Heat pipe technologies for industrial applications

ETEKINA

Thermal energy recovery

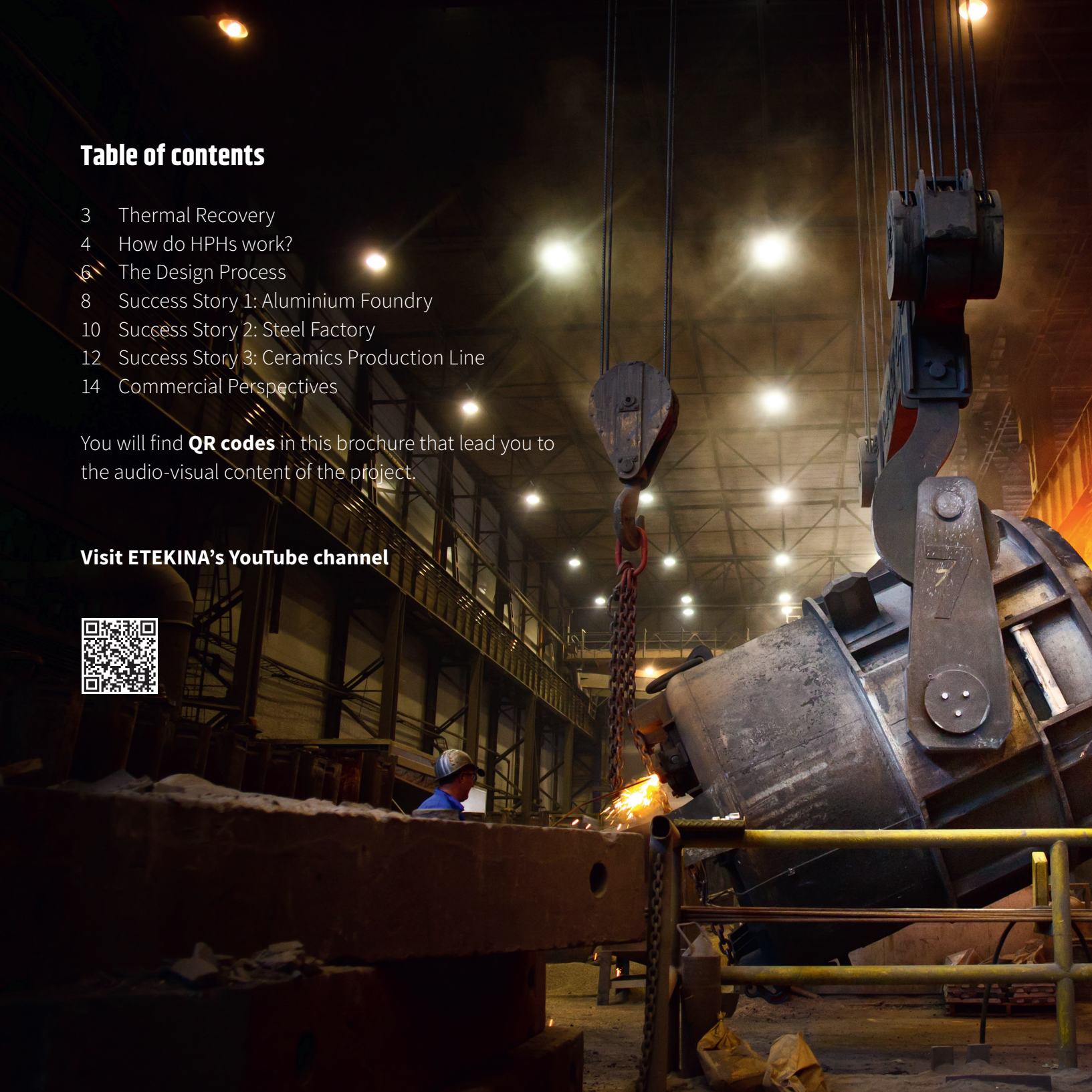


Table of contents

3 Thermal Recovery
4 How do HPHs work?
6 The Design Process
8 Success Story 1: Aluminium Foundry
10 Success Story 2: Steel Factory
12 Success Story 3: Ceramics Production Line
14 Commercial Perspectives

You will find **QR codes** in this brochure that lead you to the audio-visual content of the project.

