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Development of a procedure for the energetic evaluation of sorption heat pumps within a standardized system

Summary

Client: Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR)
im Bundesamt für Bauwesen und Raumordnung (BBR)
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Title

Development of a procedure for the energetic evaluation of sorption heat pumps within a standardized system

Inducement / Initial Situation

Fuel-powered sorption heat pumps can open a reliable future perspective for sustainably supplying the existing building stock with heat (also new buildings). Problems in the consideration of the German Energy Saving Ordinance and the regulations based thereon arise, especially for those new buildings. That is why there is an urgent need for a suitably qualified procedure to energetically evaluate this technology within the standardized system.

Subject-matter of the research project

As a part of the research project, after an extensive literature and market analysis, the test bench measurements of gas heat pumps (gas-hp) were analysed, and a simulation model for describing the behaviour of gas heat pumps at different operating conditions has been created within the numerical simulation software TRNSYS-TUD (figure 1). The results of extensive simulations were compared with the results of field studies. With consideration of the results from the existing simulations and the knowledge on the operation of gas sorption heat pumps, that was won during the implementation of the research project, an approach for a method of calculation to standardized evaluate sorption heat pumps was derived. In doing so it was ensured, that the level of detail is analogous to the evaluation of other technologies, the as significant recognized energy-related factors of influence are considered, and a sufficient compliance with real energy consumption is available.

Afterwards an evaluation proposal for national standards (Update of DIN V 18599) was prepared and provided to the competent standardization committees (DIN NA 041-05-01 and DIN GA 005-56-20).

The developed calculation method is based on the annual gas utilization efficiency for space heating and hot water preparation according to VDI 4650 Page 2, as well as on the average electrical power input in operation and at standstill of the gas heat pump. Because of sometimes different operating characteristics, different approaches for the determination of the efficiency factor of adsorption- and absorption heat pumps in operation were chosen, depending on their load. In addition to the other input parameters of the proposed calculation approach for the energetic evaluation of adsorption gas heat pumps the lower modulation limit of the heat pump $P_{int,lower}$, and nominal output of the heat pump system $P_{n,WP}$ are defined.

The efficiency factor in operation is corrected to the design temperature and with the load factor of the sorption gas heat pump, which is determined as a function of the monthly calculated duration of heating and the nominal performance of the GHP. By taking into account the specific operating conditions of the sorption gas heat pumps, the differing coverage amounts of energetic completely differently efficient heat pump systems and peak heat generators are recorded. With this information an adsorption gas heat pump can e.g. be operated depending on the load, either mainly in the pure heat pump operation, in mixed mode, or only in direct heating. The higher the ratio of the operating as a heat pump is, the higher is the total annual efficiency factor of the facility. Therefore, in a building with a lower heat load, a higher total annual efficiency factor is determined, than in a building with a higher building heat load (figure

2 and 3). At the same time lower system temperatures cause to increase the total annual efficiency factor (figure 4).

In addition to that, the influence of the operation method (intermittent, continuous) on the efficiency factor of the overall system in the proposed evaluation approach is significantly recognizable, so that optimization measures concerning the method of operation can be performed in a specific design case in consideration of the operating specifics of the selected gas heat pump. So, for example, leads the continuous operation of the system to an extension of the time periods in which the heat supply is in a more efficient load point for the adsorption gas heat pump (figure 5). On the other hand however, the heat energy demand is increased by the continuous operation. With the help of the calculation approach it can be examined whether the energy overhead of the continuous operation can be equalized by the higher energy efficiency at low load levels in the specific design case. For the system variations with adsorption GHP that were part of the research project a continuous operation is in energetic summary recommended. This causes an increase in the efficiency of the overall system compared to an intermittent mode of operation (figure 6).

As the result of the proposed evaluation methodology, the final energy demand for space heating and hot water preparation of the sorption gas heat pump is calculated. The fuel demand and the auxiliary energy demand are shown separately.

Conclusion

The objective of the research project was to develop a qualified procedure for energetic evaluation of gas heat pumps within the standardized system. The developed method allows a proper comparison with other technologies and is essential for the planning of an energy efficient heat pump use.

At the same time a physically and technically correct evaluation of the heat pumps promotes the progression activities of the manufacturers, as the energetic advantage of better products will feasibly be verified. By improving the situation in the field of the standardized systems and avoiding the expenses associated with verification, the market entry barriers for gas heat pumps can be reduced.

