Best practice

IEA HPP Annex 32

Economical heating and cooling systems for low energy houses

Single-family house with air-to-water heat pump for floor heating emission system and alternate domestic water production

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

Contribution of the Austrian national project

Summary

The Austrian Institute of Technology developed a standardised heat pump monitoring as quality control measure.
This Best Practice Sheet presents field monitoring results of an air-to-water heat pump for space heating and DHW. The system is a split type air-to-water heat pump system, where the evaporator is located on the outside. The space heating emission system is a 309 m^2 floor heating system with maximum design temperature of 40°C. The measured average temperature at the heat pump outlet is 31°C and thus considerably lower.
The space heating emission system is directly connected to the heat pump without a buffer storage. DHW is produced by switching the heat pump to an 800 l storage, which supplies the heat to instantaneously heat the water. The average DHW temperature is 42.5 °C and thus very low.
In heating mode, the air-to-water heat pump yields a good seasonal performance factor of the generator system SPF-G of 3.4. In DHW operation, the seasonal performance factor is with an SPF-G of 3.6 even better and significantly higher than SPF values commonly reached with conventional air-to-water heat pumps. Thus, the overall seasonal performance of SPF-G of 3.5 is high for an air-to-water heat pump.
Compared to a condensing gas boiler of high efficiency the heat pump system can reduce the CO_2-eq.-emission by 58% and reaches an SPF based on primary energy of 2.8. Thereby, a reduction of primary energy of 69% is reached. These values are based on primary energy and CO_2-eq.-emission factors used in Austria.

Building data

- Location: Rutzenmoos, Upper Austria
- 2 inhabitants
- Year of commissioning: 2006
- Medium-weight construction, heated area 309 m^2
- Design heat load (ÖNORM B 8135): 6.7 kW (22 W/m^2)

International Energy Agency
Heat Pump Programme

Background

The Austrian Institute of Technology AIT has developed a standardised monitoring method for heat pump systems in order to enhance the quality management of heat pump installations. The monitoring method is an instrument to prove the functionality and performance of installed heat pump systems. In the course of the IEA HPP Annex 32 project, heat pump systems were tested under real conditions in order to evaluate their efficiency. Therefore, nine conventional heat pump systems and two compact units, which were situated in Upper-, Lower Austria and Styria, had been analysed. The system described in this Best Practice Sheet uses a split-type air-to-water heat pump system with floor heating emission system for space heating (SH) and for domestic hot water (DHW) production.

The front view of the monitored building

Technical concept

The low energy building with a specific heat load of 22 W/m^2 is equipped with an air-to-water heat pump for alternate space heating and domestic hot water production.

The heat pump is a split unit, where the evaporator is installed on the outside and the heat pump inside the building. The nominal heating capacity of the heat pump is 8.3 kW at A2/W35. An additional 2.7 kW direct electrical back-up heating is installed to cover peak loads.

The space heating emission system consists of a floor heating system, which is directly connected to the heat pump without a buffer storage. This avoids additional storage losses and due to the thermal capacity of the floor heating, no problems with cycling of the heat pump are expected. The maximum supply temperature was set to 40 °C during planning to reach an indoor temperature of 20 °C at a design outdoor temperature of -14 °C. However, the surface of the floor heating system is with 309 m^2 quite large. The circulation pump of the distribution system has a nominal electrical power consumption of 80 W.

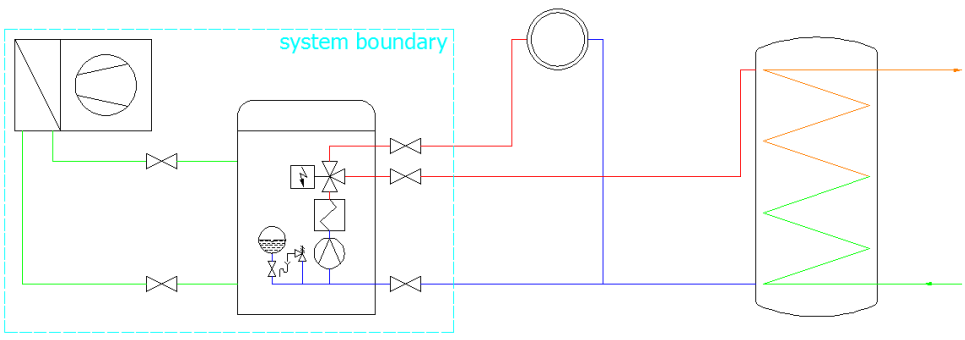
The DHW is produced by switching the air-to-water heat pump from the space heating to the DHW operation. An 800 l storage is included as DHW storage tank.

The DHW is produced by the instantaneous water heater principle. The DHW temperature was set to the relatively low temperature of 45 °C.

Evaporator of the split air- to-water heat pump unit

Market status

The heat pump is available on the market.