Visit ETEKINA's YouTube channel

Recovering more than 40% of the waste heat stream in energy intensive industries

Thermal Recovery

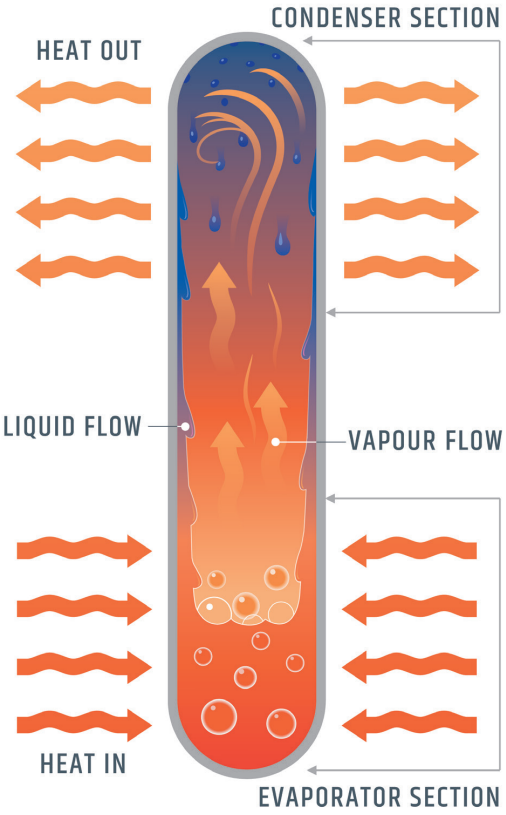
Waste heat is a common challenge in industries requiring high temperatures. With the help of heat exchangers, waste heat can be recovered and channelled to other processes within the same facility. But corrosive exhaust gases and high temperatures pose critical challenges to engineers when they try to extract thermal energy from flue gases.

In 2017, ten companies and institutes from across Europe joined forces to develop and test a new type of heat pipe heat exchanger (HPHE) for energy-intensive industries. In 2021 they installed three individually-designed HPHEs that are expected to recover more than 40% of the waste heat stream in three factories producing aluminium, steel, and ceramics respectively. They will continue to monitor the system until summer 2022.

The energy recovered in the three industrial settings are now used to reduce the industrial plants' energy consumption, thus reducing their greenhouse gas emissions in accordance with new regulations. This energy recovery gives them a good image of corporate and social responsibility, alongside the financial incentives.

How do HPHEs work?

Heat pipes are hermetically-sealed metal tubes that contain a working fluid. They transfer thermal energy passively from a hot to a cold stream by a boiling condensation cycle inside the tube. In this way, heat from the hot area can be transferred efficiently to a cold part of the pipe.

