	SI	11 Mar'20
		Essential Safety Requirements	SI	11 Mar'20
		Operating Manual	SI	11 Mar'20

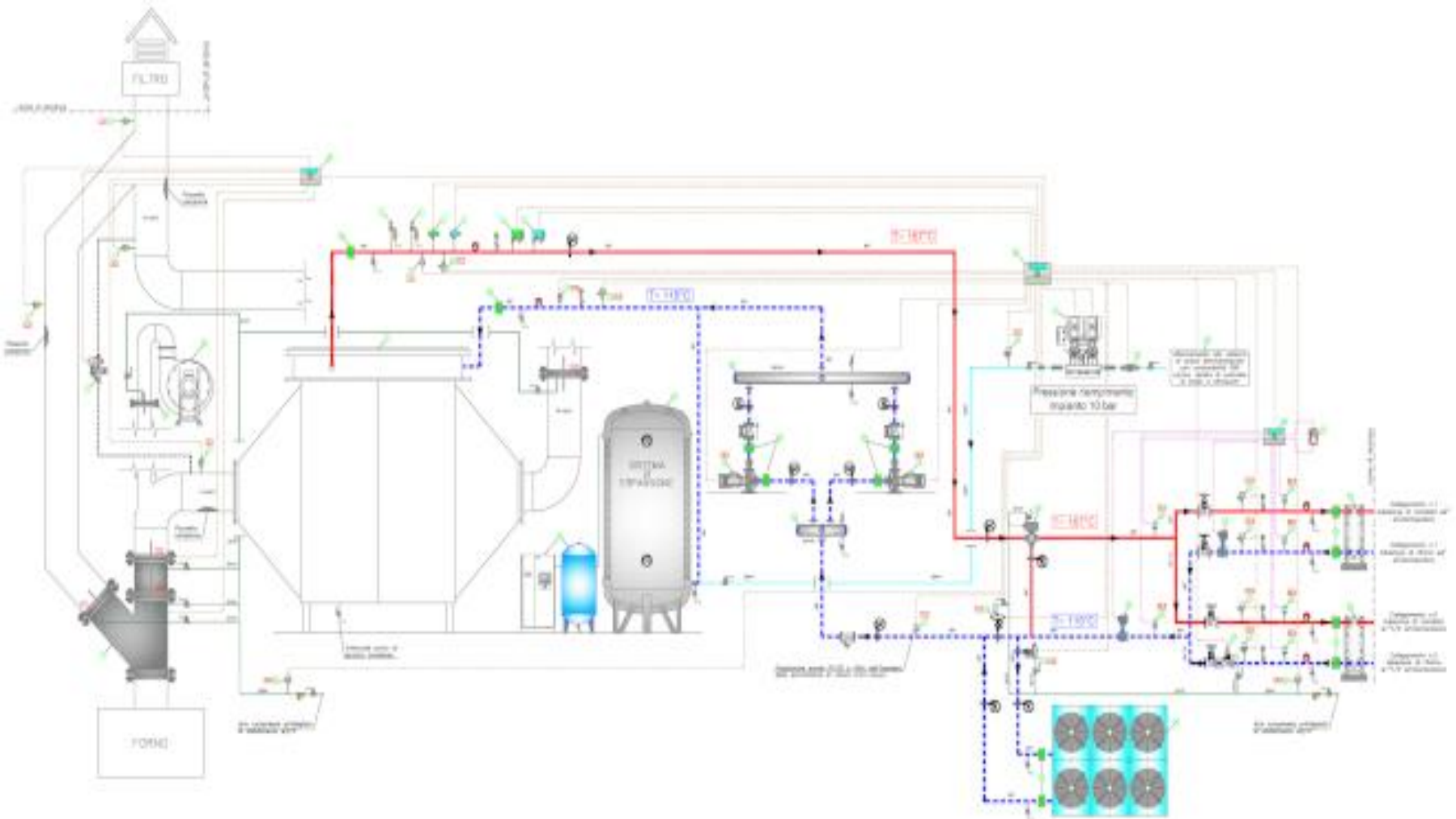
Status Key

A Examined
SI Retained as supporting documentation for information only

Distribution

Lloyd's Register Inspection Services (Birmingham) 1 Set
Lloyd's Register Inspection Services (Sheffield) 1 Set
Econotherm (UK) Limited 1 Set

