Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

Annex 37

Demonstration of Field Measurements of Heat Pump Systems in Buildings

Good Examples with Modern Technology

Executive Summary

Operating Agent: Sweden

2016

HPP-AN37-SUM

EXECUTIVE SUMMARY

The aim of this project was to present examples of domestic heat pump systems with good performance, and to give guidance on what could be considered good performance. Data from 12 installations in domestic properties was analysed in detail to illustrate the principles of design and installation that ensure good performance.

As the term modern systems are used in the annex title, we clarify that we by modern in this Annex refer to systems installed in the years 2008-2012.

The heat pumps were located in Switzerland (5 heat pumps), the United Kingdom (UK) (4) and Sweden (3). A range of configurations was covered, as illustrated in Table 1 below:

Table 1.Description of evaluated heat pump systems.

Heat source	Heat sink	Domestic hot water provision	Heating capacity	Annual heat load (space + water)
6 ground source, 6 air-source	Underfloor, underfloor + radiators and radiators	9 out of 12 systems	5–14 kW (average 7.6 kW)	12,400-25,100 kWh (average 17,500 kWh)

In addition, comparisons were made to fulfilled field monitoring projects across Europe.

Background and Objectives
There are many published examples of field measurement data from domestic heat pump systems. The aim of this project was to carry out detailed analysis of monitoring data from a selection of heat pump sites with good performance.

Methodology
For each site, the analysis included:

- Calculation of the seasonal performance factor as SPF_{H3}. This factor describes the seasonal (annual) efficiency of the heat pump, taking into account the electricity used by the inlet fan or ground loop pump, the electricity used by the Heat Pump (Compressor, crank case heaters, control system, …) and any back up electricity used for space heating or domestic hot water production.

- Calculation of the CO_2 emissions relative to a gas or oil boiler. CO_2 emissions have been calculated using the EU average CO_2 coefficient of electricity generation and the appropriate national coefficient.

- Calculation of the cost of running the heat pump, as compared to the cost of a gas or oil boiler or the cost of electric heating by a hydronic system.

More detailed analysis was carried out on a selection of sites, including:

- Calculation of $SPF_{H1\text{-}H4}$ for each month of the monitoring period

- Calculation of SPF_{H3} for each year of the monitoring period, for those sites with long monitoring periods.
- Daily average seasonal performance factor (SPF_{H3}) as a function of external temperature
- Separate calculation of space heating and water heating efficiencies (as SPF_{H3})

Results and Conclusions

Figure 1 shows the annual seasonal performance factors, presented as SEPEMO-Build (SEPEMO onwards) SPF_{H3}, for the 12 sites examined. The average performance of the air-source systems is 3.2, while the average performance of the ground-source systems is 4.1.