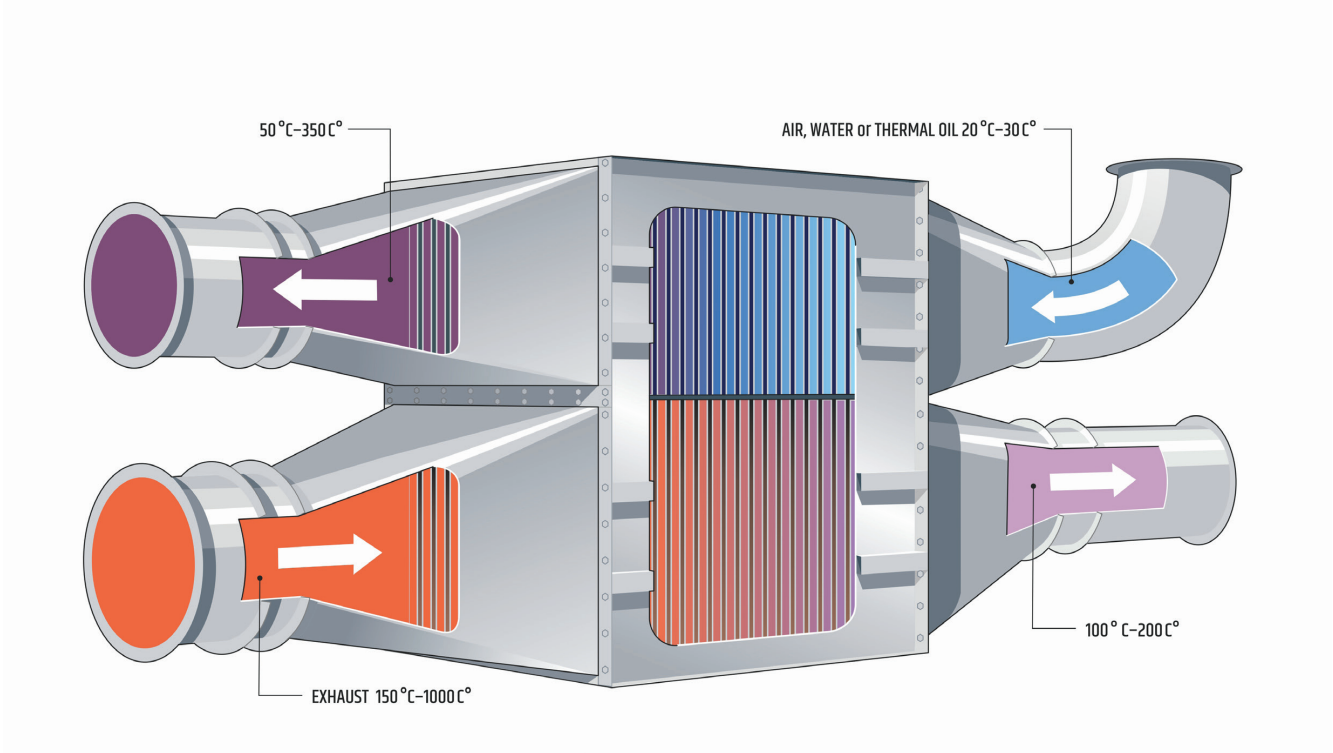


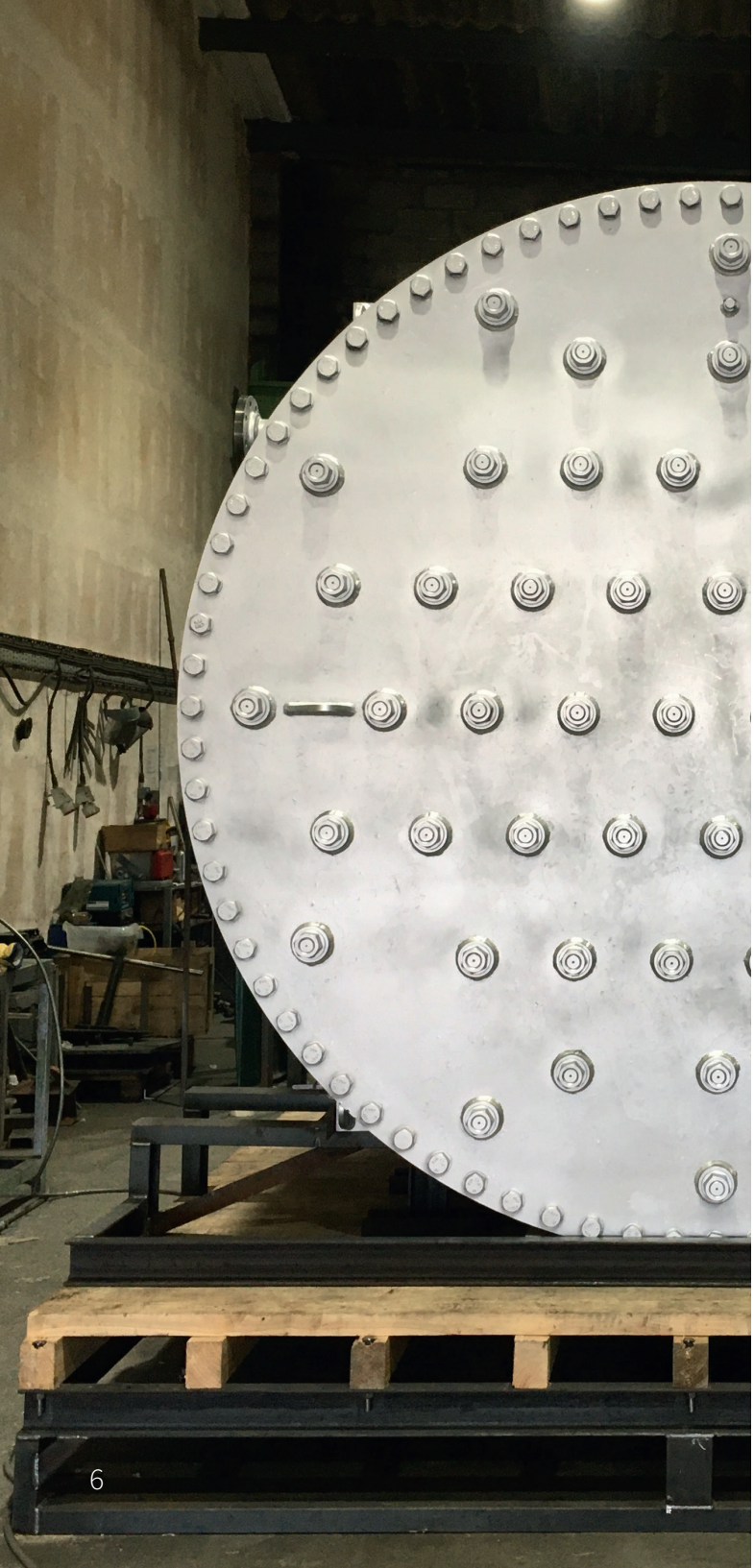
In the ETEKINA project, engineers have, through thermal and mechanical designs, arranged many such heat pipes and created a heat exchanger design according to the specific needs of each production plant. Heat pipe heat exchangers are very efficient heat transfer units that can be used in various applications and sectors.

The hot production steam passes at the bottom of a container to heat the liquid inside the many tubes working together in parallel. At the other end of the heat exchanger cool air, water or thermal oil flows along, absorbing the heat from the condenser sections. This heated air or water can now be transported to parts of the production line where it can be re-used to preheat combustion air, treat automotive parts, or dry clay for example.

The heat pipe heat exchanger concept developed during this project is highly scalable and can be adapted to any type of industrial exhaust in a wide range of temperatures for different heat sinks (hot air, hot water, pressurised water, thermal oil etc.). The estimated lifetime of an ETEKINA HPHE is 10 – 20 years.