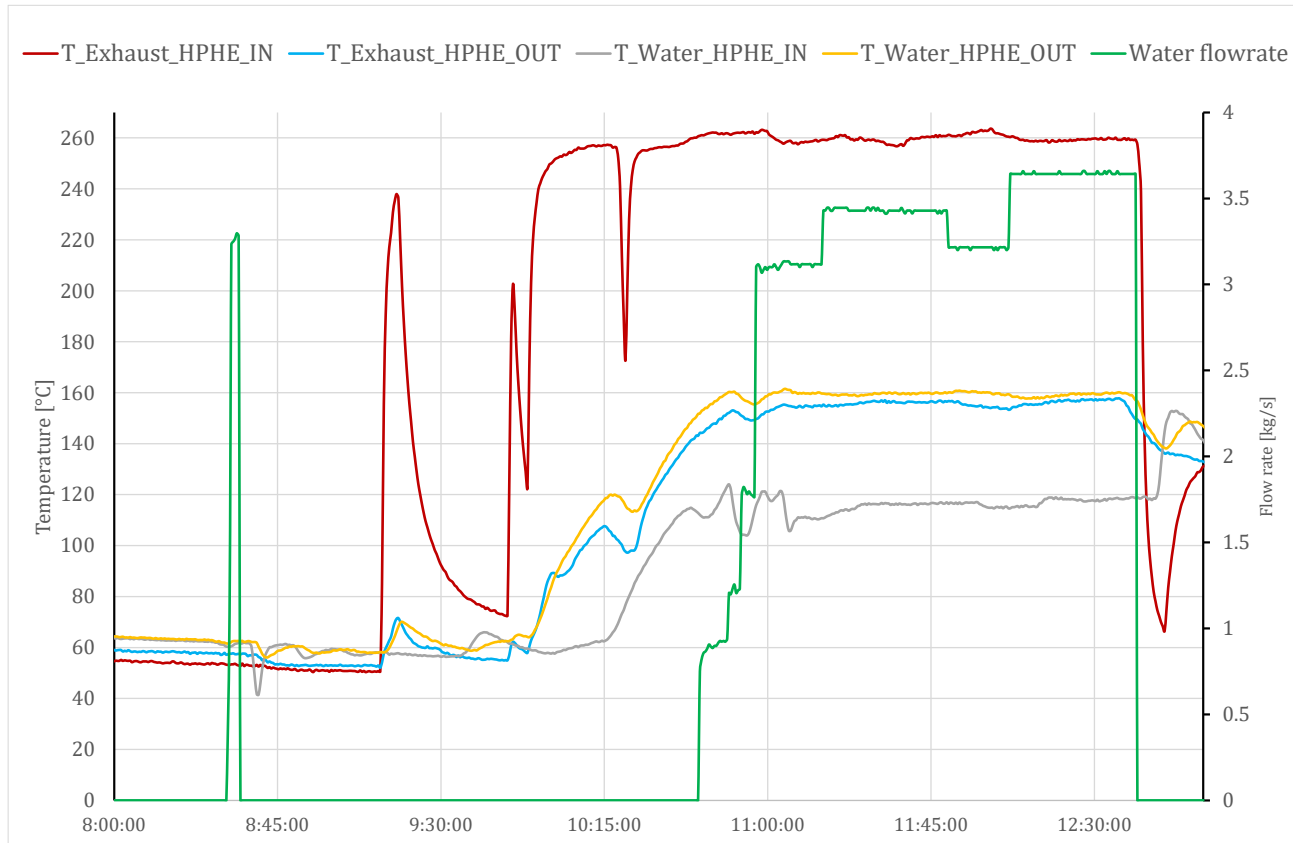
Ceramic Industry Piping and Instrumentation Diagram