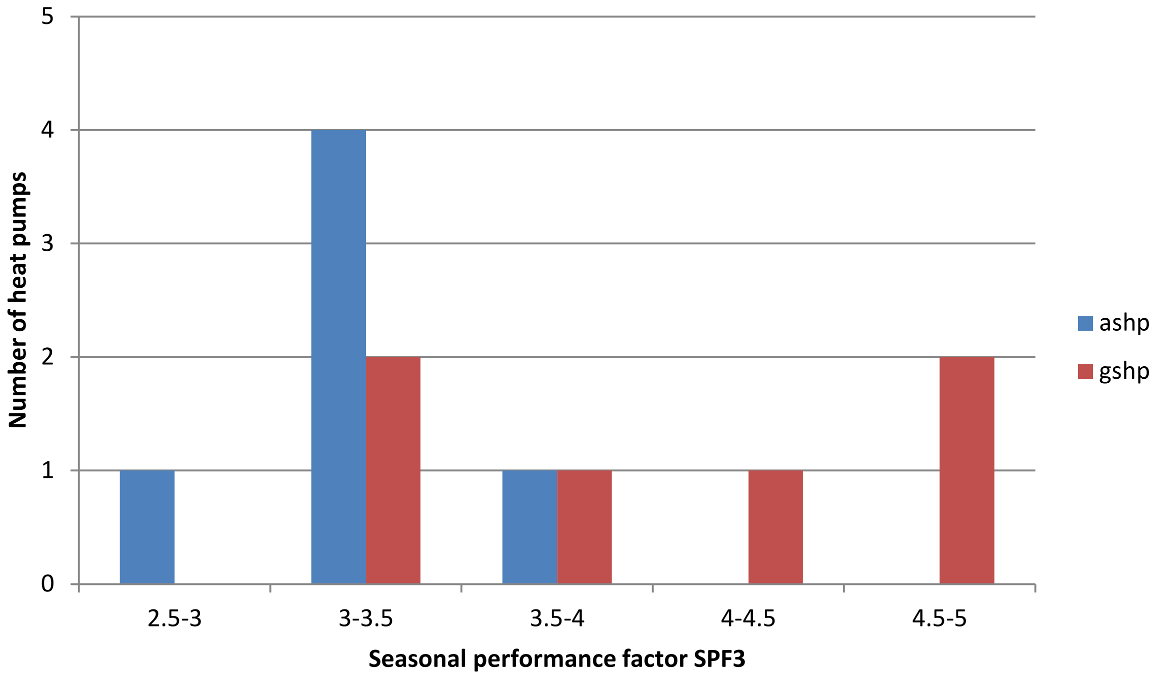

Figure 1. Histogram of heat pump performance factors (SPF_{H3}).

Heat pumps can reduce CO_2 emissions. In Sweden and Switzerland, where the carbon content of electricity is low (0.04 $kgCO_2/kWh$, 2009 figures), using a heat pump resulted in average CO_2 savings of more than 5 tonnes as compared to an oil boiler for the evaluated sites. In the UK, the default fuel is gas and the carbon content of electricity is considerably higher (0.49 $kgCO_2/kWh$), but the average saving was still 1.25 tonnes CO_2/year, Figure 2.

