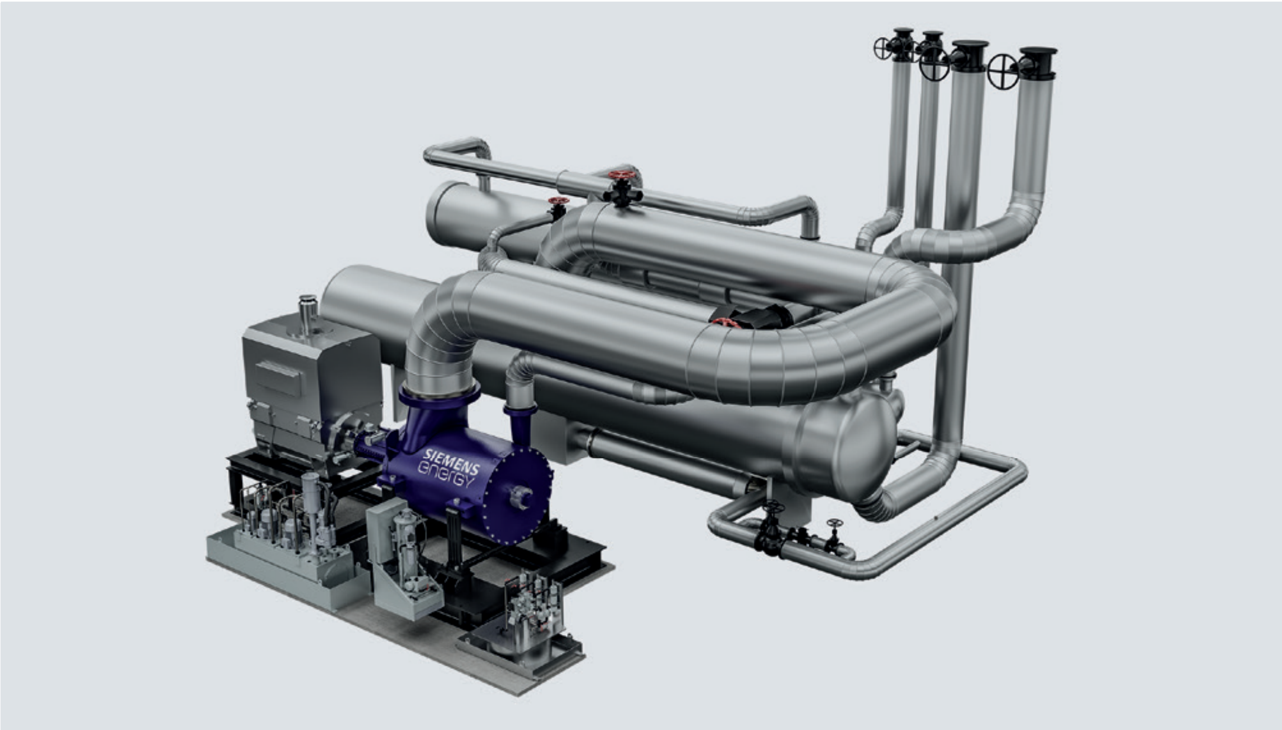


A high-temperature heat pump will make the most out of waste heat Source: Siemens Energy

# Making the Most of Waste Heat

Before the end of 2022, at Potsdamer Platz in the German capital Berlin, a novel high-temperature industrial heat pump will start supplying the city's district heating system with net-zero heat. This is a pioneering project on the way to decarbonizing heat.

No doubt, it's got a quirky name: "Qwark$^3$". It's actually the German acronym for "Quartiers-Wärme-Kraft-Kälte-Kopplung", which in English translates as "Coupling of district heating, power, and cooling". Though it may sound complicated, Qwark is a very real and straightforward pilot project for decarbonizing heat right at the heart of Berlin.

As a joint project between Vattenfall Wärme Berlin AG and Siemens Energy, Qwark$^3$ aims to prove that it's possible to use large-scale heat pumps for urban district heating in a way that not only helps to achieve Berlin's net zero goal by 2050 but can also make economic sense. How? Essentially, by efficiently utilizing waste heat, which would otherwise go unused, together with electricity from 100% renewables. It will generate $CO_2$-free heat for the urban infrastructure it's embedded in. And could Qwark$^3$ be a blueprint for other cities? The Bundesministerium für Wirtschaft und Klimaschutz (German Federal Ministry for Economic Affairs and Climate Protection) endeavors to answer this question and is therefore funding the pilot project.