Ceramic Industry, Commissioning



Ceramic Industry Results



Return On Investment of less than 24 months, 700 kW





**Innovative WATER recoverY Solutions through
recycling of heat, materials and water across
multiple sectors**

<https://www.iways.eu/>

H2020 funding €10.5M

Brunel's income: €817k

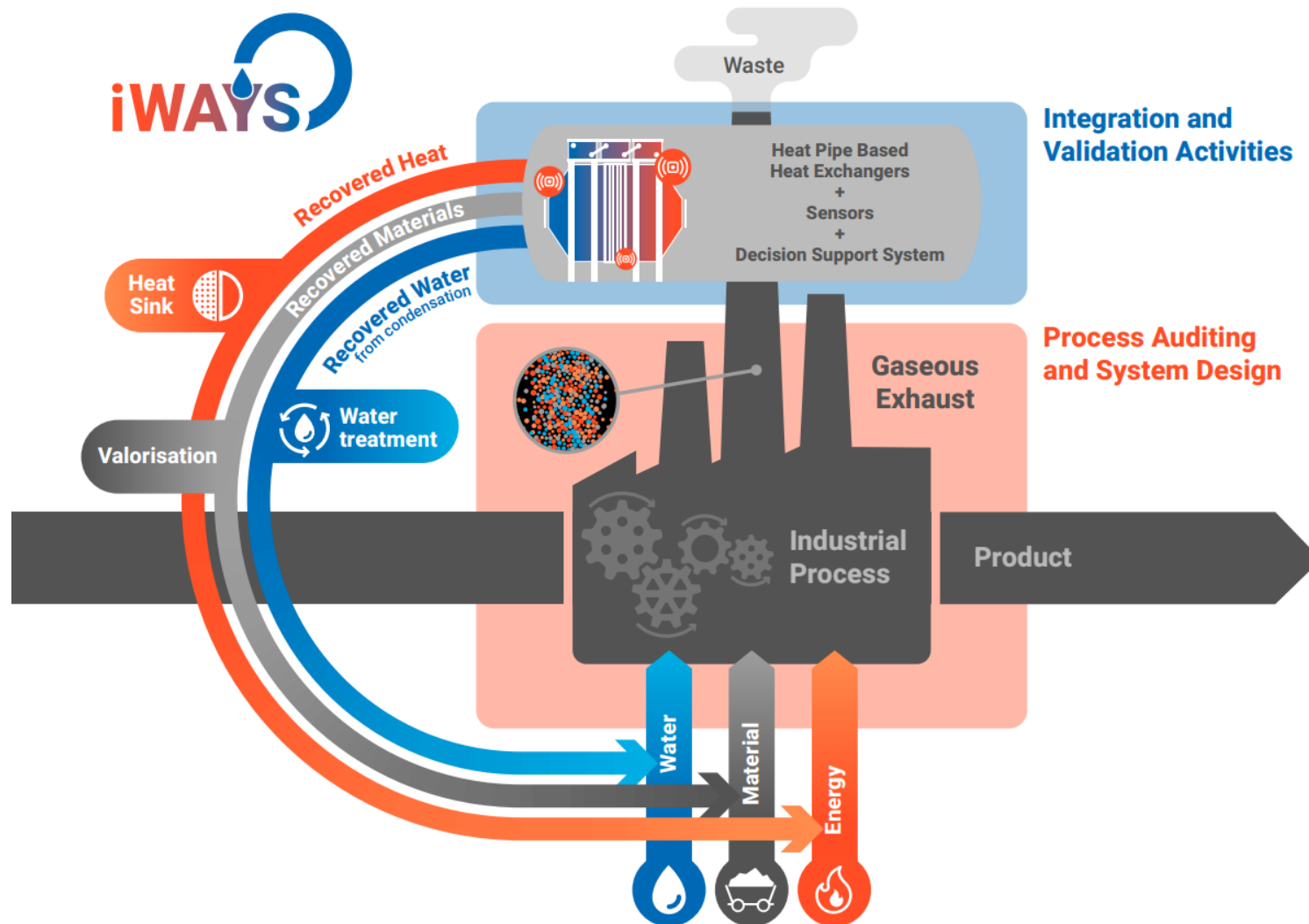


The consortium

27 June 2022



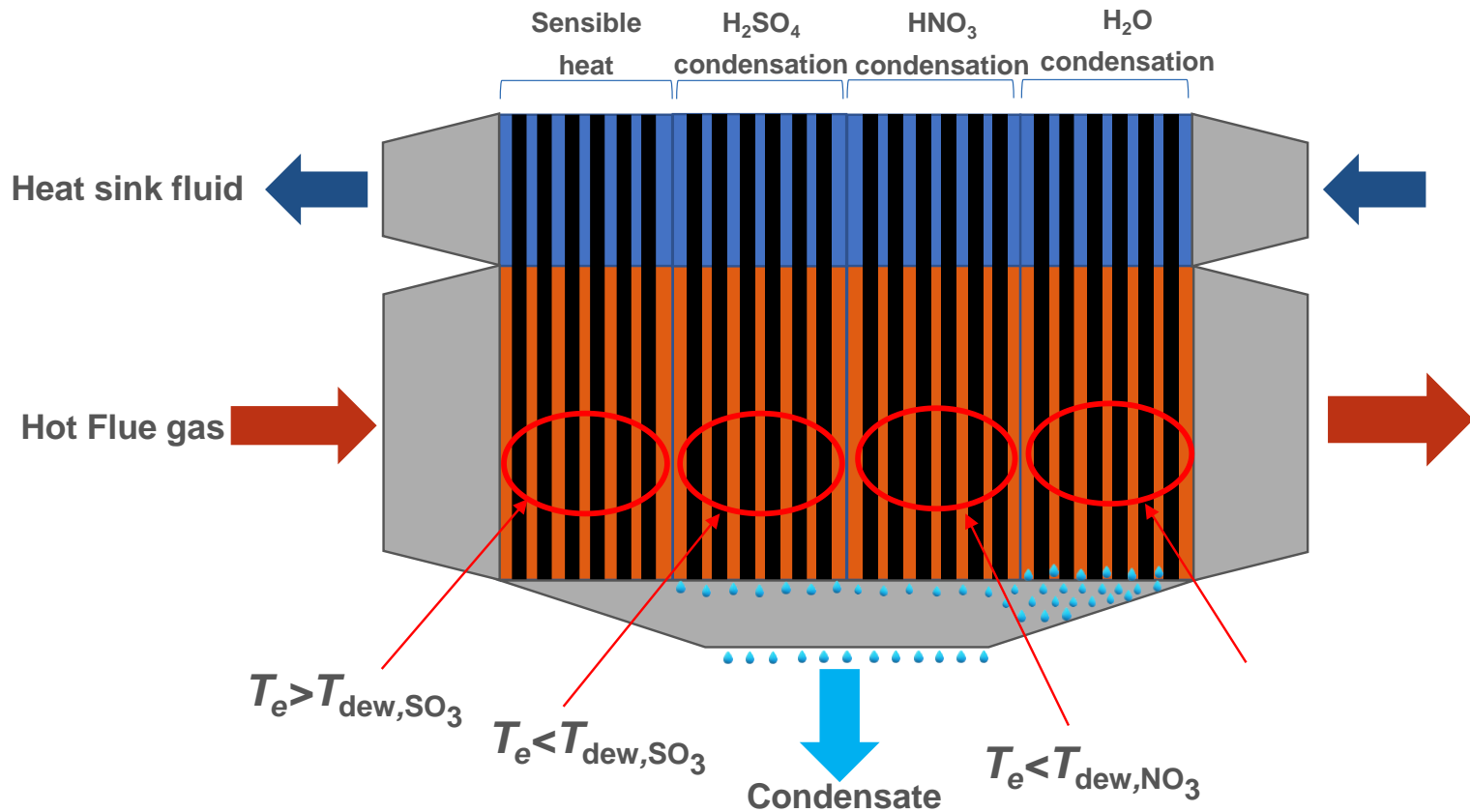
Innovative WATER recoverY Solutions through recycling of heat, materials and water across multiple sectors



