DEFINITION OF PERFORMANCE FIGURES FOR SOLAR AND HEAT PUMP SYSTEMS

Technical Report 5.1.3

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Quality Assurance in solar thermal heating and cooling technology – keeping track with recent and upcoming developments

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Nomenclature

COP	coefficient of performance
E	energy in kWh
EER	energy efficiency ratio
f_{sav}	fractional energy saving
P	power in W
PER	primary energy ratio
q	specific energy in kWh/m^2
$\dot{Q}$	thermal power in W
RER	renewable energy ratio
SCOP	seasonal COP
SEER	seasonal EER
SPF	seasonal performance figure
ε	primary energy coefficient

Subscripts

AS	air-source
BU	back-up
C	cold (low temperature)
coll	collector
DHW	domestic hot water
el	electrical
F	final
H	hot (high temperature)
Heat	heating
HP	heat pump
HS	heat source
p	primary
ren	renewable
SC	solar circuit
ST	solar thermal
th	thermal

Superscripts

IFC	indirect fired cooling

1 Introduction

In order to be able to compare different SHP systems among themselves, but also with other technologies for heating, cooling and domestic hot water (DHW) preparation, a set of consistent, transparent and well defined performance indicators is needed. There is a need both for clear nomenclature of different performance indicators, as well as for a clear definition of the system boundaries and boundary conditions under which these indicators have to be determined.

As shown in Technical Report TR5.1.1 of the QAiST project [1], there is a multitude of different system configurations among SHP systems. The system boundaries have to be defined in such a way, that they can be equally applied to all of them.

In Technical Report TR5.1.2 [2], a review of standards and guidelines for solar thermal and heat pump components and systems showed that, although in many cases the nomenclature and definition of performance indicators are comparable among the documents, there are still some differences that make direct comparability difficult.

When developing performance indicators for SHP systems, their comparability to other technologies has also to be taken into account, especially if current development in the field of quality assurance and EU wide energy labelling for domestic energy related products[1] is considered. In this context, it is essential to establish methods for fair and transparent methods for determination of the performance and efficiency of SHP systems under laboratory conditions, for numerical simulations and in real installations.

This document has been elaborated as a first proposal for further discussions, especially with regard to the IEA SHC Task 44 / Annex 38 “Solar and Heat Pumps”[2], an international activity entirely dedicated to SHP systems (see Chapter 2.3). Collaboration between the two projects ensured a harmonised approach regarding this topic.

Further work will concentrate on:

- Validation of the definitions through implementation on available field trial data;
- Extension of performance figures to cooling applications;

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[1] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products – “ErP guideline”

[2] http://www.iea-shc.org/task44/

- Discussion on the primary energy ratio, possible definition of primary energy factors;
- Definition on the reference systems for different applications / regions for the calculation of f_{sav};
- Definition of procedures for the calculation of the RES utilisation;
- Procedure for the calculation of system performance in different operation modes, e.g. DHW preparation and heating;
- Definition of further performance figures, which might help in analysis and transparent reporting on the performance of SHP systems, e.g. solar yield, high and low temperature solar fractions, back-up energy fraction etc.;
- Definition of performance of multienergetic systems in terms energy consumption.

2 Related current activities

A number of national and international activities are, among other goals, currently aiming at developing quality assurance methods including test procedures and performance indicators for different technologies, both well established and new ones. Especially interesting are those activities, which deal with technologies or system configurations represented in SHP products.

Therefore an effort was made to harmonise the output of these projects related to performance indicators, in order to obtain good comparability with other technologies, as described in previous Chapter.

2.1 Project SEPEMO

Within the IEE Project SEPEMO-Build[3], a number of SPFs have been defined according to the system boundaries shown in Figure 1:

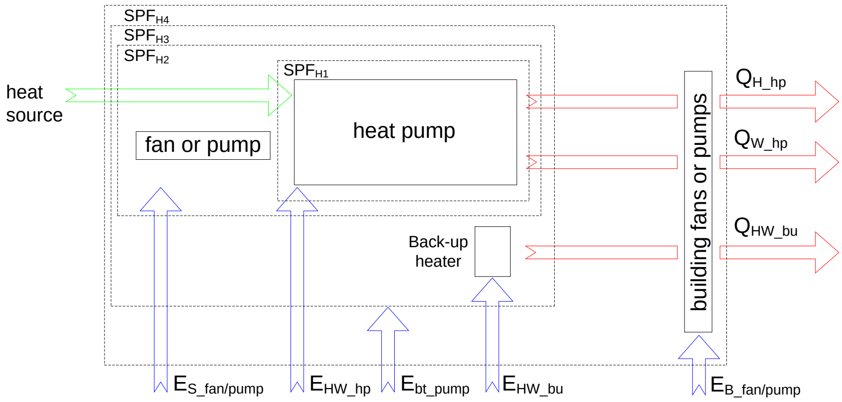

Figure 1: Overview of the test and performance evaluation related work in Subtask B (Source: [3])