GIF of HPHE
www.etekina.eu/thermal-recovery/





The Design Process

The main challenges in industrial waste heat recovery are the composition and thermal characteristics of the exhausts. The flue gases have a relatively high temperature range and the suspended particles within the exhausts include corrosive elements. Fouling is another big challenge in conventional systems, as thin walls and a large surface area are needed for effective heat transfer. This usually leads to particulates sticking to the exhaust's walls. In contrast to conventional heat exchangers, the ETEKINA HPHEs have a high overall heat transfer rate to surface area and a remarkably low pressure drop, which allows them to mitigate these issues.

The ETEKINA design team identified the various settings and selected the relevant materials for the heat pipes so that the thermal recovery works efficiently inside the plant's environment and within the temperature range applied. They incorporated different heat pipe working fluids within the same unit to maximise the heat recovery. This means the ETEKINA HPHE can reuse the recovered heat in the recipient processes without compromising on the quality of the produced parts.

Prof. Hussam Jouhara demonstrating the HPHE at the ceramics production line

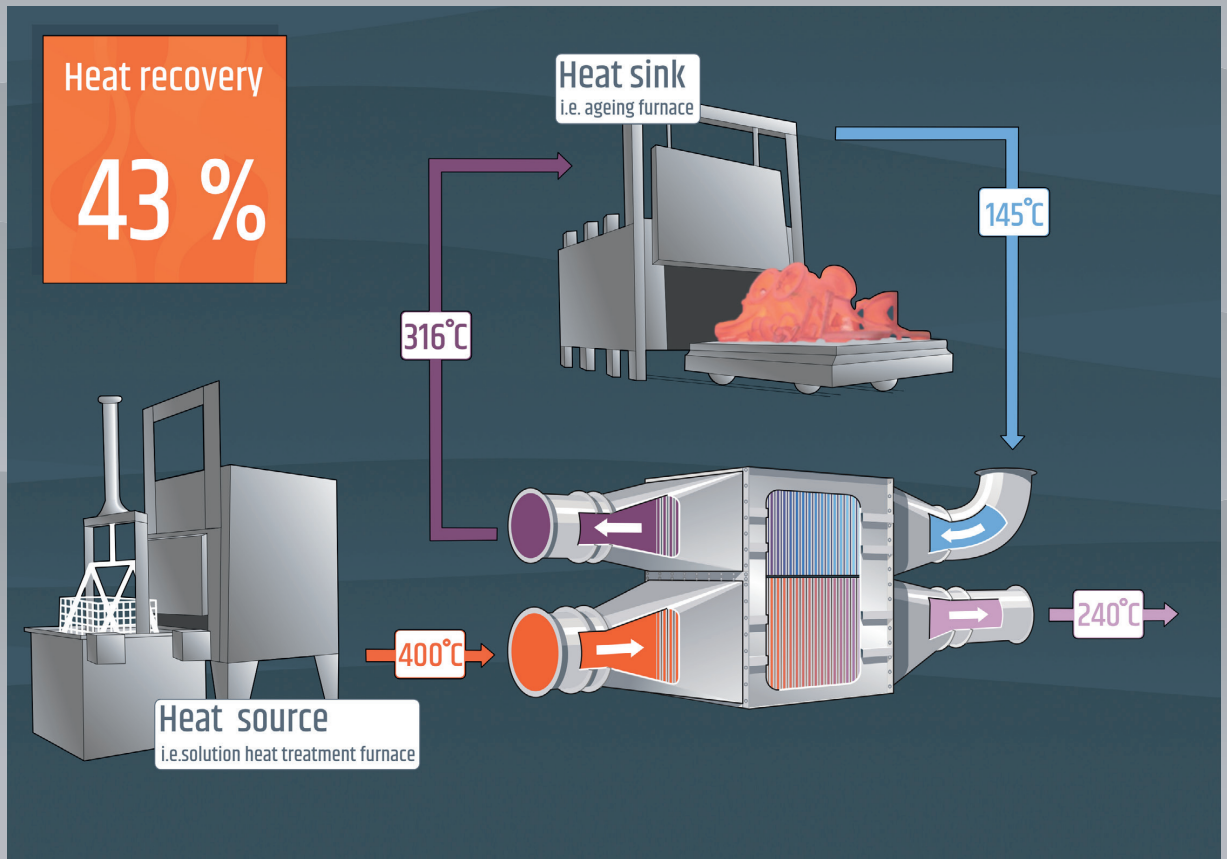
“Our ETEKINA heat pipe heat exchangers are not like conventional heat exchangers. To design them, you have to have, in addition to heat transfer and fluid dynamics experience, a proper understanding of the chemistry and material science. And you have to have proper understanding of the business case to ensure that it will be adopted by the industries.”

