



**Energy**

National Research Programmes 70 and 71

# Project

## Compact adsorption heat pumps



A new type of heat pump helps to use heat more efficiently



## A new type of heat pump helps to use heat more efficiently

At present, little use is still made of waste heat. This could be changed with the help of so-called adsorption heat pumps. These could siphon off and increase waste heat from factories or thermal energy from renewable sources. To date, however, the investment costs of such plants have been very high.

Researchers from the University of Applied Sciences Rapperswil have therefore now developed a new heat pump that is more efficient and thus more economical.



The newly developed adsorption heat pump: in the future, such plants should use waste heat for heating and cooling.  
Source: Institute for Solar Technology, University of Applied Sciences Rapperswil (HSR)





## At a glance

- At present, a lot of energy is lost as waste heat. This thermal energy could be captured with the help of adsorption heat pumps and used for both heating and cooling.
- Until now, the high investment costs prevented the spread of such systems. This is why researchers at the University of Applied Sciences Rapperswil have developed a new heat pump with an improved heat exchanger.
- This is likely to be more efficient and cheaper to operate than all previous systems.

Half of all energy in Switzerland is consumed for the heating and cooling of buildings, the production of hot water or the driving of industrial processes. If we exclusively look at electricity consumption, 40 % of this is used for heating and cooling rooms or materials. And this energy still primarily comes from fossil sources and nuclear energy. "If thermal energy was used more efficiently, this would reduce both CO<sub>2</sub> emissions and our dependence on nuclear energy", says Andreas Häberle, a Professor for Renewable Energies and Environmental Technology at the University of Applied Sciences Rapperswil.

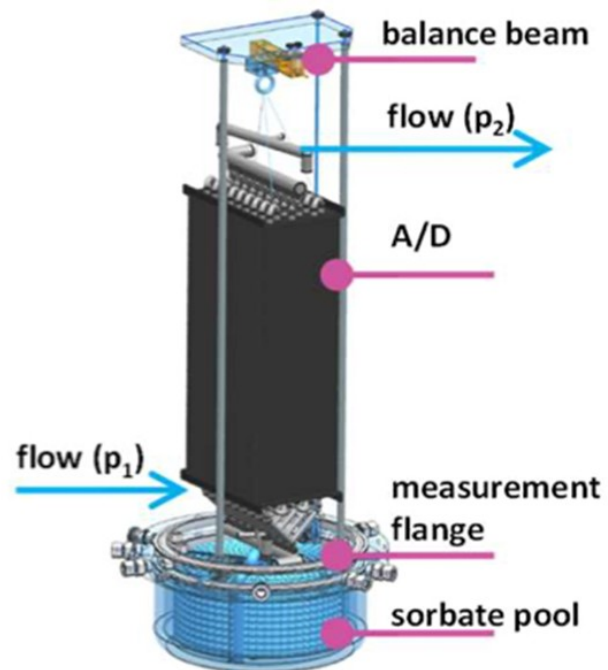
Among other things, more efficient use means making more systematic use of waste heat. At present, valuable heat energy is still lost in many places. This could be collected using so-called adsorption heat pumps. These could, for example, collect waste heat from factories or computer centres or increase energy from solar thermal systems. Until now, however, the use of such systems has failed due to their high investment costs. For this reason, Häberle and his research team have further developed the design of adsorption heat pumps in a sub-project of the joint project "Heat utilisation with solid sorption technology". They equipped the interior of the system with newly developed, optimised components and in doing so improved the heat flow within the system. This makes the newly designed heat pump more efficient and economical than previous systems.

## Heat exchanger as a cost factor

Like the compression heat pumps already widely used today, adsorption heat pumps can also extract heat from their surroundings and increase it. To this end, however, they need a higher initial temperature of 50 to 60 degrees Celsius. They do, however, have a decisive advantage over conventional heat pumps: they require almost no electricity and instead primarily use heat as a drive source.

The process works as follows: the environmental heat is firstly used to evaporate a refrigerant – this is usually simply water in adsorption heat pumps. The water vapour is fed into an adsorption heat exchanger and then adsorbed and compressed inside by a sorption material. This further heats the adsorbed steam and the sorption material. The system now needs some additional thermal energy at a higher temperature to release the hotter steam once more. In technical jargon, this is referred to as desorbing. The heat gained can finally be fed into a heating circuit. However, just like conventional heat pumps, adsorption heat pumps can also work in the opposite direction for cooling.

The most expensive part of such a system is the adsorption heat exchanger. The researchers have therefore newly developed the components of the heat exchanger and initially built and characterised them on a small scale under laboratory conditions. To this end, they constructed a measuring chamber which they were able to place under vacuum. In this measuring chamber, they tested the new heat exchanger element with adsorption-desorption cycles of different lengths and at different drive temperatures. Using a scale installed in the chamber, they determined how much refrigerant was absorbed by the sorption material inside the heat exchanger in each case. For example, the researchers investigated the effects of a drop in pressure and also determined the performance of the heat exchanger during heating and cooling.



The measuring chamber is open in the photo: from the round refrigerant reservoir at the bottom, the steam enters the heat exchanger where it is adsorbed and compressed. At the top, a balance beam measures how much steam is stored in the heat exchanger. SPF, HSR

to transform their tests and evaluations into a research-based scientific application in



In performing their tests and optimisations, the researchers had one specific application in mind: the cooling of a computer centre. Here, they based their activities on the work of another sub-project in which a total of four promising scenarios for the future application of adsorption heat pumps had been designed and evaluated.

## The system becomes larger

After the environmental technicians had optimally adjusted the heat exchanger element for computer centre cooling in the laboratory tests, they increased the scale: they constructed somewhat more efficient elements from aluminium – with a length of 80 centimetres instead of 50 as before – and combined six such elements to create a heat exchanger.

