# Interview: How waste heat recovery will change the landscape

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Each year industries across Europe allow a valuable source of heat energy to simply escape out their chimneys. An EU-funded project called ETEKINA has reimagined a decades-old technology called heat pipe heat exchangers that allow companies to re-use the heat they generate. So far three sites that installed the prototype technology have slashed their fuel costs by 40%—an aluminum casting production plant in Spain (Fagor Ederlan), a steelworks in Slovenia (SIJ Metal Ravne) and a ceramic producer in Italy (Atlas Concorde).

Hussam Jouhara, a professor of thermal engineering at Brunel University London is the technical coordinator of the project and shared his thoughts about the project with ESCI.

Interviewer: Professor Jouhara, you and the team in the ETEKINA project have found a way to add a new type of heat exchanger to recover heat from one industrial process and reuse it in another part of the factory. What's at the core of this technology?

Hussam Jouhara: A heat pipe is a thermal superconductor. The key is you don't need to force a fluid using pumps or fluid piping between the hot region and the cold regions to facilitate the heat transfer process. The heat pipe itself can do that in a passive manner as long as you allow it access to the hot stream and the cold stream under the correct heat transfer conditions.

When you look at the system from the outside, it looks rather simple. Tubes come in between two chambers, and these tubes are just absorbing the heat and delivering the heat to where it is required. But if you look deeper inside each tube, you have a very complex science. You're dealing with two phase heat transfer—liquid changing its phase from liquid to vapor and in the process carrying the latent heat to deliver it to the condenser section where this vapor condenses, which then heats the heating fluid.

## Can you give some examples about the different

## liquids you may be using or the different materials?

In the ETEKINA project we used two fluids inside those heat pipe systems. One fluid is ultra-pure water. But when we have high temperature applications, we also have fluids that are capable of being used effectively inside the heat exchanger itself to make the heat pipes function safely. As these fluids are confined inside the system, there is only a small amount of them that is being used.

## The ETEKINA project started four years ago. What was your intention for the project? What started you on this idea?

The idea of putting the ETEKINA project together was really just to demonstrate the importance and the potential of the heat pipe technology and how it can be used to recover waste heat from very challenging streams that other conventional systems couldn't manage to recover and reuse the heat that is being recovered in the plant itself. This then leads to reducing the plant's carbon footprint and reducing the energy demand and enhancing the plant energy efficiency in general.

I do also think that ETEKINA is contributing by enhancing the efficiency of these systems, using the right technology that will facilitate that. The target for ETEKINA was 40 percent recovery of the available heat that is being wasted from the exhaust streams. I am pleased to say that after four years and having installed the three units, the consortium managed to get the 40 percent as the minimum.

We are actually above that in all three demo cases. This is something that is a pleasure to report, and it is a success for the whole consortium.

The other intention was to deliver a high TRL heat pipe heat exchanger design that can be delivered directly to the wider industrial community. In addition to that, the involved RTDs in this project have developed system modeling capabilities that can help any interested industry in modeling various waste heat recovery options to achieve the highest thermal efficiency possible.

## I think it's a critical question—why is it that it's only now that we have been able to design, build and implement this heat pipe technology? The principle is around forty years old.

You must have a proper understanding of the chemistry. You must understand the material science. You must have proper understanding of the business case to ensure this is something that will make a proper business sense to any company that will adopt it. You have also to understand very complex heat transfer phenomena; mainly two-phase transfer, two phase flow, complex terms. You need to combine the knowledge of all of these to comprehend the requirements for the design.

And it's been a real pleasure working closely with our manufacturing company in Wales in the UK to develop the capabilities of manufacturing those heat pipes. We design the manufacturing process and installation together.

## Can you give some examples of what you mentioned the heat pipe technology will be dealing with, for example the steel case? Do you know what kind of temperatures we are dealing with? What is the situation in a steel furnace?

We have a demo case in Italy—the Ceramic producer Atlas Concorde—and the requirement is to provide high pressure hot water up to a hundred and seventy degrees for use in the process itself in various areas. And this water will be heated using the waste heat that we recovered from our heat exchanger.

The unique feature about the heat exchanger we built was that the exhaust stream is running through a section which is at near atmospheric pressure. So, there is no real investment that you need for high pressure equipment on the exhaust stream, which makes the system cost effective. In addition, we have managed the fouling that is expected as of the particulate loading in this exhaust.

The steel works SIJ Metal Ravne in Slovenia have requirements for multiple heat sinks. The heat sink fluids are the fluids that are being heated from the heat that is recovered. So, in Slovenia, the unit there had two heat sinks. The first recovers the heat from a high temperature exhaust coming in, and this heat has direct use in preheating air that is used in the combustion chamber, which will directly lead to reduction in the fuel that is being used to give them the temperature they require in the process.

This exhaust will leave that section with enough energy also that can be recovered to heat water to 90 degrees. The company is not only reusing the heat, that they recover. It also exporting energy to the wider area, making it more integrated with the community.

As for the aluminum alloy production line Fagor Ederlan in Spain, which is the unit in one of our partners facilities, that unit is dealing with very high temperatures. High temperatures that usually require very complex designs and a very iterative approach to ensure that under any circumstances you don't have any cross-contamination between the two streams, and you manage the high temperature to give the process high temperature heats and fluid to that they can use in the process. It is something that we actually managed in ETEKINA in a cost-effective way and successfully installed the unit.

Each of the units that we delivered in this project dealt with a complex and challenging exhaust stream in a specific way. That's what is so unique about the heat pipe technology. It can deliver solutions to complex scenarios.

**Also, from an investor point of view you have amazing numbers.**

In this project it's not only an academic challenge. It is an applied project. We had to deliver three systems with a return on investment figure within 24 months or less. Otherwise, we can't convince the wider industry to adopt it.

Therefore, as you said, the business case for the units was rather amazing, and the validation came from the data that we collected so far. We are achieving our goal if these units are to be installed or designed for a similar process anywhere in Europe or worldwide.

## So what's next? Are we going to save the world with this technology?

Well, I'm hoping so. The thing is nowadays in Europe, if you think about our continent, the cost of emissions is extremely expensive. The interesting thing about this project is that halfway through ETEKINA and running some experiments in one of the sites, we realized that we could do even more things with this technology.

While working in this project and working with very capable partners, we unlocked another idea that we are now exploring under another project. And that project hopefully will save the world again because it will not only recover the wasted heat, but it will also recover wastewater.

## And what kind of exploitation do you see for ETEKINA on a commercial level?

Now we have a technology that is at the right technology readiness level (TRL) that will enable the manufacturer in this case, Econotherm, to have much wider markets to deliver these units to industries at the right business case level.

You can still see chimneys emitting vapors. It does tell you that there is something else that we can do, and there is something we can do to eliminate those chimneys and recycle everything in the plant itself, which is not a dream. It can be a reality with the right approach.

## What kind of impact does ETEKINA have on academia?

We had the target of delivering new solutions for well-established, leading industries in their fields. But in parallel, we work together as universities and research institutes.

For example, we have achieved new modeling capabilities. Usually, these modeling capabilities make for very expensive research. That is, if it is to be done in the lab, it would be extremely expensive to be able to do that research and using IT equipment. And we had these published.

These are now available to the wider research community everywhere in the world who have access to these articles. That makes the makes ETEKINA as useful to academia as it was useful for the industrial sector.