Prof. Hussam Jouhara,
ETEKINA Technical Coordinator,
Brunel University London, UK

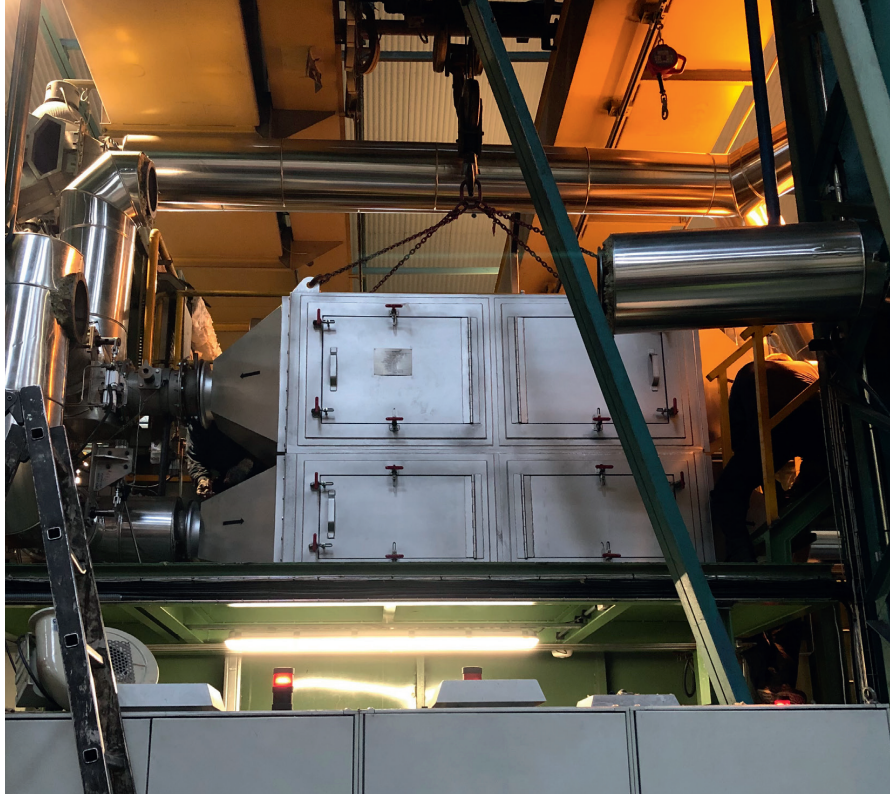
The research for ETEKINA was coordinated by the thermal management and heat pipe research group of Brunel University London, led by Professor Hussam Jouhara. He overlooked the activities that demonstrate the heat pipe-based waste heat recovery systems in the three demo sites. New designs were generated and optimised using a combination of theoretical models laboratory testing. The university also developed a methodology for using the waste heat recovery system based on the industry type and the required heat sinks.

Success Story 1: Aluminium Foundry

Fagor Ederlan in Arrasate, northern Spain, is a global leading manufacturer of automotive components and one of Spain's largest foundries. The individually designed HPHE implemented at one of the Aluminium casting facilities of Fagor Ederlan, uses the excess heat from the Heat Treatment furnace (with an average exhaust inlet of 400°C) to preheat fresh air for the ageing furnace. Monitoring results show that the unit recovers heat of 88 kW, which means that **43% of the waste heat stream is being recovered.** This means, the prototype system will be able to reduce the greenhouse gas emissions by 110 tonnes of carbon dioxide (CO_2) equivalent (tCO_2e) per year.

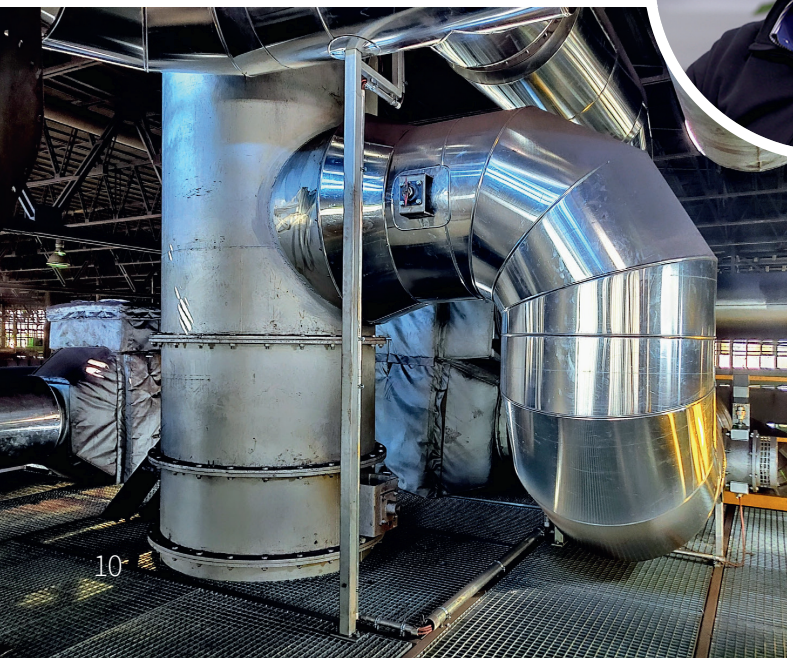


“Aluminium can be recycled as many times as we wish, and it doesn’t lose any of its characteristics. However, the production of aluminium as a raw material needs a lot of energy, and the transformation of a raw material to a component is also an energy-consuming process. It is important to recuperate the heat wherever it is possible, to consume less energy and thus to reduce emissions.”