Key data

Short Title: Method for the energetic evaluation of sorption gas heat pumps

Researcher / project management: M.Eng. Bernadetta Winiewska / Prof. Dr.-Ing. Bert Oschatz

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Project Duration: 06/2012 - 08/2014

IMAGES / PICTURES:

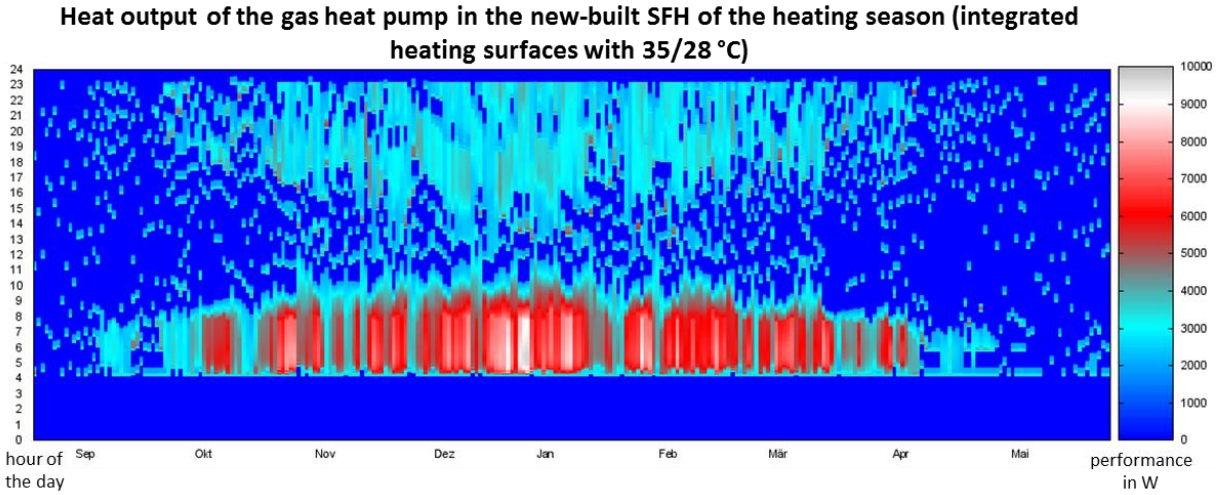

Figure 1: Heat output GHP in a new-built single-family house.jpg
Caption: heat output of the gas heat pump in the new building of the heating season (new-built single-family house with 160 m² living area, integrated heating surfaces with 35/28 °C)

