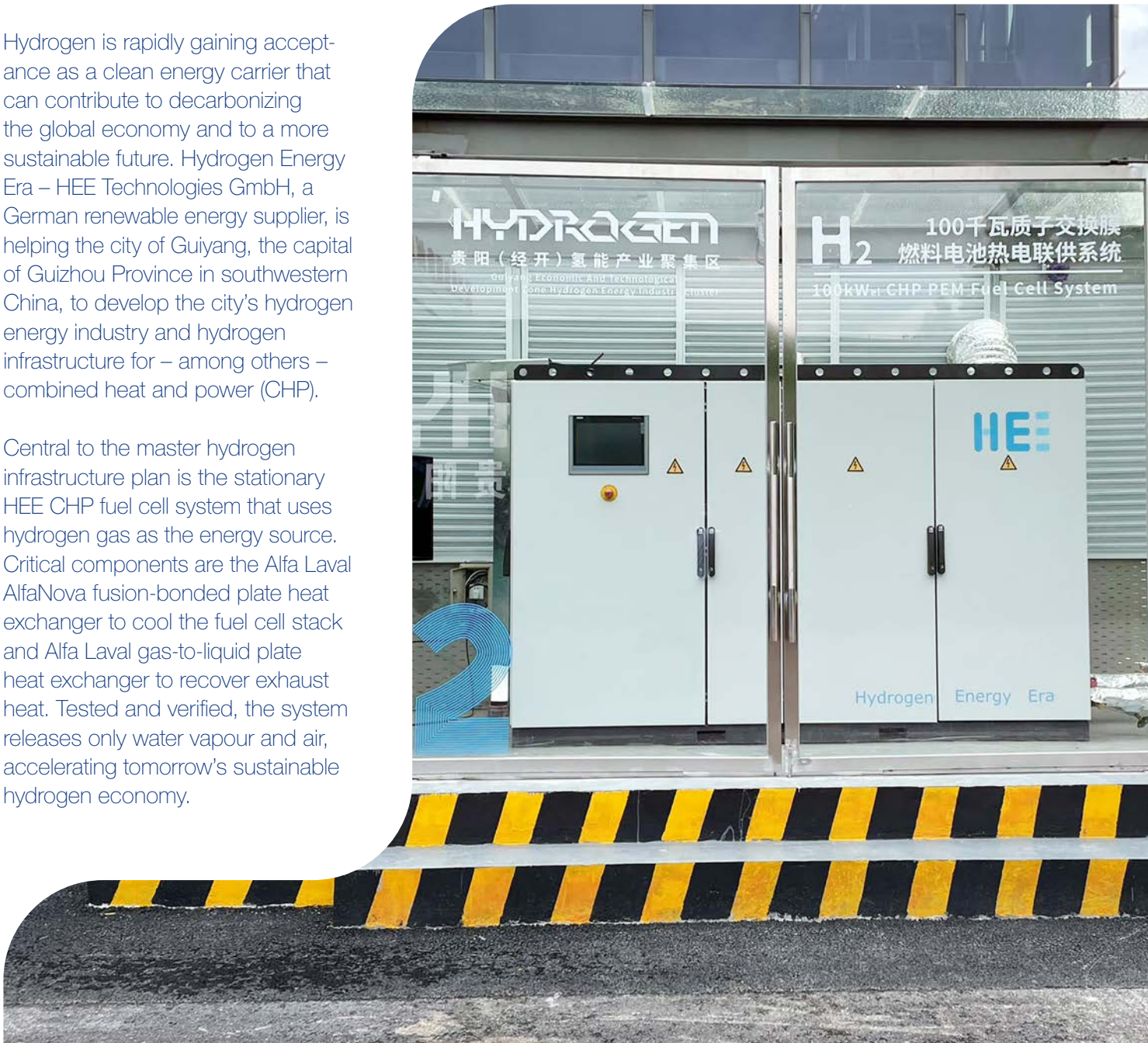
CASE STORY

Hydrogen-based fuel cells spur the transition to combined heat and power based on renewables