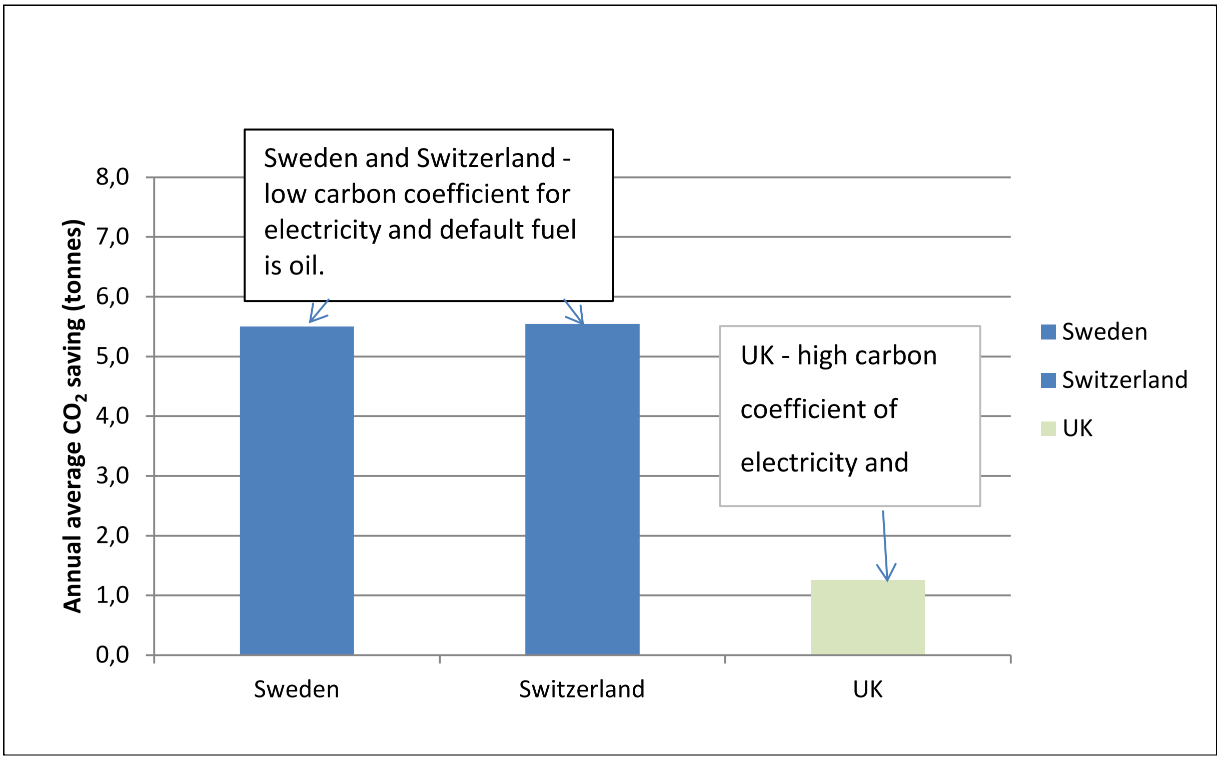

Figure 2. Average annual CO_2 savings using a heat pump as compared to oil or gas boilers for the evaluated heat pump sites.

Substantial cost savings can be made with heat pumps, depending on the heat pump efficiency and the relative prices of electricity and alternative fuels, Figure 3. Annual cost savings were the highest in Sweden (which has cheap electricity and expensive oil) and the lowest in the UK (which has expensive electricity and relatively cheap gas).

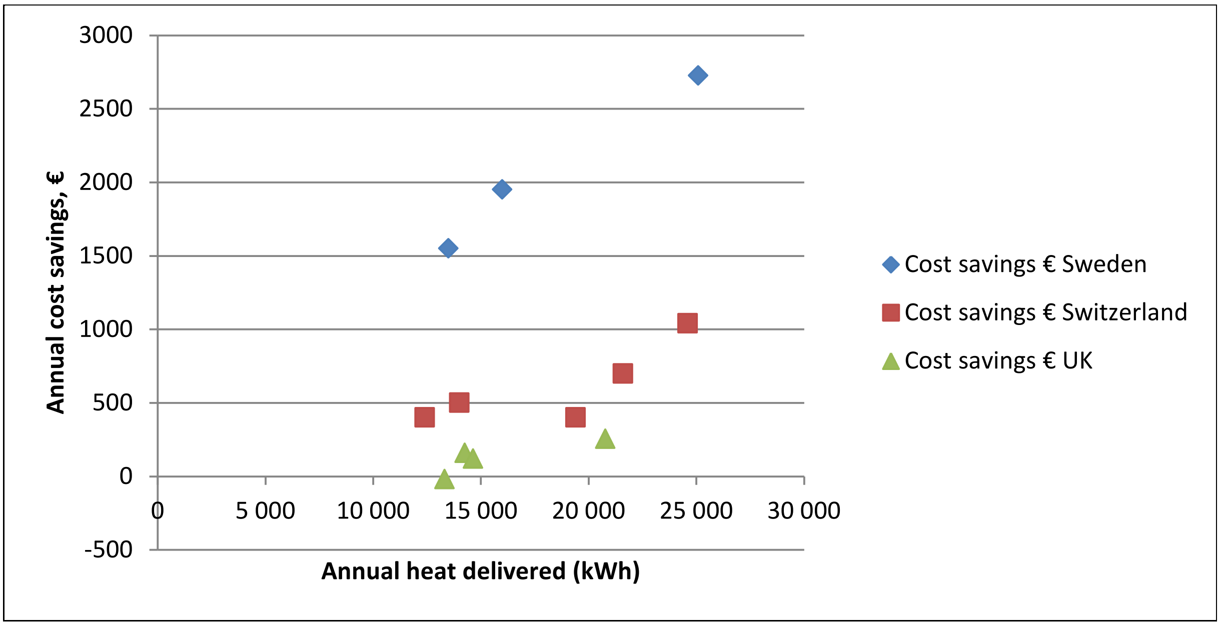

Figure 3. Cost savings versus annual heat delivered based on 2012 figures.