Dr. Eva Gonzalez,
Partnership & Technological Vigilance Edertek Technology Centre, Fagor Ederlan Group, Spain

“Within the ETEKINA project, SIJ Metal Ravne had the opportunity to improve its own energy and environmental performance, and consequently its overall competitiveness. We found that the project helped us to increase our energy efficiency across the main production processes. We see this project as an important step towards the complete replacement of traditional fuels for heating and hot water preparation with alternative energy sources, namely waste heat.”



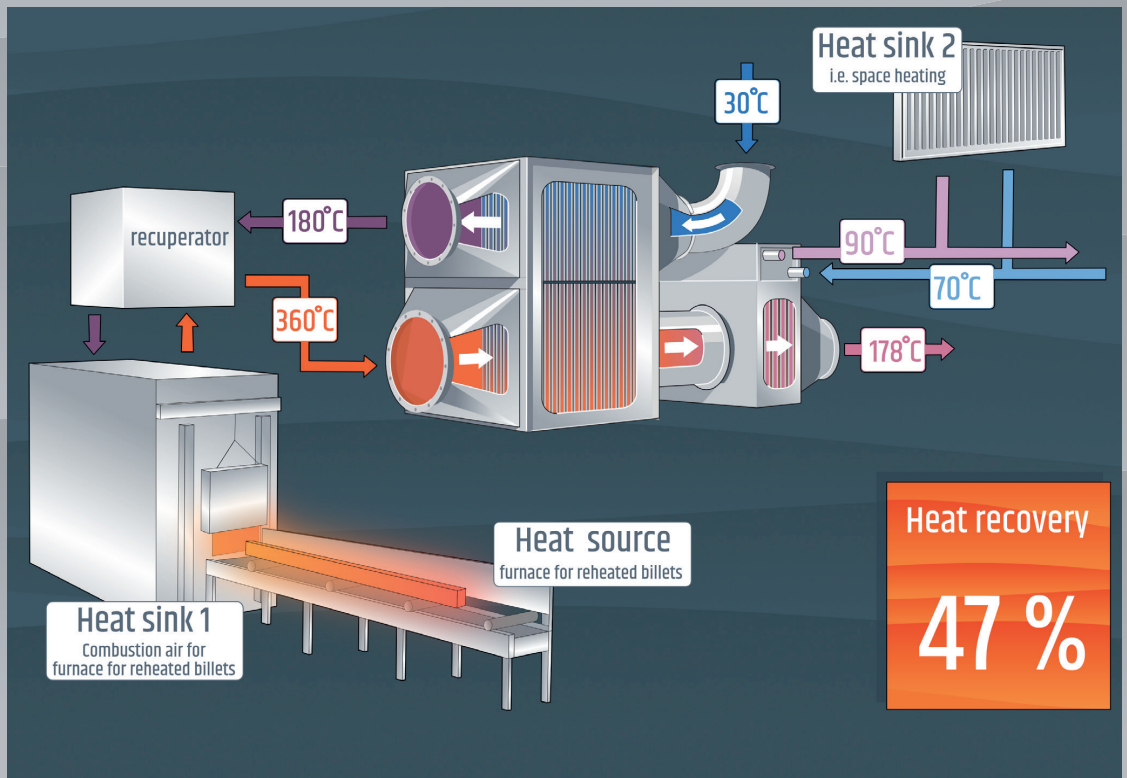
Kristijan Plesnik,
Energy Manager, SIJ Metal Ravne, Slovenia

Interview with Kristijan Plesnik

Success Story 2: Steel Factory

SIJ Metal Ravne is a member of SIJ Group – the largest Slovenian metallurgical group in Slovenia and a leading player in the global niche steel markets. Before the installation of the ETEKINA heat pipe heat exchanger, the flue gases of the furnace were released into the environment at a temperature of 380°C. The new system was commissioned in summer 2021 and consists of two connected sections. The first one raises the temperature of the combustion air in the furnace itself while the second section heats water for heating nearby office buildings. The unit recovers 350 kW, which corresponds to an average reduction of 425 tCO_2e greenhouse gas emissions per year. **The recovery rate of wasted heat is 47%.**