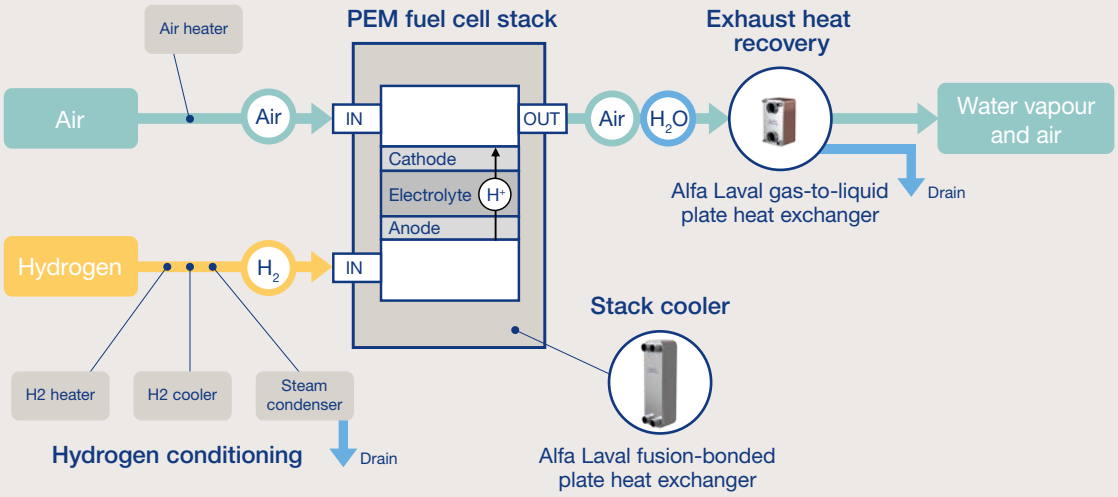
HEE Technologies GmbH, Germany

Hydrogen is rapidly gaining acceptance as a clean energy carrier that can contribute to decarbonizing the global economy and to a more sustainable future. Hydrogen Energy Era – HEE Technologies GmbH, a German renewable energy supplier, is helping the city of Guiyang, the capital of Guizhou Province in southwestern China, to develop the city's hydrogen energy industry and hydrogen infrastructure for – among others – combined heat and power (CHP).

Central to the master hydrogen infrastructure plan is the stationary HEE CHP fuel cell system that uses hydrogen gas as the energy source. Critical components are the Alfa Laval AlfaNova fusion-bonded plate heat exchanger to cool the fuel cell stack and Alfa Laval gas-to-liquid plate heat exchanger to recover exhaust heat. Tested and verified, the system releases only water vapour and air, accelerating tomorrow's sustainable hydrogen economy.



Schematic diagram of a generic hydrogen fuel cell system



Hydrogen flows into the stack, generating electricity. The Alfa Laval fusion-bonded plate heat exchanger cools the stack; the Alfa Laval gas-to-liquid plate heat exchanger recovers heat from the warm air for reuse. Only water vapour and air are released.

Enabling the hydrogen economy

Established in 2018, HEE is realizing its mission to secure a clean energy future by developing, validating and implementing safe, affordable, and sustainable energy solutions based on hydrogen.

"The rapid transition to renewable energy systems is urgent," says Stephan Duch, Managing Director, HEE. "Hydrogen will play a vital role in helping the world reduce its dependency on fossil fuels and move towards net-zero emissions."

Sourcing critical components for the HEE CHP fuel cell system initially proved challenging. The Alfa Laval gas-to-liquid and the 100% stainless steel Alfa Laval AlfaNova fusion-bonded plate heat exchangers were clear choices for exhaust heat recovery and stack cooling.

"We approached Alfa Laval based on its expertise, solid track record, proven plate heat exchanger technology, ability to ramp up to commercial-scale production, and shared vision of accelerating the transition to renewable energy," says Mr. Julius Jelden-Thurm, Co-Chief Technical Officer, HEE.

Size was a crucial parameter for the HEE CHP fuel cell system since its design is derived from similar automotive industry systems. The gas-to-liquid plate heat exchanger stood out as a solid choice as an exhaust heat recovery unit due to its ultra-compact design, high efficiency, exceptionally high performance, and superior thermal fatigue resistance.

The same is true of the 100% stainless steel Alfa Laval AlfaNova to cool the stack while ensuring process cleanliness.

Best price-to-performance ratio

Small footprint, durability and high thermal efficiency were the primary considerations in selecting Alfa Laval gas-to-liquid and fusion-bonded plate heat exchangers for the HEE CHP fuel cell system. The price-to-performance ratios were convincing.

"The Alfa Laval plate heat exchangers delivered solid performance at 20% lower costs than comparable units, our analysis showed," says Mr. Jelden-Thurm. "So the decision to move forward with Alfa Laval was easy. Plus, both have unique design features that have proven fundamental to the success of our stationary CHP fuel cell systems."

Meeting hydrogen-powered CHP requirements

Compact and durable, the Alfa Laval gas-to-liquid plate heat exchangers minimize the overall footprint and associated installation costs of the HEE CHP fuel cell system. The plate heat exchangers feature asymmetrical channels with dimple-pattern plates on the gas side to accommodate a large flow of gas and high heat transfer efficiency. This proved the best overall solution to meet the application demands. The brazing material holds the plates securely together at the contact points, ensuring optimal heat transfer efficiency and pressure resistance. Moreover, the footprint of the gas-to-liquid plate heat exchanger is 75% smaller than comparable shell-and-tube units and much smaller than other plate heat exchangers HEE considered.