Space heating can be performed more efficiently than water heating, but good water heating efficiencies (>2.5) were found for some of the sites, Figure 4.

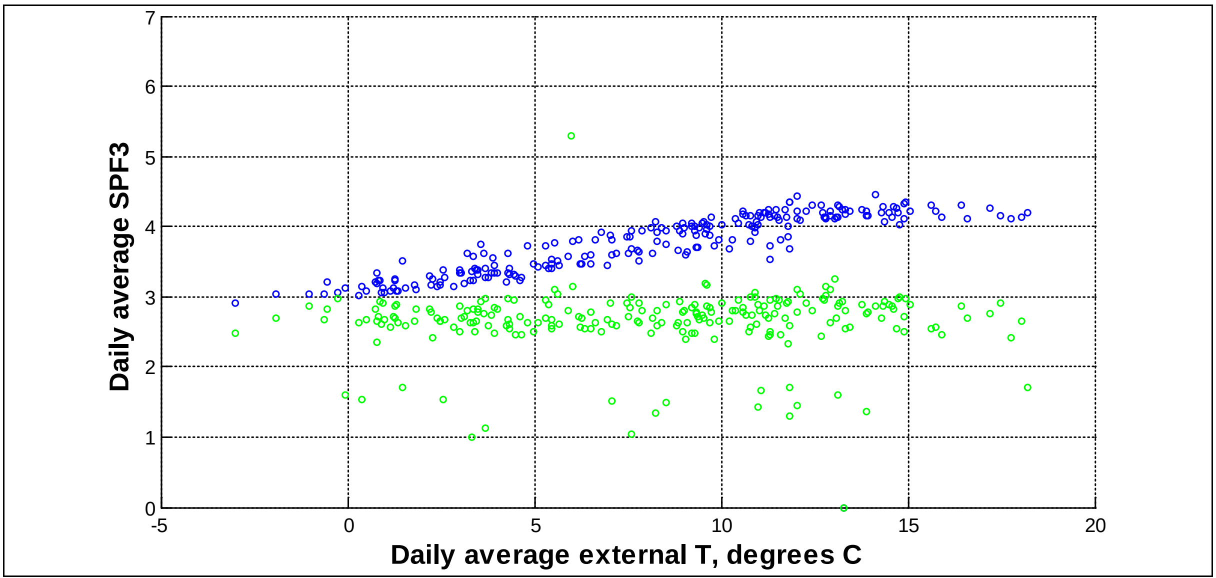

Figure 4. Daily average COP[1] for space heating (blue) and DHW production (green) vs. average outdoor temperature for an air source heat pump in the UK, monitored at the SPF_{H3} level.

Considering legal requirements from e.g. energy label and the Ecodesign regulations in Europe, theoretical achievable levels and the positive effects on energy cost, CO_2 abatement and primary energy reduction, according the conclusions from this project, air-source systems should be considered as good systems if they have a SPF_{H3} value of 2,8-3,2 and above and a ground source system having an SPF3 of 3,3-3,9 and above should be considered as well performing heat pump systems. When floor heating in heat pump systems for new houses is assumed and radiators heating for retrofit installations are assumed, the figures below represent good performance, see Table 2 below. These values concern DHW + space heating. Supply temperatures for new systems can be regarded as those required for underfloor heating (35 °C), and temperatures for retrofit systems can be regarded as those required for radiator heating (55 °C).

Table 2. Threshold values to be regarded as a good system.

	ASHP, new	ASHP, retrofit	GSHP, new	GSHP, retrofit
SPF_{H3}	3.2	2.8	3.9	3.3

[1] SPF is generally a value achieved over a longer period of time (**Seasonal** Performance Factor) of monitoring. In this report, we have used the term COP when we refer to shorter time monitoring results (instantaneous, hourly, weekly).

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