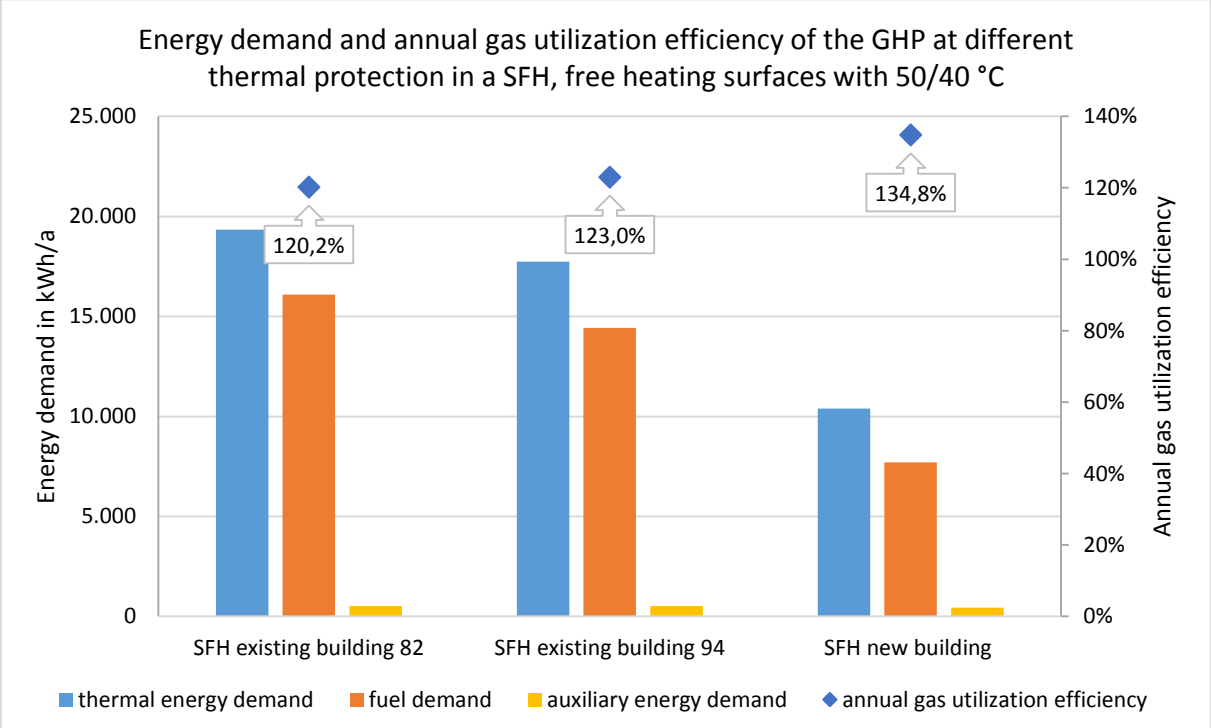

Figure 2: Influence of the heat insulation.bmp
Caption: energy demand and annual gas utilization efficiency of the gas heat pump at different thermal protection (single-family house with 160 m² living area, free heating surfaces with 50/40 °C)

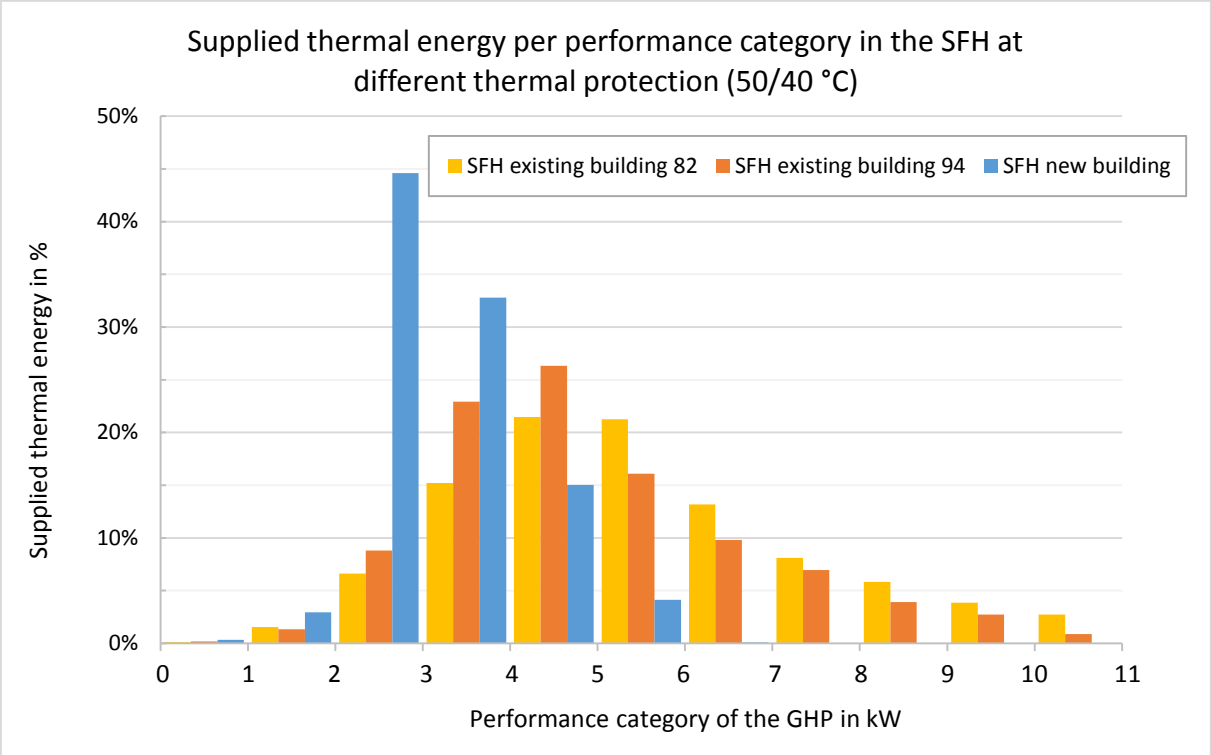

Figure 3: Thermal energy per performance category.bmp

Caption: Supplied thermal energy per performance category in the single-family house at different thermal protection (single-family house with 160 m² living area, free heating surfaces with 50/40 °C)

