NRP Energy
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Project

Pilot of adsorption heat pump

Where waste heat can be better utilised

Where waste heat can be better utilised

At present, waste heat is not used in many places – partly because its temperature is too low for it to be utilised directly. This could be changed with the help of adsorption heat pumps. The systems can bring heat to the desired temperature without the need for additional electricity. Physicists from the University of Applied Sciences and Arts of Western Switzerland have now investigated the applications in which heat pumps would generate the most added value.

The Hagenholz waste incineration plant in Zurich (right), together with the Aubrugg wood-fired power plant (left), supplies most of Zurich's district heating grid. However, a lot of heat energy is still lost elsewhere. This could be utilised with the help of adsorption heat pumps. *Source:* Wikimedia/Marc Forster

At a glance

- So-called adsorption pumps could in future ensure that more waste heat is collected and reused. However, their introduction has so far failed. This is because, among other reasons, there have been no well-thought-out scenarios for their application.
- For this reason, researchers from the University of Applied Sciences and Arts of Western Switzerland have analysed where such heat pumps could best help to make more efficient use of heat as a resource. They drew up four promising scenarios and determined the technical requirements for the systems.
- If adsorption heat pumps were used across Switzerland in just the considered scenarios, emissions of greenhouse gases would fall by up to 5 %.

In Switzerland, a lot of energy is still lost in the form of waste heat. In some places, waste heat is already being used, for example from waste incineration plants. It can be used to heat buildings or even entire districts. However, valuable waste heat from factories or computer centres still escapes into the air. One of the reasons for this is that the temperature of the heat is often too low for it to be used directly. So-called adsorption heat pumps could help here in future. Similar to conventional compression heat pumps, they can collect and increase heat. Furthermore, adsorption heat pumps have an advantage over compression heat pumps: they require almost no electricity and instead use heat as a drive source.

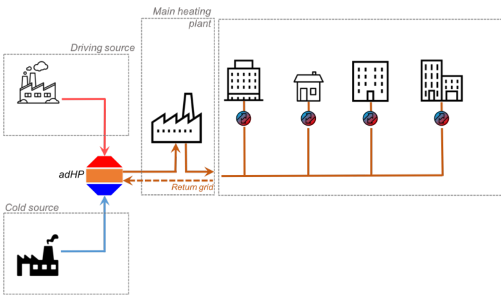
Until now, however, the systems have been relatively expensive. There have also been no well-thought-out scenarios that showed in which existing heating infrastructures the systems could be best integrated. For this reason, Stéphane Citherlet, a physicist at the University of Applied Sciences and Arts of Western Switzerland in Yverdon, has worked together with his research team to evaluate possible applications in practice and to determine which technical requirements the heat pumps would have to meet in each case. The work was completed as part of the joint project “Heat utilisation with solid sorption technology” in which further sub-projects looked at the further technical development of the systems, their influence on the environment and their economic viability. The aim of the joint project was to develop the adsorption heat pumps as far as possible to market maturity.

Making better use of heat as a resource

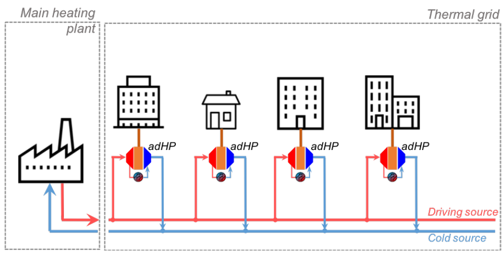
In future, the systems will help to reduce emissions of the greenhouse gas CO_2 and lessen our dependence on nuclear energy. In Switzerland, the energy used to heat and cool buildings or industrial processes still primarily comes from fossil sources – and accounts for more than half of total energy consumption. If we look at electricity consumption separately, 40 % of this is used for heating and cooling rooms or materials. At present, around half of this electricity still comes from nuclear power plants. “That is why it is worth using thermal energy more efficiently than before”, says Citherlet. “One way to do this is to use waste heat with the help of adsorption heat pumps”.