For sure, it's only just one small building block that aims to make its contribution to the world's ambitious decarbonization goals. Today, as most countries are aiming for net-zero emissions by mid-century, energy demand is expected to rise significantly at the same time. In the EU, the target is to increase energy efficiency by 32% while reducing emission by 40% by 2030.[1)]

But as small as the project in Berlin may seem at first glance, it also leads towards bigger things, of which the decarbonization of heat is crucial for achieving net zero. Today heat accounts for about half of the total energy consumption in the EU. Two-thirds of this heat is still generated by fossil fuels. At the same time, more and more fossil-fueled power stations generating heat are taken offline. So, the decar-

1) https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2030-climate-energy-framework_en

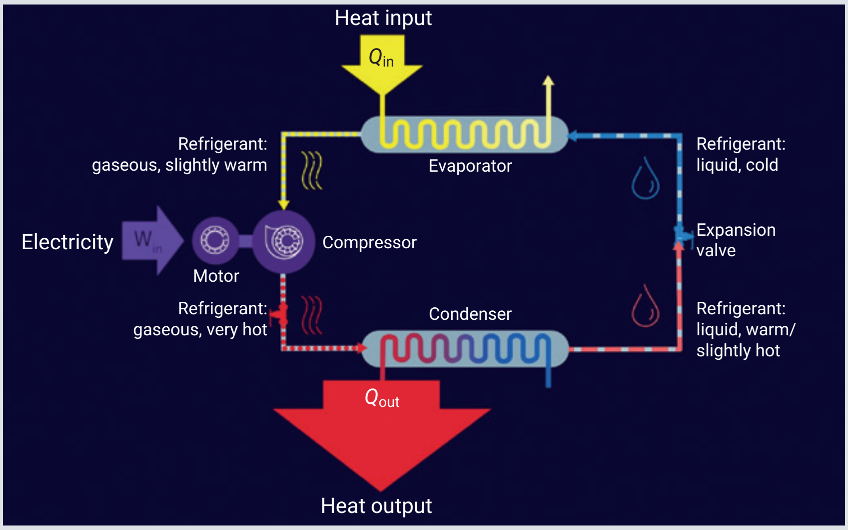


Figure 1. Working principle of a heat pump Source: Siemens Energy

bonization of the heat sector will inadvertently be a central component of the energy transition.

And unsurprisingly, it also warrants a special focus on industry – and consequently, industrial scale heat pumps. Within the EU, industry accounts for a quarter of energy consumption and 20% of direct emissions. Heat is the most prominent energy, as roughly two-thirds are being applied in glass, steel, chemical or paper industries.[2]

Heat pumps operate based on a simple working principle (figure 1): With a certain amount of additional energy, in most cases electricity, they lift temperature from a low-temperature heat source to a usable level at the heat sink or consumer. Thus, they generate much more heat than a direct conversion of electric power to heat.

This also shows how heat pumps can foster decarbonization. It's a two-step process. First, the heat supply is greenified by using renewable electricity instead of generating it with fossil fuels. Second, this sector coupling of green electricity with heat is much more efficient than direct electric heating.

And this technology can be deployed in all kinds of environments, as heat pumps can make use of various heat sources, such as industrial waste heat generated by a chemical plant or a data center, geothermal heat sources, ambient air, or even rivers or the sea They can be used in diverse contexts, such as industry, district heating or individual buildings.

Unsurprisingly, that's why heat pumps are expected to be deployed at a large scale in the coming years, paving the way for electrifying the heat sector. Currently, heat pumps in Europe are mainly used in smaller units for heating and cooling buildings. They're mostly limited to a temperature range below 90 °C and expected to be used on a much larger basis than today. In Germany, for instance, the Federal Ministry for Economic Affairs and Climate Protection expects around 5.5 million heat pumps installed mostly for individual buildings with around 33 TWh by 2030, compared to 7 TWh today.

Yet recent developments, especially new refrigerants, have facilitated new heat pump applications with temperatures of up to 150 °C. These are called high-temperature heat pumps. They can help industry capture waste heat and reuse it to provide hot water or steam for process heating. In steam production, this temperature limit can even be further pushed e.g., by applying steam compression. These heat pumps can also be used for district heating or effectively raising low temperature levels of available heat sources to the level of district heating.