SPF_{H1}

This system contains only the heat pump unit. SPF_{H1} evaluates the performance of the refrigeration cycle. The system boundaries are similar to the COP defined in EN 14511, except that the standard takes, in addition, a small part of the pump consumption to overcome head losses in the liquid heat exchangers, and most part of the fan electricity consumption.

[3] SEPEMO - Seasonal Performance factor and monitoring for heat pump systems in the building sector, project funded by Intelligent Energy Europe (IEE) Programme financed by the European Commission, Contract No. IEE/08/776/SI2.529222

SPF_{H2}

This system contains the heat pump unit and the equipment to make the source energy available for the heat pump. SPF_{H2} evaluates the performance of the heat pump including heat source. This figure corresponds roughly to the $SCOP_{NET}$, as defined in prEN 14825, excluding most of the heat source consumption.

SPF_{H3}

This system contains the heat pump unit, the equipment to make the source energy available and the back-up heater. SPF_{H3} represents the heat pump system and thereby it can be used for comparison to conventional heating systems (e.g. oil, gas, etc.). This system boundary is similar to the SPF in VDI 4650-1, EN 15316-4-2 and the $SCOP_{ON}$ in prEN 14825, excluding most of the heat source consumption for most cases. For monovalent[4] heat pump systems SPF_{H3} and SPF_{H2} are identical.

SPF_{H4}

This system contains the heat pump unit, the equipment to make the source energy available, the back-up heater and all auxiliary drives, including the auxiliary consumption of the heat sink system. SPF_{H4} represents the heat pump heating system including all auxiliary drives which are installed in the heating system.

2.2 IEA HPP[5] Annex 34 “Thermally Driven Heat Pumps for Heating and Cooling”

Within Task B of the IEA HPP Annex 34, a proposal for a set of system boundaries and corresponding performance figures (including nomenclature) was made [4]. It was based on a comprehensive standard review and included the development of a generic system for different applications of thermally driven heat pumps (TDHP).

For every of the defined application of TDHP, system boundaries with corresponding performance figures were proposed. In Figure 2, system boundaries for a reference indirect fired system (including solar cooling) are shown. Indirect fired cooling system was chosen, because it corresponds in a number of features with an SHP system (both include a solar system combined with a heat pump or chiller). The figures shown apply for cooling only. Instead of a heat source taking available heat from the environment, a heat sink delivering excess heat to the environment is needed. However, the methodology remains the same.

[4] Monovalent heat pumps are heat pumps without supplemental (backup) heating.

[5] IEA – International Energy Agency; HPP – Heat Pump Programme (Implementing Agreement of the IEA)

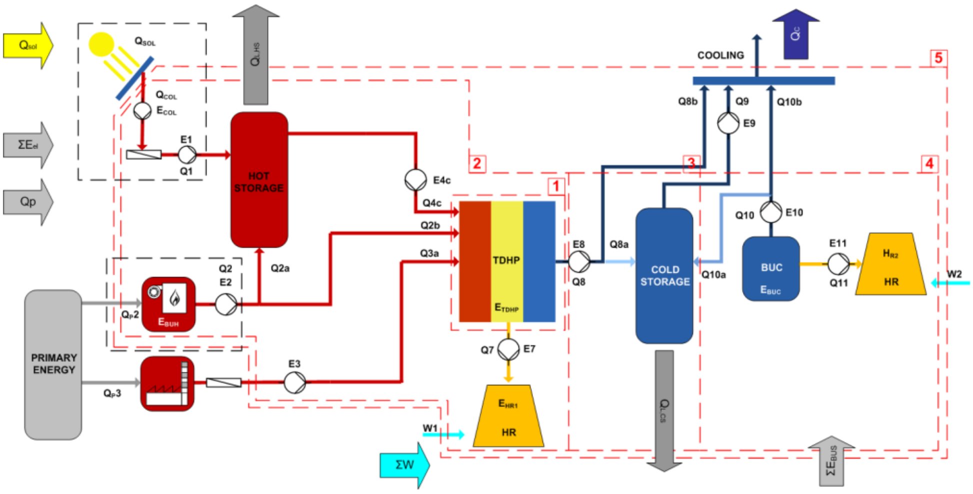

Figure 2: Reference TDHP system for indirect fired cooling with system boundaries – proposal from IEA HPP Annex 34. Source: [5]

The following performance figures which apply for the performance of systems in real installations were defined for the represented system boundaries:

System boundary 1

$SPF_{th,a}^{IFC}$ as the thermal seasonal performance factor and $SPF_{el,a}^{IFC}$ as the electrical seasonal performance factor are defined similarly to SPF_{H1} from the previous Chapter.