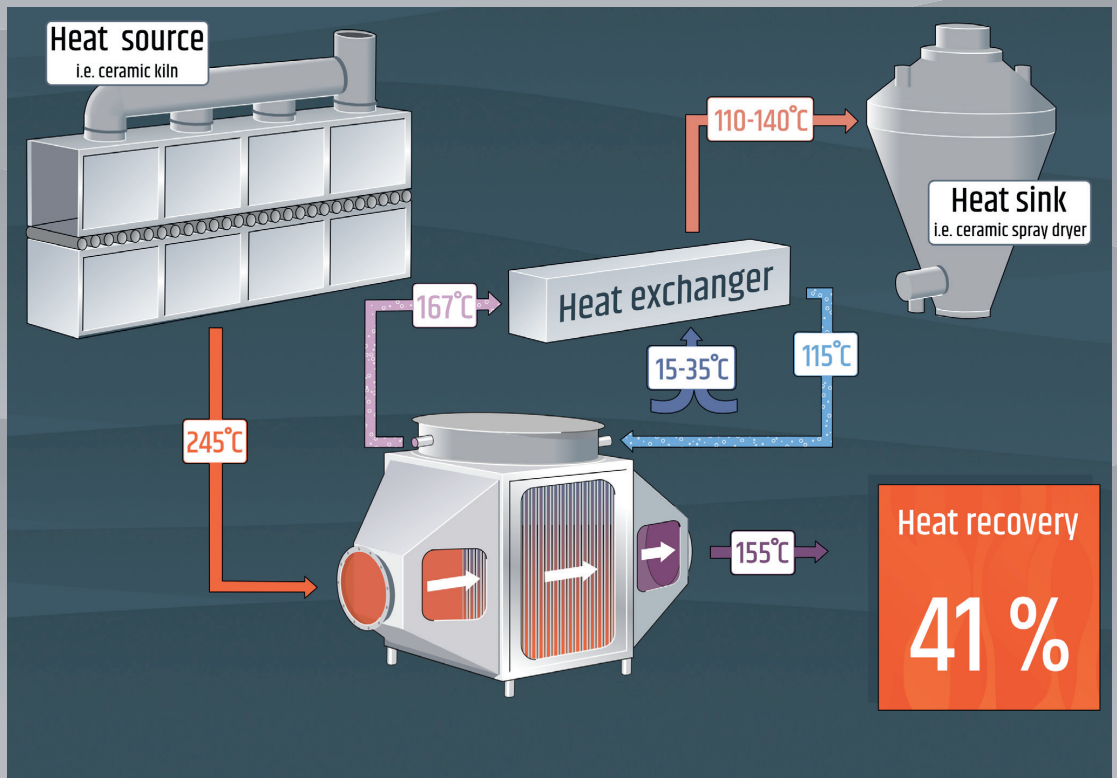
There are nearly 70 furnaces in operation in the factory. Since only one HPHE is installed for the purpose of the ETEKINA project, there is much more potential for energy savings using this technology. The management of SIJ Metal Ravne is investigating how they can adapt the ETEKINA concept at a larger scale to make full use of the energy saving potential by HPHEs.



Success Story 3: Ceramics Production Line

Ceramiche Atlas Concorde is one of the global leaders in the ceramic tile industry. Over the last years energy has become more and more relevant in ceramic tile production. The Italian ceramics sector has begun to focus on improving the energy efficiency of their production lines to counteract rising energy prices and global competition from producers using cheaper power supplies.

The main challenge for recovering heat from ceramic furnaces is corrosive and dusty kiln exhausts. The concept of the ETEKINA system mitigates this problem and so is able to transfer the heat to a pressurised water circuit. The heated water is then used in a secondary heat exchanger for the spray dryer to dry a water/clay mixture at the beginning of the production process. The engineers have decided to transport the heat by water to a remote area, since the size of piping is smaller and the cost of additional installations is also reduced. This heat transfer process leads to a heat recovery of 700 kW and an average reduction of greenhouse gas emissions of 850 tCO_2e/year. **The total heat recovery in this system amounts to 41%.**



“After a filtration process, the fumes from the kilns are usually released into the atmosphere. So, what we have done is to capture this heat, lower the thermal pollution and reduce the use of natural gas within our company. The recovered waste energy is then transferred to other equipment in our production line that can use this energy. This means our burners use less gas thanks to the energy that comes from the kilns’ exhaust.”