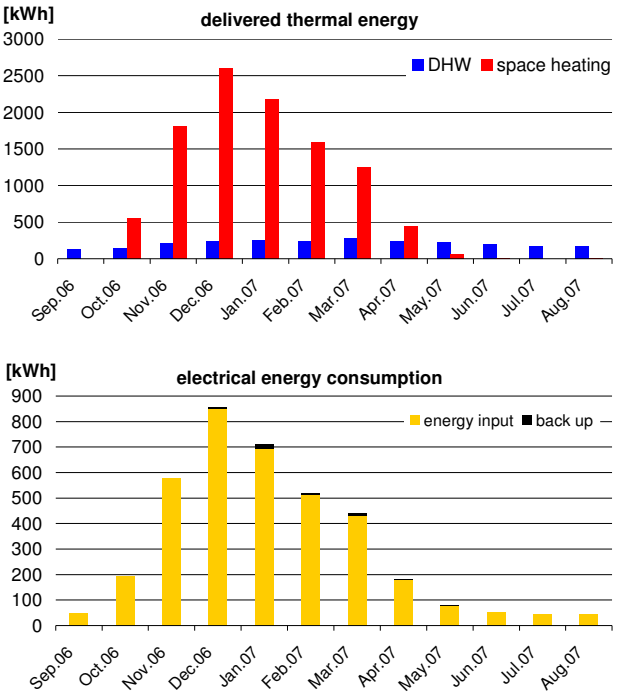
Hydraulic sketch of the space heating and DHW system of the investigated heat pump and system boundary for the performance evaluation

Technical data of the unit

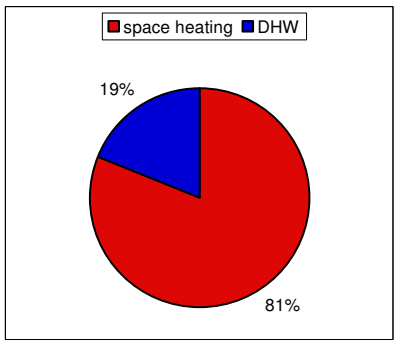
Heating unit:	**air-to-water heat pump with scroll compressor for alternate SH and DHW operation**
	Split unit with evaporator located outside
	DHW production by instantaneous water heating
Thermal output / COP (heating unit):	
A2/W35:	**8.3 kW / 3.5**
A-7/W35:	**6.6 kW / 3**
DHW mode:	
A7/W50:	**8.4 kW / 2.8**
Refrigerant:	**R404A, charge 4 kg**
DHW storage:	**800 l**
Nominal power of the circulation pump	**80 W**

Field monitoring

The system boundary includes the generation system comprising the heat pump and eventually installed back-up heaters as well as the source system.
The monitoring period covers year-round monitoring data from 4. Sept. 2006 - 4. Sept. 2007
The total heat energy produced by the heat pumps in the monitored period is 13036 kWh. 81% of the heat corresponding to 10567 kWh (42 kWh/m^2) are consumed for space heating operation which is lower than the standard building consumption of the period and in the range of a low energy house. The DHW consumption is with 2469 kWh or a fraction of 18% on the lower edge of the typical consumption of a low energy house, but the house is inhabited by only 2 persons. The corresponding electrical energy consumed is 3714 kWh.
The electrical energy consumption of the direct electrical back-up heater occurs mainly in the winter month January and is with 54 kWh (1.5% of total electricity consumption) negligible.
The overall Seasonal Performance Factor of the Generator (SPF-G) of the complete system is 3.5, resulting of a SPF-G in SH-mode of 3.4 and SPF-G in the DHW-mode of 3.6. The SPF-G in the SH mode is quite high regarding the rather high design temperature of the floor heating system of 40°C. However, due to the large area of the 309 m^2 floor heating emission the average supply temperature during the heating operation has been evaluated to 31 °C. The indoor air temperatures are in the range of 22 °C, so sufficient heat is emitted to the room.
The SPF-G of the DHW operation, though, is quite high and even higher than in space heating operation. Due to the instantaneous water heater principle and the large DHW storage of 800 l, it is possible to set a low average temperature for DHW. The design temperature of 45°C is already quite low. During the measurement, however, the average temperature in the DHW storage is with 42.5 °C even lower. Thus, with high outdoor air heat source temperatures the monthly PF-G for DHW in summer time surpass the space heating values in wintertime. With these temperature combinations, the slightly higher SPF in DHW mode can be explained.
Due to the measurement concept, only the total electricity consumption has been measured, and thus the auxiliary energy can be evaluated separately.