System boundary 2

$SPF_{th,b}^{IFC}$ and $SPF_{el,b}^{IFC}$ take into account the TDHP with all components needed to provide the driving energy for the chiller Iincluding possible storage losses) and all components of the heat dissipation system. It evaluates the performance of the TDHP with all the components needed for its operation.

System boundary 3

This system boundary yields $SPF_{th,c}^{IFC}$ and $SPF_{el,c}^{IFC}$ which extend the system boundary 2 for the cold storage tank. The losses of the cold storage, as well as the energy needed for its charging is considered.

System boundary 4

The back-up cooling system is added to the boundary - $SPF_{th,d}^{IFC}$ and $SPF_{el,c}^{IFC}$ show the efficiency of the entire system excluding the cold distribution.

System boundary 5

Finally, the entire system with the cold distribution is included in this system boundary.

2.3 IEA SHC[6] Task 44 / HPP Annex 38 "Solar and Heat Pump Systems"

The objective of Subtask B of this joint SHC and HPP implementing agreements activity is "*to reach a common definition on what are the figures of merits of solar and heat pump systems and how to assess them*". Thus, the goals of the Task 5.1 of the QAiST project and of that Subtask overlap to a certain extent. Therefore, it was agreed to harmonise the work between the two groups, especially since many of the QAiST participants are also active in the Task 44 / Annex 38.

3 Nomenclature and definition of performance figures

There is a need to introduce a uniform nomenclature and definitions of the performance figures related to different system boundaries and operation modes. This applies not only for solar and heat pump but for all heating and cooling systems.

A systematic approach to the main performance figures for SHP systems, based on the analysis of the available standards, is proposed in Figure 3.

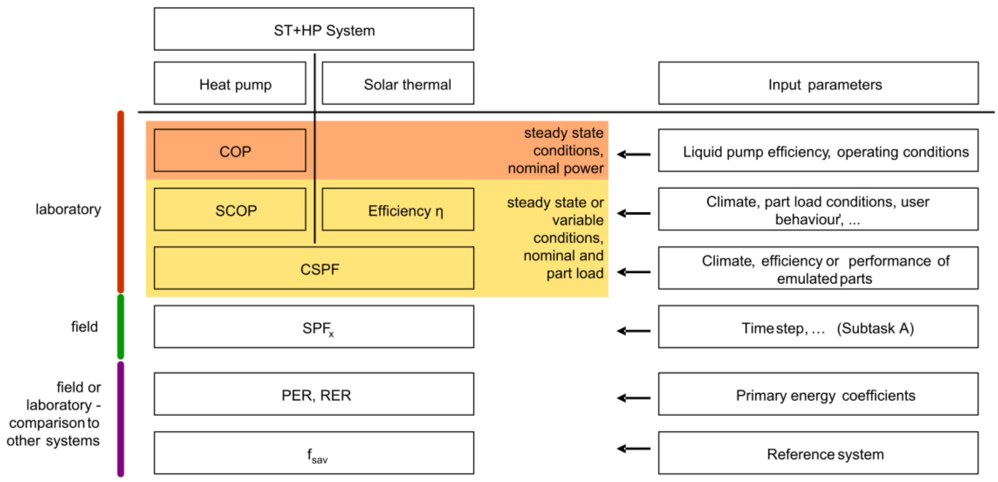

Figure 3: Overview of the main performance figures for solar and heat pump system

[6] SHC – Solar Heating and Cooling (Implementing Agreement of the IEA)

This approach takes the following aspects into account:

- where the measurement on the system is carried out - under laboratory conditions or on a real, installed system;
- whether the performance of the system is used to compare it with other SHP systems or with other technologies;
- for which system or subsystem should the performance be estimated: heat pump or (parts of) solar thermal system or entire SHP unit;
- whether the operating conditions for the measurement are steady-state or transient.