Luca Manzini,
Energy Manager Gruppo Concorde

Commercial Perspectives

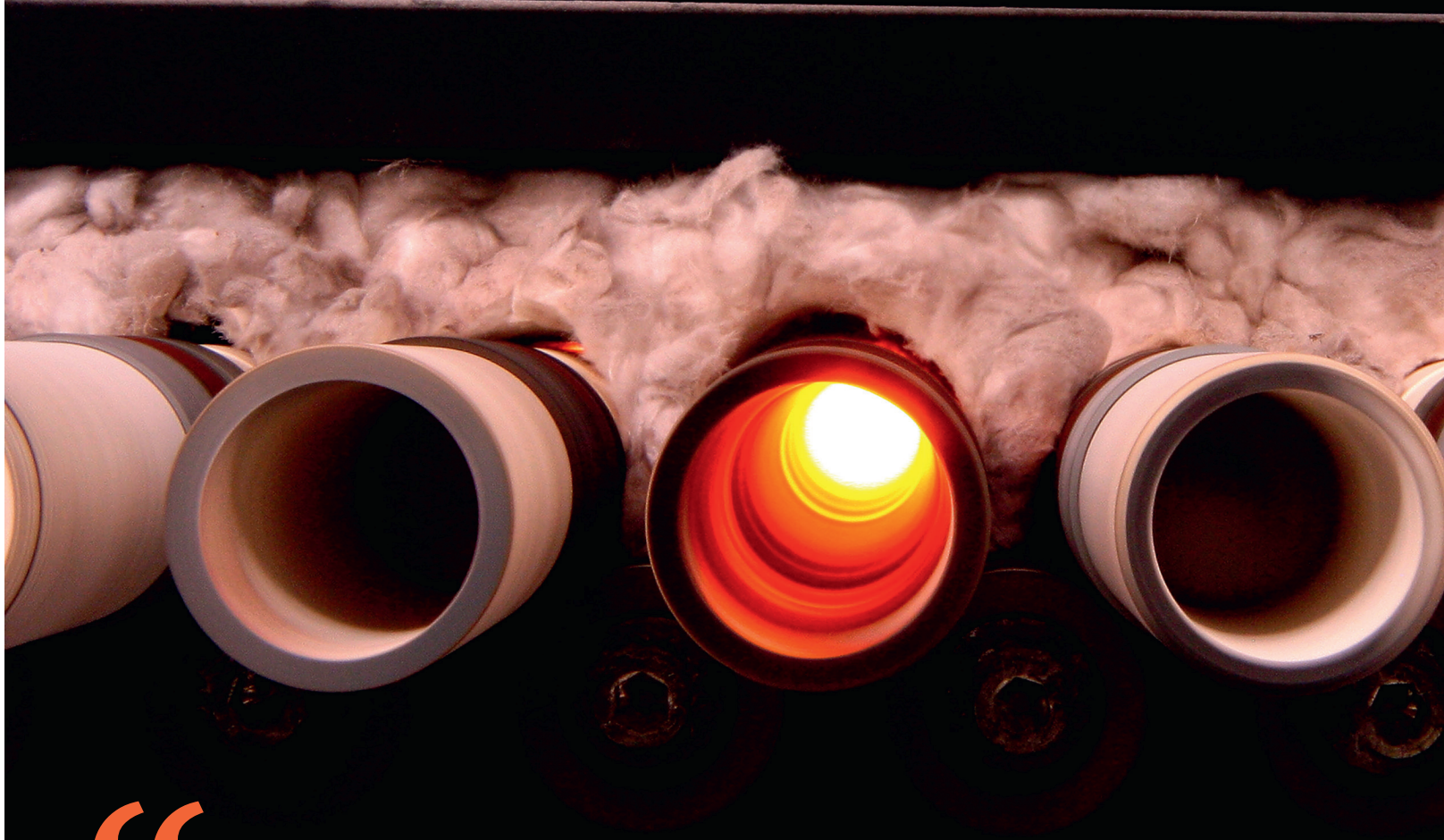
The ETEKINA project started in 2017 with the aim to reduce energy consumption by at least 40%. In 2022, after installing three prototypes in a steel factory, an aluminium foundry, and a ceramics production line, this objective has been achieved. In fact the latest monitoring data suggests that the system is outperforming the expected waste heat reduction, and that recovery rates of up to 50% are possible.

Lowering waste energy was not the only objective of the project. Equally important was the commercial viability of the technology and a technology readiness level TRL7 has been achieved. Calculations show that the Return of Investment (ROI) of the ETEKINA prototypes are extremely interesting for a commercial exploitation. Under market conditions, the HPHE of the aluminium foundry and the ceramics plant both reach an ROI of 24 months*, while the heat exchanger of the steel producers achieved an ROI of only nine months*.

With such impressive economic data, the consortium now hopes that their technology will trigger interest by other companies in the steel, ceramics or aluminium sector – or from any other industry that deals with high temperatures and high energy costs. At the COP21 meeting in Glasgow in 2021, political leaders agreed that energy intensive industries should become carbon neutral by 2050. It may still be a long way to go, though with a new technology like the heat pipe heat exchanger on the horizon it's already becoming a much more realistic vision.

HPHE prototype	Recovered Heat	Return of Investment*
Aluminium	88 kW	24 months
Steel	350 kW	9 months
Ceramics	700 kW	24 months

* ROI figures are based on 21/22 prices



“The installed system does not interfere with the process, which is paramount in any waste heat recovery installation, so we should all be proud of this joint achievement.”

Prof. Hussam Jouhara,
ETEKINA Technical Coordinator, Brunel University London, UK

PARTNERS

Ten companies and institutes from across Europe have joined forces to improve the energy performance of energy intensive processes.

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