SESeasonal PErformance factor and MOnitoring for heat pump systems in the building sector (SEPEMO-Build)

Contract No.: IEE/08/776/SI2.529222

Important parameters influencing heat pump systems efficiency and reliability
Delivery date: 2012-04-25
Authors: R. Nordman, P. Rivere
Work Package 2/3

The sole responsibility for the content of this document lies with the authors. It does not necessarily reflect the opinion of the European Communities. The European Commission is not responsible for any use that may be made of the information contained therein.
**Introduction**
Heat pump systems performance is important and depends on many more issues that the heat pump itself. Both the quality of the installation and the maintenance of the system affect the system SPF.

In this deliverable, a number of often foreseen issues that affect performance and reliability are discussed.

**Systematic analysis based on system boundaries**
The system boundaries that were developed in this project can serve as an important tool in the analysis of system performance. The system boundaries presented schematically in Figure 1 below gives a neat division of the energy using components in the system. Combining that with the evaluation of the performance associated with each system boundary, it can easily be seen where performance is degraded in the system. This is exemplified in Figure 2 where it can be seen that the performance of that particular system is decreased substantially between SPF H2 and SPF H3. It can then be concluded that the reason for this is a very high use of back up heating. Then an analysis of why the backup heat usage is so high can be conducted, and measures to lower the back up heat usage can be implemented.

![Figure 1. System boundary concept.](image-url)
Areas of general improvement of heat pump systems
That there is not only one area, but many areas where heat pump performance can be improved. This is exemplified below.

Pumps / Fans capacity controlled
The effect of capacity controlled pumps/fans compared to on-off controlled pumps can be large, since the electricity used by the pumps can be kept at a minimum. In older, retrofit systems, it is also very important that the existing circulators are controlled by the heat pump system so that they are e.g. not running in periods of no heat demand.

Heat emitters for low supply temperature
Investing in low temperature heat emitters indoors pays off in increased HP COP, and thereby the SPF of the system. Generally, as a rule of thumb, each degree the condensation can be lowered improves the COP of the heat pump by 2-4 %. Thus, an investment in extra heat transfer area in radiators can give very good payback over the lifetime of the system. This is generally why underfloor heating systems achieve such high SPF’s, that the heat supply temperature can be kept very low all over the year. Limit the temperature set points of heat pumps to the lowest level possible. For Air distributed systems and systems with low thermal mass of the building, night setbacks or during inoccupation periods should be considered.

Insulation of piping
Very often, heat distribution pipes are not insulated properly. To avoid that heat is emitted where it is not supposed to, proper insulation should always be considered.
Hot water circulation and heat loss from accumulators

In systems with hot water circulation, there should be the possibility to control the circulator with e.g. a time control to avoid unnecessary circulation at times where there is no need for DHW. For example in homes where there is no one at home during the day, hot water circulation will contribute to the heating of the building through the heat losses. This water have however been produced to supply a high temperature, unnecessary high for heating, thus resulting in worse COP of the heat pump than what should have been the case if the heat had been supplied by heating water. In summertime, the heat losses could even contribute to unwanted cooling requirements. Table 1 summarise situations where losses could be considered useful or not. The same principles are relevant for accumulators with high stand by losses. Each heat pump system should therefore strive to have accumulators with low heat losses.

Table 1. Specification of losses are useful or not.

<table>
<thead>
<tr>
<th>Heat pump placement</th>
<th>Winter (heat demand)</th>
<th>Summer (cooling demand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside</td>
<td>Losses are not useful</td>
<td>Losses are not useful</td>
</tr>
<tr>
<td>Inside garage</td>
<td>Losses could be useful</td>
<td>Losses are not useful</td>
</tr>
<tr>
<td>Inside house</td>
<td>Losses are useful</td>
<td>Losses are not useful</td>
</tr>
</tbody>
</table>

Overarching control systems

To have an overarching control system including circulating pumps and fans can increase system performance. Temperature prediction could also contribute to better performance, especially in buildings with small time constant. This will prove especially important in future smart grids, where the cost of using electricity not necessarily intercepts with the best conditions to run the heat pump. Then an overarching control system with cost optimisation over the day could become reality.
Increased communication for bivalent systems including air source air based heat pumps will become more important. At the moment, most systems are controlled independently. In the case of the Villecerf site, this leads the air-to-air heat pump to work with relatively high indoor air temperature in winter time despite the unit could probably be stopped.

Cleaning of filters (A2A)
In air-to-air heat pumps, it is essential to regularly clean the filters. The filters are put in place to protect heat transfer surfaces from dust, but with time, the filters will clog and increase the pressure drop. This in turn will increase the fan power required to put through the required amount of air. Eventually, the heat pump might face irreparable damage. In an earlier monitoring made by SP, it was shown that the COP increase about 10% instantaneously after cleaning of the filters. They had at the time not been cleaned for about three weeks during operation.

![Figure 4. Example of filters filled with dust.](image)

Placement of air distributing units (A2A, ASHP)
To avoid flow mal distribution, outdoor units should not be put in spaces where the flow pattern is short circuited. Short circuiting can lead to lower ambient temperatures exposed to the HP evaporator, thus decreasing the performance. Instead look for an open space to put the outdoor unit.
Conclusions and recommendations

- For A2A heat pumps, have automatic warning of filter cleaning (OR Inform end consumers on the importance of maintenance to keep up performance and keep costs down)
- Put requirements on low temperature distribution systems into policy
- Harmonise DHW temperature legislation within EU to lowest possible without infringing on legionella risks.
- Require system performance guarantees on all heating systems
- Encourage manufacturers to integrate on board SPF measurement functions and other automatic diagnostic of heat pump performance / misperformance