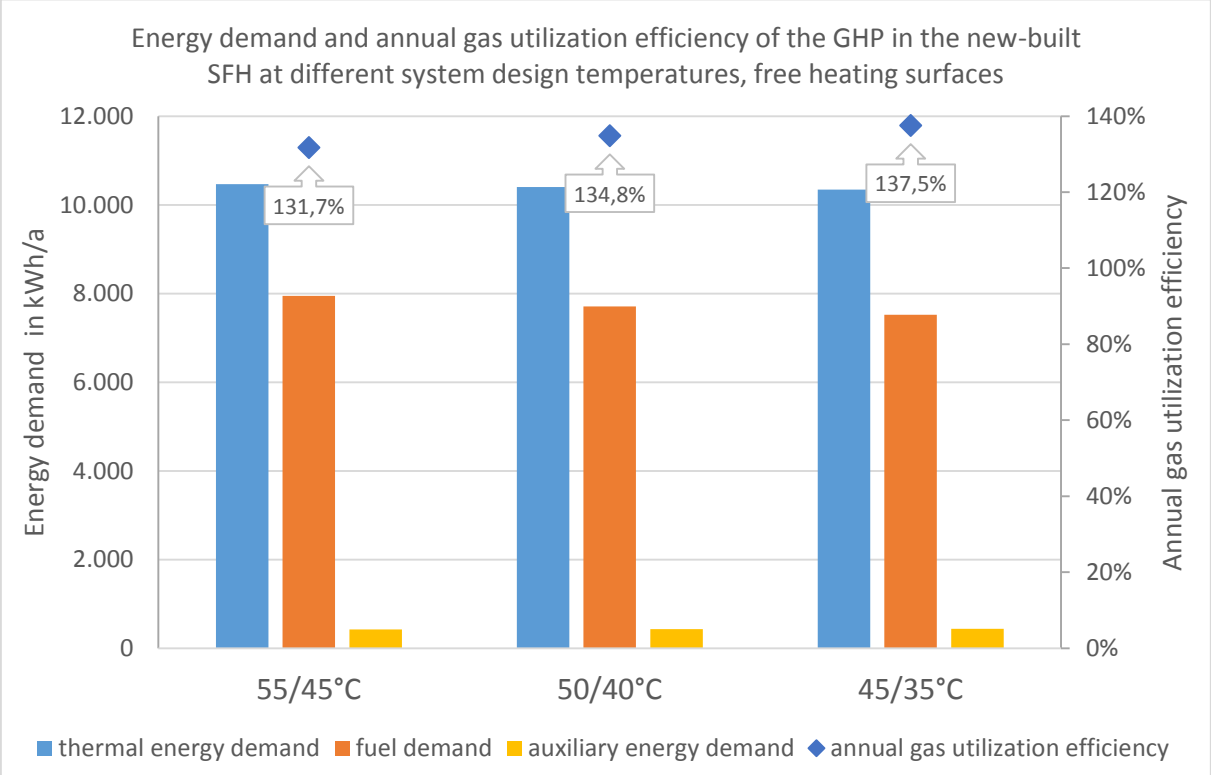

Figure 4: Influence of the system temperature.bmp

Caption: energy demand and annual gas utilization efficiency of the gas heat pump in the new single-family house at different system design temperatures (new-built single-family house with 160 m² living area, free heating surfaces)