To find the best application scenarios for the heat pumps, the researchers initially created a computer model in which they depicted the technical and thermodynamic properties of such systems. They also calculated the unused potential for waste heat across Switzerland. And they determined what temperatures district heating grids and various other possible consumers require. For example, when it comes to heating, there is a difference between modern buildings with underfloor heating and older, less well insulated houses with radiators.

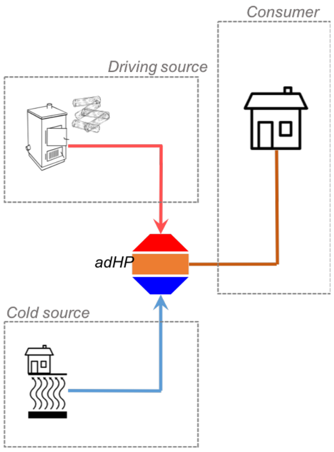
Generating the desired temperature



Scenario 1: The heat pump (given the abbreviation adHP in the illustration) upgrades waste heat from industrial plants with a low temperature and generates the appropriate temperature for the district heating grid. This means that a comparatively small amount of waste heat – as shown in the image from the second, colder industrial plant – can also be used. Citherlet et al.

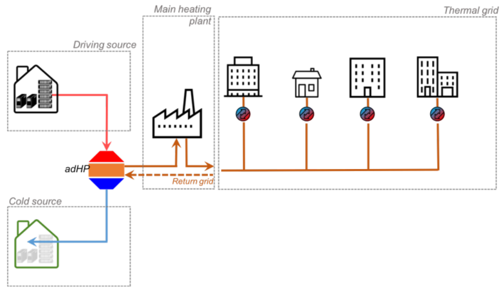


Scenario 2: Here, heat pumps connected directly to the buildings reduce the temperature from the district heating grid to a suitable heating temperature. At the same time, this increases the capacity of the entire heating grid, meaning more heat is used efficiently. Conversely, the same scenario could also be used to increase low temperatures from waste heat for heating. Citherlet et al.



Scenario 3: Linked to a wood pellet heater, the system gets the most out of the produced heat. For modern buildings with underfloor heating, it lowers the heating temperature, while it can increase the heat for older buildings with radiators. A scenario that also ensures the more efficient use of heat away from centralised district heating pipelines. Citherlet et al.

In these scenarios, the heat pump has to manage different input temperatures and generate different target temperatures. “The processes and working temperatures inside the system change accordingly," says Citherlet. Here, the input heat is initially used to evaporate water. The water vapour is then fed into a heat exchanger and adsorbed and compressed inside by a sorption material. This further heats the steam – increasing the heat. The hotter steam is then condensed back into water. Finally, it can transport and release the gained heat.



Scenario 4: Just like conventional heat pumps, adsorption heat pumps can also work in the opposite direction for cooling. This fourth scenario includes all such cooling tasks. The researchers took a closer look at two case studies: the cooling of water for the cement industry and the cooling of a computer centre – each using its own waste heat, meaning that no additional energy is required. Citherlet et al.

From scenarios to technology

In order to use the heat pumps in the various scenarios, it is necessary to adjust the three working temperatures of the systems accordingly – the high, medium and low temperatures. For each of the four scenarios, the researchers calculated which working temperatures provide the highest efficiency. For example, the optimum temperatures for the first scenario are 95, 40 and 16 degrees Celsius, while for the second scenario they are 82, 58 and 48 degrees Celsius. The researchers passed these working temperature requirements onto the teams in the associated sub-projects, where they served as the basis for the technical further development of the systems.

Finally, Citherlet's team calculated how much energy could be saved by the future use of adsorption heat pumps and what impact this would have on the environment. Result: if just the four scenarios were introduced nationwide by 2050, greenhouse gas emissions would fall by up to 5 %.

Produkte aus diesem Projekt

- Project THRIVE: Heat utilisation with solid sorption technology
  Date of publication: 15.07.15
- https://www.flickr.com/photos/ibm_research_zurich/sets/72157651308697141/
  Date of publication: 30.11.-1
- Nutzen statt wegwerfen
  Date of publication: 22.07.15
- Project Poster: Heat Utilization with Solid Sorption Technology
  Date of publication: 30.11.-1
- Tests, simulation and validation of adsorption heat pump applications
  Date of publication: 14.12.18

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