Using the output of the standards' assessment from Technical Report TR5.1.2 [2], it is proposed to use the following nomenclature for the performance figures:

COP and EER

The Coefficient of Performance (COP) of the heat pump is the ratio of the heating capacity divided by the overall electricity consumption, measured under steady-state operating conditions[7]. The counterpart of the COP for cooling applications is the Energy Efficiency Ratio (EER). The boundary conditions for the measurement correspond to boundary HP in Figure 6. Using the given nomenclature, the COP can be calculated as

$$COP = \frac{\overline{\dot{Q}_H}}{\overline{P}_{el,HP}} \qquad (1)$$

In some European Standards (e.g. EN 15879-1 [7]), the heating (or the cooling) capacity for hydronic distribution systems is corrected for the (assumed) amount of energy dissipated from the liquid circulation pump to the heat transfer fluid. The corrective amount of heat is calculated from the measured pressure drop over the heat exchanger and assumed circulation pump efficiency. The electricity consumption due to pumping work needed to overcome the pressure losses of the heat transfer fluid within the heat pump unit is corrected for the same amount of energy.

SCOP and SEER

SCOP (Seasonal Coefficient of Performance) for heating applications and SEER (Seasonal Energy Efficiency Ratio) represent the calculated (estimated) performance of the heat pump unit with the same system boundary as for the

[7] According to the currently valid version of EN 14511 [6], the sequence for air-source heat pump testing includes defrosting cycles of the heat pump unit, which is a highly transient process.

COP or EER, for defined climate conditions and reference heating or cooling demand. It is proposed to use the definition given in EN 14825:2011 [8].

Collector thermal efficiency

Collector thermal efficiency η is defined both in ISO and EN standards as "*the ratio of the energy removed by the heat transfer fluid over a specified time period, to the product of a defined collector gross area and the solar irradiation incident on the collector for the same period, under steady-state or transient conditions*". This definition might be sufficient for solar collector types which are designed to transform solely solar radiation into usable heat. However, many SHP system configurations are designed to use low temperature heat also from the ambient air, including condensation heat form the moist air. In this case, collector thermal efficiency cannot provide full information on the collector performance.

Specific Solar Yield

In order to take into account the overall energy provided by the collector to the system, including sensible or latent heat from the surrounding moist air or any other phenomena, additional performance figures must be used.

The first proposal is to use the Specific Solar Yield (q_{sol}) of the collector, which can be defined as the overall energy output from the collector per collector area for defined operating conditions. In order to obtain a realistic value for a collector being used in a specified SHP system, control settings regarding temperature levels, switching between solar radiation and ambient air for hybrid collectors etc. might be considered for the development of testing sequences.

It might also be useful to additionally define two more specific solar yields, one for "high temperature output" and the other one for "low temperature output" of the collector.

As these proposals could not been further investigated within the QAiST project, the work will be continued within IEA SHC Task 44 / HPP Annex 38.

SPF

The Seasonal Performance Factor should be used for the evaluation of the system working under real operating conditions e.g. in field trials. The SPF can be defined for different system boundaries and is calculated as the useful energy output to the overall useful energy input to the system within the respective boundary. In the following Chapters, some of the system boundaries for the calculation of SPF will be defined.

The seasonal performance factor can be defined separately for heating and cooling applications, or for heating and DHW or DHW and cooling applications etc., depending on the intended application of the system and usage of the performance figures. In further text, only the heating application is considered.

Depending on the purpose of the measurement, as well as on the availability of the measurement equipment, accessibility of the installed components and their connections etc., it is favourable to define a standardised set of boundaries and respective SPFs in order to be able to compare and analyse different systems with the same performance indicators.

SPF^{calc}

SPF^{calc} should be defined for the same system boundaries as the SPF obtained from the field measurements. However, it is proposed to distinct the estimation of the system performance based on laboratory measurements and obtained from a calculation (simulation) method for assumed boundary conditions (climate, heating, cooling and DHW loads) from the one obtained from on-sight measurement results, e.g. with a superscript “calc”. In this way, an estimated performance can be unmistakably distinguished from the measured one.

Primary Energy Ratio, Renewable Energy Ratio

If the system boundaries are extended from the final energy input to the system to the primary energy input, further performance figures related to efficient primary energy usage or renewable energy usage can be added.

Primary Energy Ratio (PER) is defined as the ratio of the useful energy output to the primary energy input. Primary energy input can be defined either as total energy input (renewable and non-renewable) or as non-renewable energy input only. In the first case, the economic aspect of the system efficiency is quantified, in the second the environmental one, Figure 4.