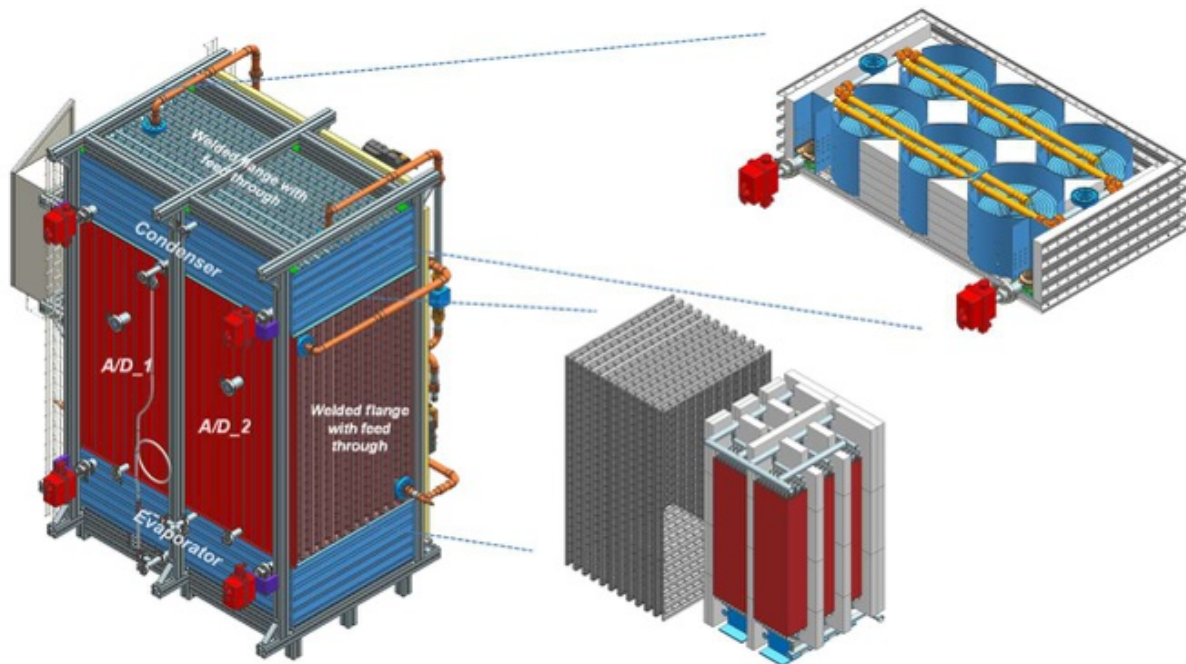




The new heat pump takes shape: Walter Camenisch from the University of Applied Sciences Rapperswil welds the heat exchanger elements together. SPF, HSR

When designing the elements, the team made sure that they could be adapted for different sorption materials. This is because the sorption material inside the heat exchangers is also decisive for the efficiency of the process – a separate sub-project therefore aimed to find a new, high-performance material for the new heat pump. It should be possible to integrate this into the new heat exchangers at a later time.

Häberle's team also developed a new evaporator and condenser. The result was an optimised adsorption heat pump with a cooling capacity of 10 kilowatts. For the sake of comparison, a 160- to 200-square-metre room could be air-conditioned with this output.



Schematic structure of the adsorption heat pump: at the bottom, the evaporator uses the input heat to convert the water into steam. This is then compressed and heated in the adsorption heat exchanger consisting of six elements connected in parallel. In the system, there are two such heat exchangers (A/D\_1 and A/D\_2), which alternately absorb and desorb steam. The warmer steam is now liquefied again by using a condenser at the top of the system. SPF, HSR

The environmental engineers initially tested the new heat pump with a widespread and inexpensive sorption material made from silica gel beads before later doing so with a more efficient but much more expensive organic-metallic material made of aluminium fumarate.

In future, however, the system is to function with the carbon sorption material developed specifically as part of the associated sub-project – and will do so more efficiently and at a lower cost than all previous adsorption heat pumps. According to environmental engineer Häberle, there should thus be nothing more standing in the way of the optimisation and increased introduction of the systems.





## Produkte aus diesem Projekt

- Cooling power determination by measuring the adsorbed vapor mass variations: comparison of mass adsorption cooling power correlation and external fluid loop power measurement  
Date of publication: 07.08.17
- Abwärme nutzen, Strom sparen  
Date of publication: 01.01.18
- Waste not, want not  
Date of publication: 22.07.15
- THRIVE Projekt  
Date of publication: 30.11.-1
- Project THRIVE: Heat utilisation with solid sorption technology  
Date of publication: 26.07.15
- Heat utilization with solid sorption technology  
Date of publication: 24.04.15
- Design and Construction of a 10 KW Sorption Heat Pump Prototype  
Date of publication: 11.04.18
- Adsorption heat pump upscaling from 1 kW to 10 kW of cooling power: experimental based modelling  
Date of publication: 07.08.19



**Energy**

National Research Programmes 70 and 71

## Contact & Team

Prof. Andras Häberle  
Hochschule für Technik Rapperswil  
Oberseestrasse 10  
3.104  
8640 Rapperswil  
+41 55 222 48 22  
[andreas.haeberle@hsr.ch](mailto:andreas.haeberle@hsr.ch)



Andreas Häberle  
Project direction



Walter Camenisch



Xavier Daguenet-Frick

Paul Gantenbein

Patrick Persdorf



Franz Steiner

Albert Trudel



**Energy**

National Research Programmes 70 and 71

All information provided on these pages corresponds to the status of knowledge as of 23.05.2019.