Keeping the fuel cell stack cool is paramount for safe, reliable and efficient operation. Process cleanliness is another key consideration. The Alfa Laval AlfaNova stack cooler, made of 100% stainless steel, minimizes ion leaching and subsequent corrosion and system degradation.

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“The AlfaNova fusion-bonded plate heat exchanger was the obvious choice for cooling the stack,” says Mr. Jelden-Thurm. “It ensures the high-purity water used as the cooling liquid has low conductivity, a must for the fuel cell system.”

Patented Alfa Laval AlfaFusion bonding technology provides superior mechanical strength and efficient heat transfer even when the temperature differential between the hot and cold media is small. This results in savings in energy costs. Another plus: it is fully recyclable at the end of its service life.

From pre-series to serial production

Validating the pilot HEE hydrogen fuel cell system paved the way to pre-series production ramp-up through a joint venture with the city of Guiyang and local and regional industrial partners. Construction of a manufacturing plant for the HEE CHP fuel cell system is underway. HEE recently ordered additional Alfa Laval plate heat exchangers for delivery at its Guiyang production facility and anticipates scaling up to serial production in two years. The aim is to supply and connect the fuel cell systems to the residential district heating grid as part of Guiyang’s renewable energy solutions.

“Right now, we are using hydrogen reformed from fossil fuels but plan to shift to hydrogen sourced from municipal sewage sludge gasification and water electrolysis powered by green energy once the infrastructure is in place,” say Mr. Jelden-Thurm. “However, there are no local emissions from our fuel cell systems since it is a closed system that releases only water vapour and air.

More than 100% total system efficiency

Most fossil fuel-based CHP systems typically achieve a total efficiency of 65–80%, according to the U.S. Environmental Protection Agency. HEE estimates that its hydrogen fuel cell has a maximum electrical efficiency of approximately 55%.

“The HEE CHP fuel cell system can reach a total system efficiency of 105% using conventional calculation methods,” says Mr. Jelden-Thurm. “Factoring in the additional 30–40% efficiency due to thermal energy recovered from stack cooling and 15% from exhaust heat recovery, the Alfa Laval plate heat exchangers are vital to increasing the overall efficiency of our system.”

Note: The calculations in the paragraph above are based on HEE’s pre-series CHP units and must be verified over the long term. The actual electric and thermal output will vary depending on the application.

The HEE CHP fuel cell system will provide hydrogen-based electricity and district heating to the city of Guiyang.

The HEE CHP fuel cell system

Collaborating for a clean energy future

Given the success of the joint venture in Guiyang so far, HEE is optimistic about the future. Other local and regional authorities across China have followed progress with interest.

"We anticipate active involvement in other joint venture agreements in China and plan to replicate the Guiyang business model elsewhere," says Mr. Duch. "We also look forward to supporting Germany in its efforts to achieve energy self-sufficiency from renewables and move away from reliance on fossil fuels."

"The Alfa Laval exhaust gas heat recovery unit and stack cooler are critical components in our stationary CHP fuel cell system. They are fundamental to our success," adds Mr. Jelden-Thurm.

> "We have come to rely on Alfa Laval and trust our collaboration will continue well into the future."
>
> Mr. Julius Jelden-Thurm, Co-Chief Technical Officer, HEE

Sustainable solutions for a better world

HEE and Alfa Laval are both working to meet tomorrow's energy demands while reducing the global reliance on fossil fuels. The HEE CHP fuel cell system, with the Alfa Laval exhaust gas heat recovery unit and fusion-bonded plate heat exchanger for stack cooling, is promoting the use of hydrogen as an energy carrier for commercially viable renewable energy.

Alfa Laval is advancing innovative energy solutions, accelerating the transition to a cleaner and more sustainable future. These solutions help reduce emissions and improve energy efficiency, while promoting more responsible use of natural resources. As always, Alfa Laval stands ready to support the fuel cell industry to meet growing global demand.

To learn more about Alfa Laval's fuel cell solutions, please visit: www.alfalaval.com/fuel-cells

The HEE CHP fuel cell system	
Electricity output	100 kW, 400V AC 50/60 Hz
Thermal output	130 kW, ~70°C
Hydrogen quality	Compliant with ISO 14687-2 and SAE J2719

To find out more about HEE's solutions for clean electricity and heat, please visit: www.hee-technologies.com

The Alfa Laval gas-to-liquid plate heat exchanger

The Alfa Laval AlfaNova fusion-bonded plate heat exchanger