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# Utilization of accumulated heat in roofs

## Energy utilization in agricultural buildings

*As a result of the significant increase in energy prices, the thermal utilization of solar energy has considerably gained in importance. In addition to the use of solar collectors, the utilization of warm air under metal roofs by means of heat pumps is a sensible alternative. Since agricultural buildings often have large roof areas, the energy thus gained can be used to heat service water and for heating purposes.*

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### Keywords

Utilization of heat, solar energy, roof areas

Due to the growing energy prices, solar thermal energy is increasingly gaining in importance in Germany. Solar thermal energy generators are mainly used in the form of solar collectors, solar roofs (by means of integration of collectors into the roof), or energy roofs (utilization of the roof skin as an absorber with an integrated liquid collector).

Simple solar collectors are generally used in order to make solar service water heating in old buildings possible. In new buildings or newly covered roofs on old buildings, however, more and more so-called solar roof- or energy roof concepts are being realized.

In these installations, heat is generated by pipe systems known from flat collector technology, which, however, are technically sophisticated. The creation of so-called energy roofs is a continuation of these solutions. These roofs are generally made out of metal. In their interior, suitable pipe systems are installed, through which a heat carrier (brine) flows, thereby allowing the system to dissipate heat. A heat pump is often used to withdraw the thermal energy from the brine, or the energy is directly used to heat water.

Currently, it is not possible to realize economically efficient solutions for the thermal utilization of solar energy without financial support. This equally applies to both collectors and commercially available solar roof solutions.

Due to the high investment expenses, the costs of solar service water heating are considerably higher than if fossil energy carriers are used, even given the current heating oil price of € 0.60 per litre.

As an alternative to solar heating with the aid of collectors, heat for service water- or support heating could be supplied by a heat pump. Today, geothermal energy is widely used by means of probes and heat pumps, for example. Outdoor air, however, is a very inexpensive heat source, which is easy to use, but which is also subject to significant temperature fluctuations.

#### Functional principle of the utilization of accumulated heat

Based on studies by [1; 2], roof areas covered with a metal roof profile in combination with a heat pump can also be suitable for service water- and support heating in buildings with large roof areas.

It is sensible to replace a classic tile roof by a metal roof because of its good heat conductivity and the very low specific heat capacity of the roof material. Given sufficient radiation power, it was even possible to heat the outdoor air on ice days to a point where a heat pump was able to be operated under these extreme conditions [2]. As compared with the values achieved with outdoor air which has not been pre-heated, air heated in the roof skin allows the performance coefficients of heat pumps to be increased significantly. Due to the low energy prices and the low degree of maturity of heat pump technology, this concept of "accumulated heat utilization" has not been pursued so far.

Therefore, the solar roof idea, i.e. the simple replacement of a classic roof tile by a metal roof, is being examined again under practical conditions. This also seems sensible because the development in the area of metal roofs has meanwhile led to architectonically very interesting and operationally reliable solutions, which can easily be realized in particular with regard to integration into existing building structures. For the future, this would mean that the owner of a building would only have to decide to choose a metal profile roof for his house in order to realize solar-thermal heat generation by means of heat pumps.

#### Pilot system

The utilization of accumulated heat under a roof is currently being studied using a newly built youth hostel of the German Youth Hostel Association in Dahme (Baltic Sea) as an example. The building has large roof areas, which make the utilization of available solar radiation and ambient heat for purposes of heat generation look sensible.