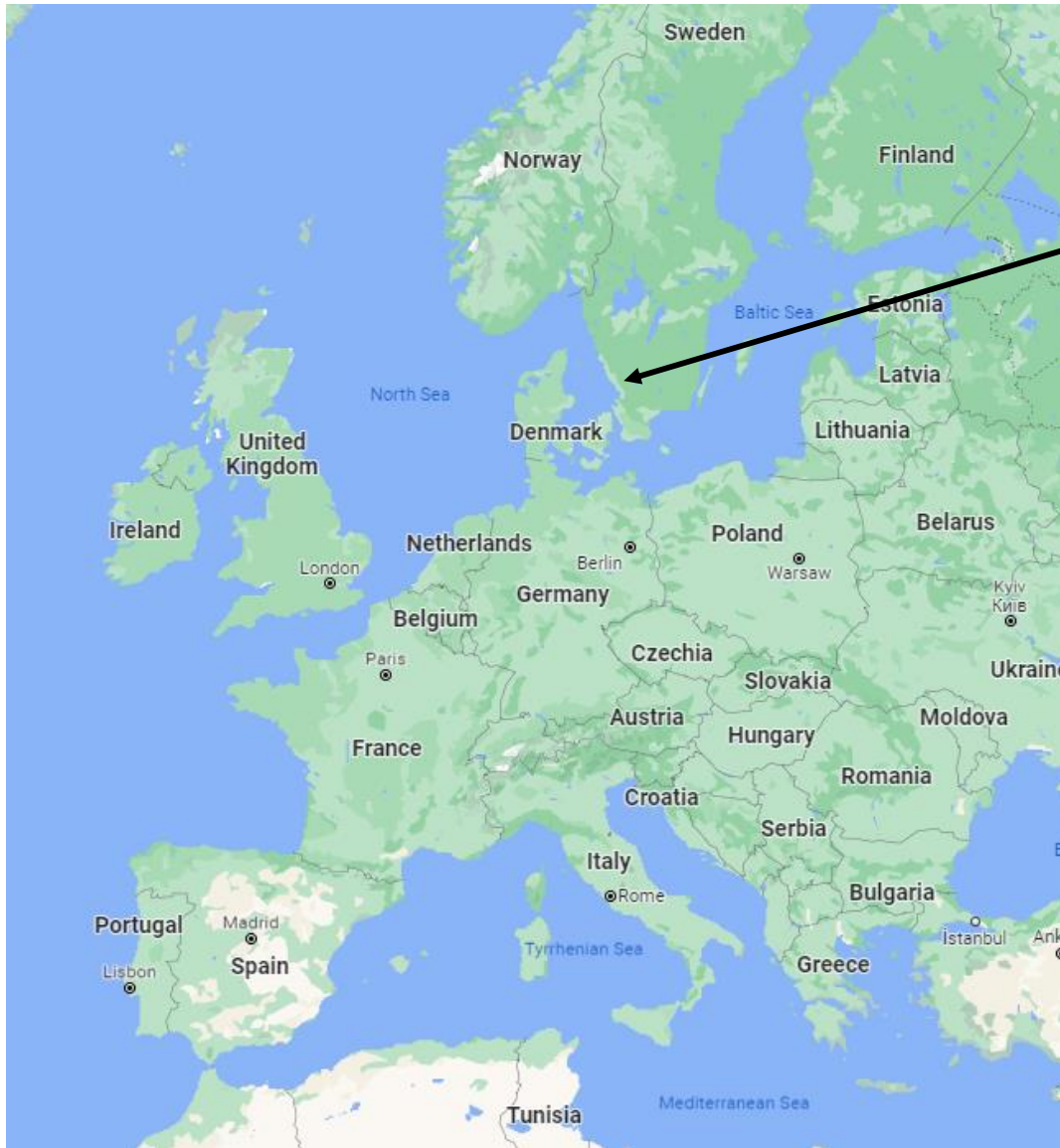
Innovative WATER recoverY Solutions through recycling of heat, materials and water across multiple sectors