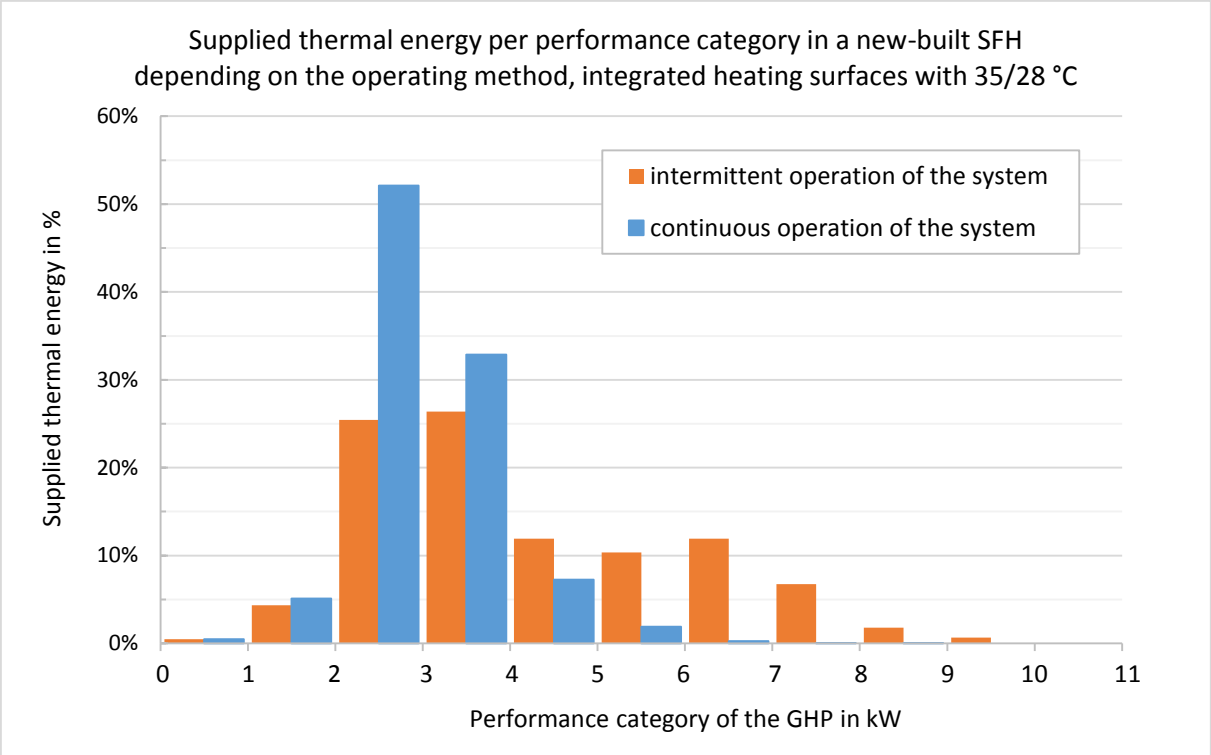

Figure 5: Thermal energy per performance category in SFH.bmp

Caption: Supplied thermal energy per performance category in a new-built single-family house depending on the operating method (a new-built single-family house with 160 m² living area, integrated heating surfaces with 35/28 °C)

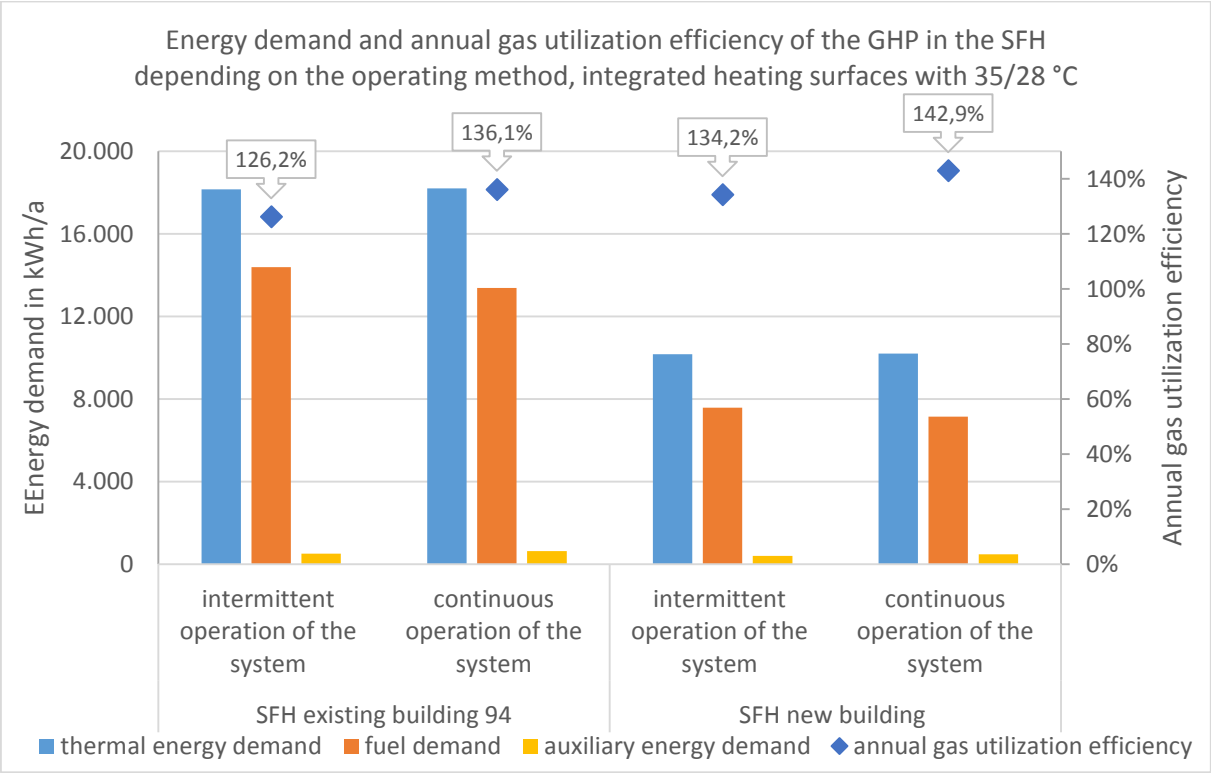

Figure 6: Influence of the operation method.bmp

Caption: energy demand and annual gas utilization efficiency of the gas heat pump in the single-family house depending on the operating method (single-family house with 160 m² living area, integrated heating surfaces with 35/28 °C)