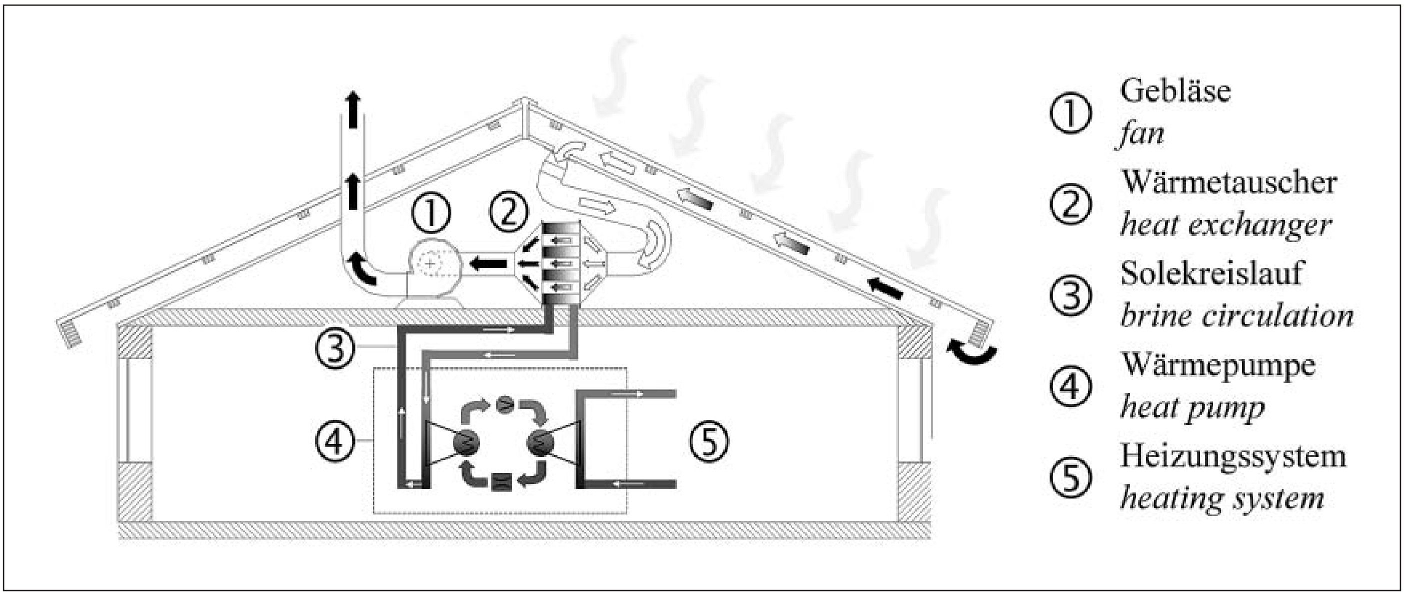


*Fig. 1: Scheme design for heat utilization under metal roofs by a heating pump*

*Figure 1* provides an overview of the structure of accumulated heat utilization. The roof cover acts as an absorber, which is used to convert the available global radiation into thermal energy. The air is sucked in through an inlet at the eaves with the aid of a fan under the roof and led through the roof in the direction of the ridge. The upper side of the necessary air duct consists of a metal roof cover out of dark-coloured aluminium sheets. On the under side, the duct is limited by an impregnated wood-based panel. In the longitudinal direction, counterlathing is placed on top of the roof battens. Thus, the roof battens are lifted such that a duct is created between the roof skin and the wood-based panel. In the flow direction of the air, this duct is narrowed in regular intervals by roof battens installed at right angles to the flow, which allows the flowing air to be whirled even at smaller air speeds. In the ridge, the heated air from the duct flows into a collecting duct, which leads to an air-brine heat exchanger. Through a pipe system, the heat is conveyed from the roof area to the heat pump via a solar circuit in order to give off its energy to the heating circle there at a high temperature level. After the air has cooled off in the heat exchanger, fans blow it out of the building (*Fig. 1*).

The heat pump from the company Spartec (Güstrow) with a rated power of 12 kW is intended to support a 225 kW boiler and thus to replace part of the energy required to heat the service water in the youth hostel. It can be assumed that it will be possible to support the room heating system in particular during the transitional periods in the spring and in autumn. In the summer months, the utilization of the energy from the roof additionally cools the building.

If the temperature of the ingoing air can be increased by 5 to 8 K by using even short phases of sunshine, the economic efficiency and the performance coefficient of the heat pump can be improved due to the smaller temperature differences between the heat source (air) and the heat sink (heating system).

### Economic efficiency and potential

The economic efficiency of accumulated heat utilization largely depends on the performance coefficient of the heat pump, the investment- and installation expenses for the heat pump and the costs of the additional air duct systems. According to our own calculations for the above-described project, the system pays off after 9.5 years given a heating oil price of € 0.60 per litre, an electricity price of € 0.15 per kWh, and a performance coefficient of 3 of the 12 kW heat pump. If a performance coefficient of 4 can be expected, the system would pay off after ca. 6.5 years. Higher performance coefficients, lower electricity prices, and higher expenses for fossil energy carriers shorten the payoff period. $CO_2$ emission reductions, which must also be evaluated monetarily, are not considered in this calculation.

### Conclusions

Heat utilization under metal roofs suggests itself in particular at sunny locations. The utilization of accumulated heat thus allows large roof areas on agricultural buildings to be used to supply energy for service water- and support heating, in particular during the transitional periods.

## Literature


Books are marked with •

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