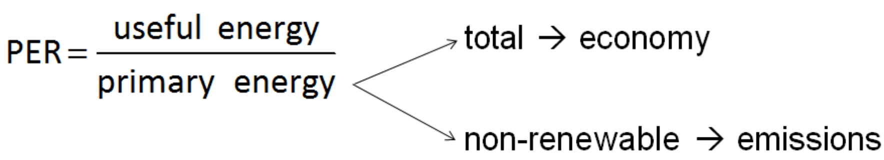

Figure 4: Definition of the Primary Energy Ratio (PER)

For systems using energy from different primary sources, PER is calculated as

$$PER = \frac{\int \left(\dot{Q}_{Heat} + \dot{Q}_{DHW}\right) \cdot dt}{\int E_p \cdot dt} \tag{2}$$

where E_p is the primary energy input into the system. The relation between the primary energy and the final energies is given by

$$E_P = \sum_i \frac{E_{F,i}}{\varepsilon_i} \tag{3}$$

The primary energy coefficients ε_i are depending on the exact location of the system (e.g. because of the electricity mix), time of the year etc. However, some generalised values (in terms of location – regional or national, or in terms of the time of the year – yearly average values) give a good approximation. Widely used tool for the calculation of the primary energy coefficients in Europe is the GEMIS[8] software.

Renewable Energy Ratio (RER) is defined as the ratio of the useful energy output to the overall input of the renewable energy to the system, analogously to the PER:

$$RER = \frac{\int \left(\dot{Q}_{Heat} + \dot{Q}_{DHW}\right) \cdot dt}{\int \sum P_{ren} \cdot dt} \qquad (4)$$

Renewable energy can by supplied to the system either directly (as high temperature solar heat) or indirectly (as heat pump source or through electricity):

$$E_{ren} = \int \sum P_{ren} \cdot dt = E_{ren,direct} + E_{ren,indirect} \qquad (5)$$

Fractional Energy Saving

Fractional Energy Saving (f_{sav}) is defined as the ratio of the difference in energy consumption between the reference system and the SHP system to the energy consumption of the reference system, equation 6.

$$f_{sav} = 1 - \frac{\text{energy consumption SHP-system}}{\text{energy consumption reference system}} \qquad (6)$$

The concept of fractional energy saving is defined e.g. in EN ISO 9488 [9].

Further performance figures describing the economic and environmental performance of SHP system should be developed to be able to provide full information on the quality of a system or an installation. This must, however, be elaborated in more focused activities, such as IEA SHC Task 44 / HPP Annex 38.

[8] GEMIS (Global Emission Model for Integrated Systems) software is a tool offering information on fossil fuels, renewables, processes for electricity and heat, raw materials, and transports developed be Öko-Institut e.V., Freiburg, Germany. www.oeko.de

4 System boundaries for heating and DHW application

4.1 Reference SHP system for heating application

In this document, only the heating and/or DHW preparation applications are discussed. Definitions for other operation modes, as well as definitions of other performance figures will be elaborated within IEA SHC Task 44 / HPP Annex 38.

For the definition of different performance figures, which can be applied to different system configurations, it is helpful to define a “reference system”. Ideally, this system should include all possible configurations and energy flows of the known systems. Particular configurations can then be obtained by removing the non-existing components and energy flows. A proposal for a reference system for solar and heat pump combined systems is given in Figure 5. The energy flow diagram is based on the representation proposed in [10].