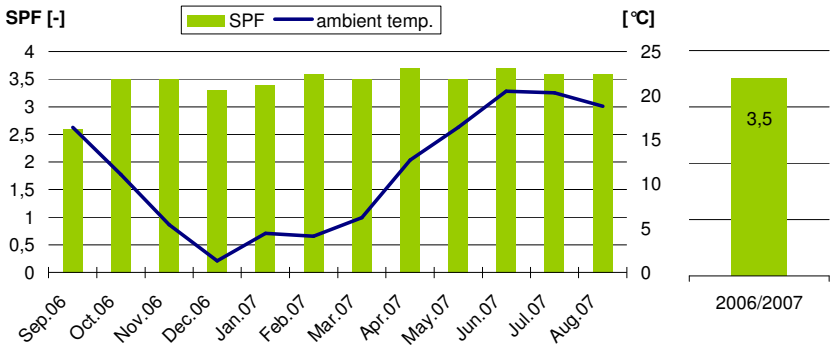


Energy delivered and consumed in 2006/2007



Space Heating:	10567,2 kWh
Hot water:	2469,0 kWh
Total:	**13036,2 kWh**
Total energy Input:	3714,0 kWh

Energy delivered and consumed in 2006/2007



Seasonal performance factor (monthly profile and total value for monitoring period) and ambient temperature (monthly average)

Performance indicators

Seasonal performance factors

Overall SPF-G of the system:	**3.5**
SPF-G heating unit:	**3.4**
SPF-G domestic water unit:	**3.6**

Operation time:

Heating period:	**190 d**
DHW period:	**year-round**

System performance and optimisation

The overall seasonal performance factor of the generator of 3.5 is very high for an outdoor-air heat pump and is higher than typical seasonal performance factors evaluated in other field tests which are in the range of 3.0. In particular the DHW performance is uncommon, but can be explained by the low measured DHW storage temperatures of 42.5 °C during the measurement period. Moreover, the monthly average outdoor air temperature is constantly above 0°C indicate the mild winter in the measurement season 2006/07.

Due to the instantaneous water heater principle and the large DHW storage of 800 l it is possible to set a low temperature for DHW. However, the average measured temperature in the DHW storage is with 42.5°C very low. Therefore, the monthly PF-G for DHW mode in summertime can be explained by the high heat source temperature of the outdoor air and the quite low DHW temperatures.

On the system side, no significant optimisation potentials are identified, since hydraulic is simple and robust, the measured temperature levels of the emission system are low and the reached seasonal performance is already above the average. However, an optimisation potential on the building side is the thermal insulation of the envelope, which was not finished during the measurements.

There have been no failures during operation, which led to full customer satisfaction.

Thus, the Best Practice Sheet gives an example, that also air-to-water heat pumps can be operated very efficiently with consequent low temperature design.

Economy, Ecology and Costs

Environmental impact of the heat pump based on thermal energy produced*:

CO_2-eq.-emission factor:	370 g/kWh$_{el.}$
CO_2-eq.-emission***:	1374.2 kg
Primary energy factor:	1.26 kWh$_{prim.}$/kWh$_{el.}$
Primary energy:	4679.6 kWh$_{prim.}$
SPF based on primary energy:	2.77

Comparative environmental impact of a condensing gas boiler based on thermal energy produced**:

CO_2-eq.-emission factor:	247 g/kWh$_{th.}$
CO_2-eq.-emission***:	3319.5 kg
Primary energy factor:	1.14 kWh$_{prim.}$/kWh$_{th.}$
Primary energy:	15320.9 kWh$_{prim.}$
Efficiency of the boiler****:	0.97
Primary energy efficiency	0.85

* values based on GEMIS Österreich 4.5
**values based on FANINGER, 2007
***values based on produced thermal energy from 09/06 until 09/07
****value based on SIMADER, 2007

Conclusion

The presented data confirms that an air-to-water heat pump system can be operated at high performance factors, if average temperatures of the space heating emission system are consequently lowered, in this system down to 31 °C for space heating.

The calculated results of CO_2-eq.-emissions and primary energy confirm considerable savings compared to a condensing gas boiler based on primary energy and CO_2-eq.-emssion factors used in Austria.

Imprint

System design
KNV Umweltgerechte Energietechnik GmbH
Mitterleiten 4
4861 Schörfling

Field monitoring
Austrian Institute of Technology (AIT)
Energy Department
Sustainable Thermal Energy Systems
Giefinggasse 2
1210 Vienna, Austria
Phone: +43-(0)50550-6309
Fax +43-(0)50550-6613
E-mail: andreas.zottl@ait.ac.at
Web: http://www.ait.ac.at

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Literature

Andreas Zottl, Heinrich Huber and Christian Köfinger
Field test of integrated heat pumps systems –
Field test of 11 heat pump systems
IEA HPP Annex 32 country report Austria Task 3
Austrian Institute of Technology, Vienna, July 2010

IEA HPP Annex 32

IEA HPP Annex 32 is a corporate research project on technical building systems with heat pumps for the application in low energy houses.
The project is accomplished in the Heat Pump Programme (HPP) of the International Energy Agency (IEA).

Internet: http://www.annex32.net