- Condensation occurs when the heat pipe surface temperature T_e is lower than the dew point of the composition $T_{dew} : T_e < T_{dew}$

$$T_e < T_{dew}$$



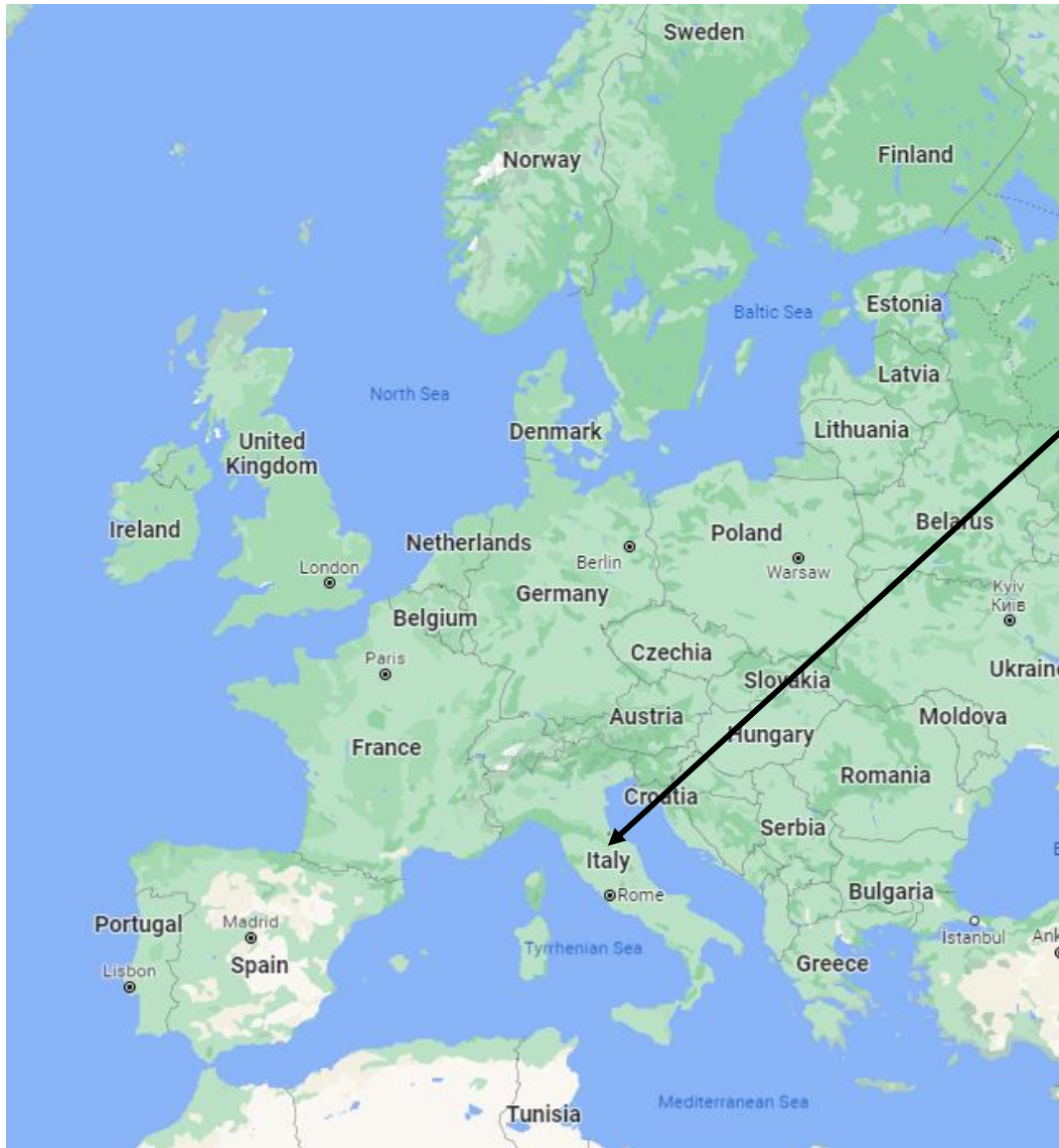
Innovative WATER recoverY Solutions through recycling of heat, materials and water across multiple sectors



alufleur



Innovative WATER recoverY Solutions through recycling of heat, materials and water across multiple sectors



atlas concorde



Innovative WATER recoverY Solutions through recycling of heat, materials and water across multiple sectors