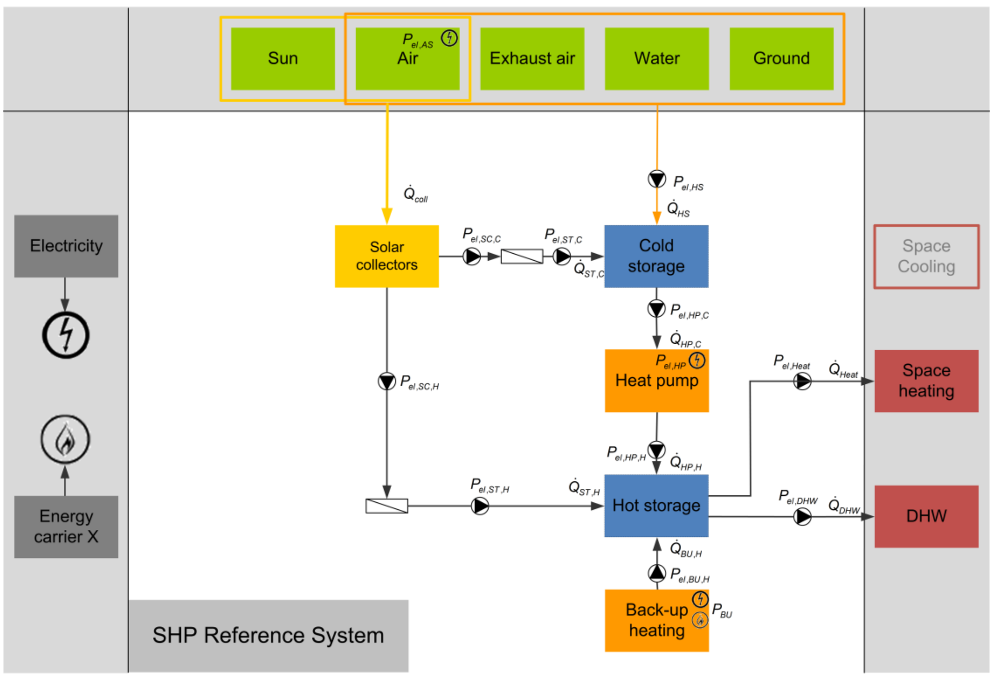

Figure 5: Reference SHP system for heating applications

In this representation, the following applies:

- The connections between components with a pump symbol represent enthalpy flows with respective energy consumptions, if relevant;
- The components presented with slashed frame can be understood as nodal points if not a part of a particular system or if direct connections possible (e.g.

the solar energy can be either stored or used directly in the evaporator of the heat pump);

- Although presented as one component, the “storage” can actually consist of more than one unit (e.g. one storage for heating and one for DHW). This implies, that the energy input $P_{el,HP,H}$ can in reality consist of more than one consumer;
- The symbols for electrical energy and other energy carriers (e.g. gas, biomass etc) within the components, as shown on the left side of the Figure 5, indicate that the energy consumed by the component should be taken into account.

4.2 Definition of system boundaries for different levels of SPF

When choosing system boundaries for SPFs, the following goals were pursued:

- Possibility of a quick analysis of the system – easy identification of optimisation potential by comparing different SPF levels;
- Applicability to different system configurations;
- Harmonisation of definitions and comparability of performance figures with other heat pump and solar thermal applications;
- Usability for various purposes: scientific analysis, testing and validation, labelling etc.

System boundary HP – Heat Pump

This system boundary includes the heat pump unit with the main energy input to the compressor, as well as a number of energy inputs for supporting systems like controls, crankcase heaters etc., Figure 6. It is similar to the one currently used for the definition of the COP and SCOP in a number of CEN standards. There, the energy inputs and outputs are often corrected as described in Technical Report TR5.1.2 [2]. If used for a performance figure calculated from the field trial results, the energy output will generally not be corrected due to considerable effort needed to obtain all measurement data needed. The corresponding performance figure $\mathbf{SPF_{H,HP}}$ is thus defined as:

$$SPF_{H,HP} = \frac{\int \dot{Q}_{HP,H} \cdot dt}{\int P_{el,HP} \cdot dt} \qquad (7)$$

$P_{el,HP}$ is the electric power of the heat pump unit including control system, crankcase heater etc., excluding the liquid pumps.