This is where Qwark[3] comes in. In future, Siemens Energy's large-scale heat pump at Potsdamer Platz utilizes waste heat very efficiently by upgrading and feeding it into the city's district heating network. But in Berlin, where no classical industrial plant can be found, where does the waste heat come from?

Since 1997, a cooling plant by Vattenfall Wärme Berlin close to Potsdamer Platz has been supplying cooling to around 12,000 offices, 1,000 housing units, and numerous cultural institutions in the area (figure 2). In doing so, it produces considerable amounts of waste heat that have so far been dissipating into the air through cooling towers. But by installing a high-temperature heat pump with a thermal capacity of up to 8 MW, this waste heat will be put to good use. The large-scale heat pump will flexibly deliver flow temperatures between 85 and 120 °C, according to the demand in the district heating network.

The heat should amount to about 55 GWh per year, with an estimated annual saving of about 6,500 t of $CO_2$ emissions and 120,000 $m^3$ of cooling water. It's a win-win situation, as it improves the efficiency of the cooling station while providing

[2] https://www.sintef.no/globalassets/sintef-energi/industrial-heat-pump-whitepaper/2020-07-10-whitepaper-ihp-a4.pdf

Berlin with green heat from renewable electricity. Moreover, it's one of the first trials for such large-scale, high-temperature heat pumps under real conditions.

And Siemens Energy is in a good position to supply this kind of solution. In the field of industrial heat pumps, the company has been offering solutions with thermal outputs of up to 70 MW from one unit. The company can also look back on numerous large heat pumps installed in the 1980s and 1990s, mainly in Scandinavian countries. Also, the contribution goes beyond mere hardware delivery, as Siemens Energy offers comprehensive turnkey solutions from conceptual design to installation, commissioning and maintaining large heat pumps by using its own compressor portfolio.

Berlin may be the first to experience such an exciting pilot project, but it's not the only one pushing for large-scale high-temperature heat pumps for district heating. In Germany today, several large-scale heat pump projects are actively aiming for district heat temperatures below 100 °C. Additionally, strong partnerships are forming with the goal of going beyond district heating. For instance, chemical giant BASF is partnering with Siemens Energy to investigate how high-temperature heat pumps can be used to decarbonize process heat generation at their headquarters in Ludwigshafen in Germany.

Keeping all this in mind, it's easy to see how this model of using large-scale high-temperature heat pumps can and should be widely adopted. As with any transition, of course, there are also caveats. The demand for district heating is unsurprisingly higher in winter and lower in the summer. To balance this out, different solutions are conceivable. For instance, one can consider connecting district heating with more steady industrial heat demand (which is feasible due to high temperature heat pumps) or storage to match heat supply with demand. Regardless of these factors, in the case of Berlin and other pilot projects, the net saving of $CO_2$ emissions is still high enough to justify the effort. And based on the calculations, it'll also be profitable within a few years.

Another important concern: If, as expected, more heat pumps, large and small, get installed, the overall electricity demand will go up. This would certainly pose a three-fold challenge. One: Energy should come from renewable sources to ensure the necessary move towards heat decarbonization. Two: As renewables are a fluctuating source of energy, energy storage solutions as well as power plants fired with clean fuels safeguarding baseload need to be in place. Three: As more electricity is consumed, grid stability services need to be in place, regardless of whether they're rotating grid stabilizers, or smart controls for distributing energy.

Finally, today large-scale high temperature heat pumps are still at an economic disadvantage compared to traditional gas-fired systems. But this can be expected to change especially with rising $CO_2$ prices. But that's not the only tool available. In Germany, for instance, the surcharge for electricity consumers must be put an end to. Though surcharging was initially implemented for the purpose of funding renewable energy generation, this could soon become obsolete, as heat pumps are expected to amortize within a few years.

Essentially, Qwark$^3$ has to offer quite a lot. As a model for the future, it shows how large-scale heat pumps can minimize heat wasted to the environment, thereby ultimately increasing the overall efficiency of an entire system. As will be seen at Potsdamer Platz, they also enable the smart integration of heating and cooling. And the best part: it's just one of many ways industrial heat pumps can help move towards a decarbonized future.

Figure 2. Vattenfall's cooling plant at the heart of the German capital

Source: Vattenfall


**Dr. Christian Huettl**
Business Owner Industrial Heat Pump Solutions, Siemens Energy Global GmbH & Co. KG, Erlangen, Germany
**support@siemens-energy.com**
www.siemens-energy.com