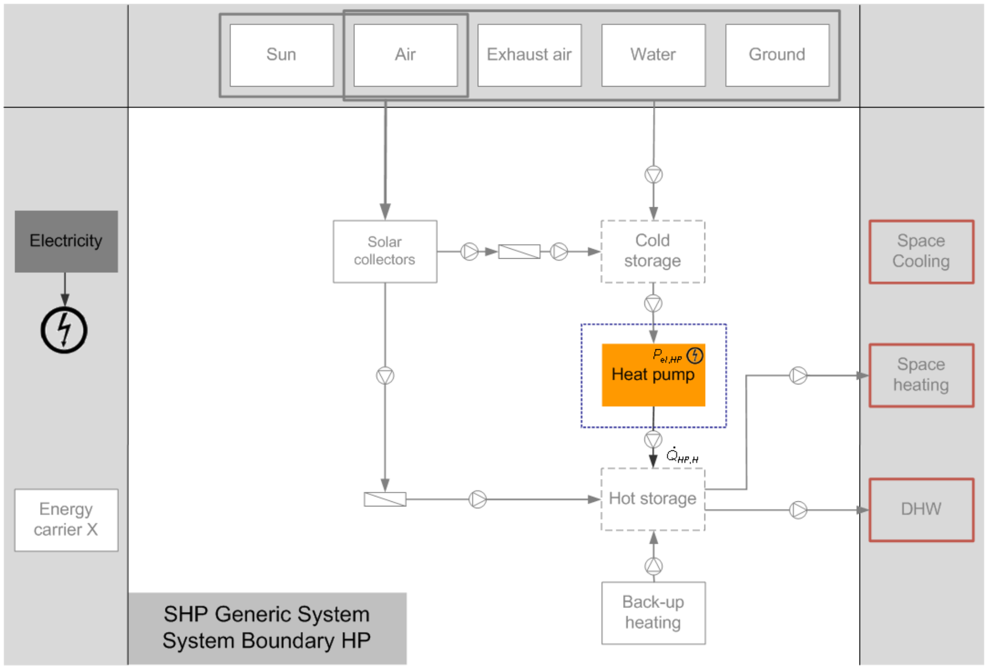

Figure 6: System boundary HP

System boundary ST,tot – Solar Thermal, total

Here, the overall output of the solar thermal system and its overall consumption are considered. The overall output can be split into the high temperature output to the hot side and the low temperature output to the cold side of the system. Besides the calculation of the subsystem SPF, this boundary can be used to calculate e.g. collector thermal efficiency or the specific solar yield.

$SPF_{H,ST,tot}$ includes the electricity consumption of the solar circuit itself and of all of the circulation pumps needed to distribute the heat to other components.

$$SPF_{H,ST,tot} = \frac{\int \left(\dot{Q}_{ST,H} + \dot{Q}_{ST,C}\right) \cdot dt}{\int \left(P_{el,AS} + P_{el,SC,C} + P_{el,SC,H} + P_{el,ST,C} + P_{el,ST,H}\right) \cdot dt} \qquad (8)$$

The electricity consumption of the control unit should also be taken into account. In case of a hybrid solar collector, the energy consumption within the collector $P_{el,AS}$ (e.g. for a ventilator) is taken into account.

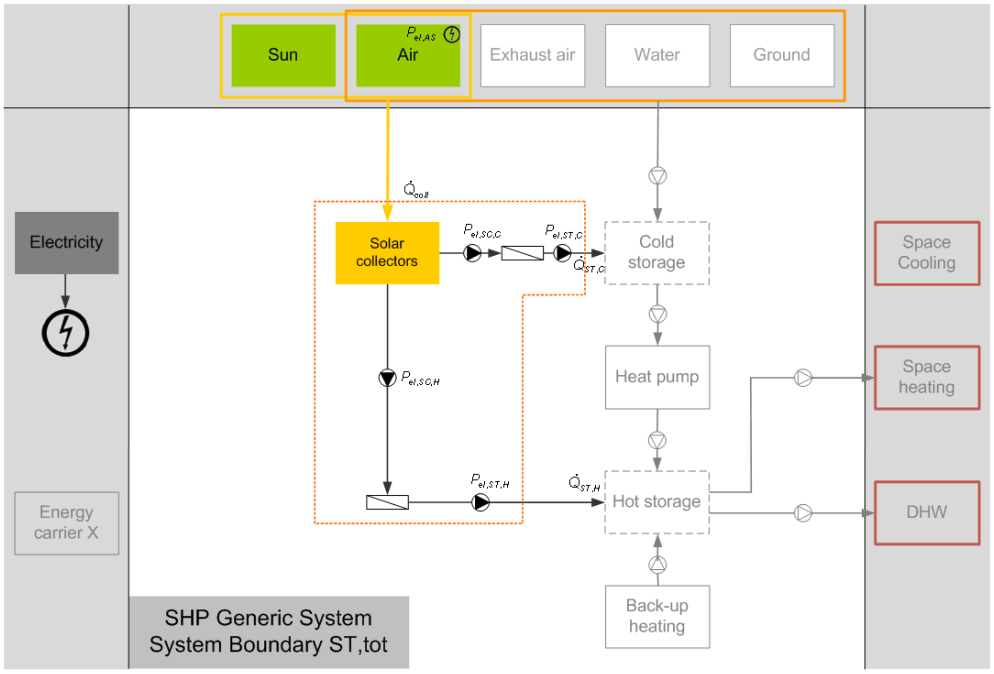

Figure 7: System boundary ST,tot

As it is difficult to define a collector efficiency η for collectors working in a wide temperature range where the influence of the ambient air temperature and humidity rises substantially, another figure for the quality of the collector within the system has to be defined. This could be the Specific Solar Yield, as defined in equation 9:

$$q_{sol} = \frac{\int \left(\dot{Q}_{ST,H} + \dot{Q}_{ST,C} \right) \cdot dt}{A_{coll}} \qquad (9)$$

q_{sol} can be divided in the high and low temperature operation yields, if feasible:

$$q_{sol,H} = \frac{\int \dot{Q}_{ST,H} \cdot dt}{A_{coll}} \qquad (10)$$

$$q_{sol,C} = \frac{\int \dot{Q}_{ST,C} \cdot dt}{A_{coll}} \qquad (11)$$

System boundary HP+HS – Heat Pump plus Heat Source

Inside this boundary is the heat pump unit with all its sources, including the low temperature storage. The energy output considered is the gross energy output of the **heat pump only** ($\dot{Q}_{ST,H}=0$), not taking into account losses due to short or long time storage, piping etc. The energy input to the system includes the overall needed input both of the heat pump and the considered solar thermal parts. If the solar collector does not interact with the heat pump directly (e.g. direct evaporation in the collector) or indirectly (e.g. feeding into the heat pump's heat source – ground, storage etc.), than it should be excluded from the calculations ($P_{el,SC,C}$=0, $P_{el,ST,C}$=0).

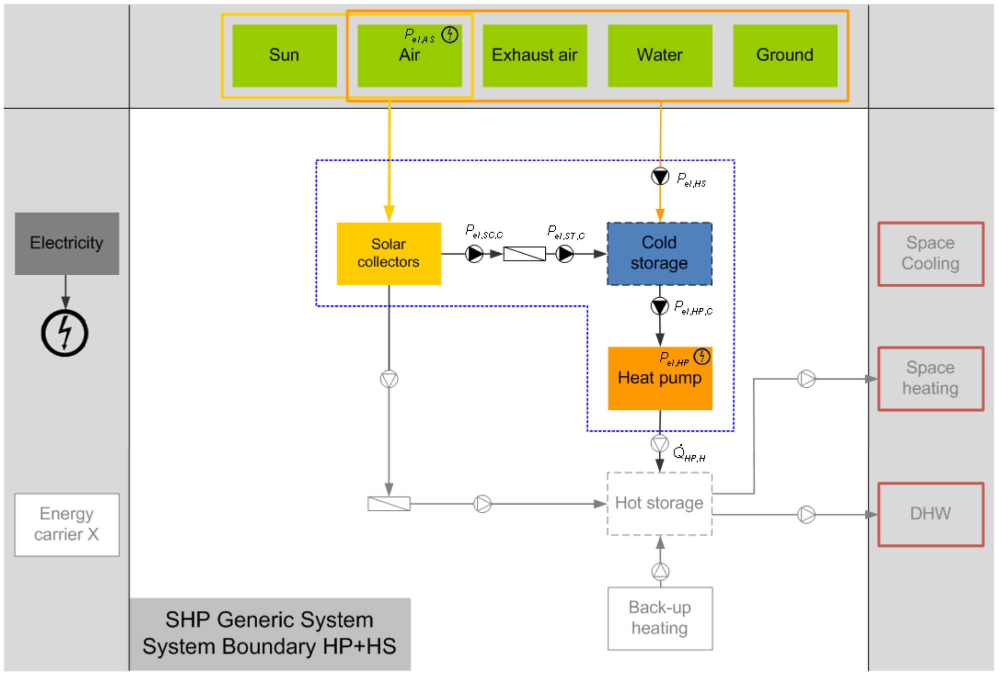

Figure 8: System boundary HP+HS

$SPF_{H,HP+HS}$ can be calculated as:

$$SPF_{H,HP+HS}=\frac{\int \dot{Q}_{HP,H}\cdot dt}{\int\left(P_{el,HP}+P_{el,AS}+P_{el,SC,C}+P_{el,ST,C}+P_{el,HP,C}+P_{el,HS}\right)\cdot dt} \quad (12)$$

The energy inputs in the denominator take different configurations into account. Depending on the configuration, relevant energy inputs have to be included, the rest can be set to zero. For example:

Direct evaporation in the collector, no secondary source, no cold storage: $P_{el,HS}$=0, $P_{el,SC,C}$=0, $P_{el,ST,C}$=0, $P_{el,HP,C}$=0.

System boundary bSt – before the Storage

The system boundary takes into account all energy outputs of the system, including the back-up heating, to the hot storage. The storage losses, as well as the energy needed to supply the heat to the storage are not included.

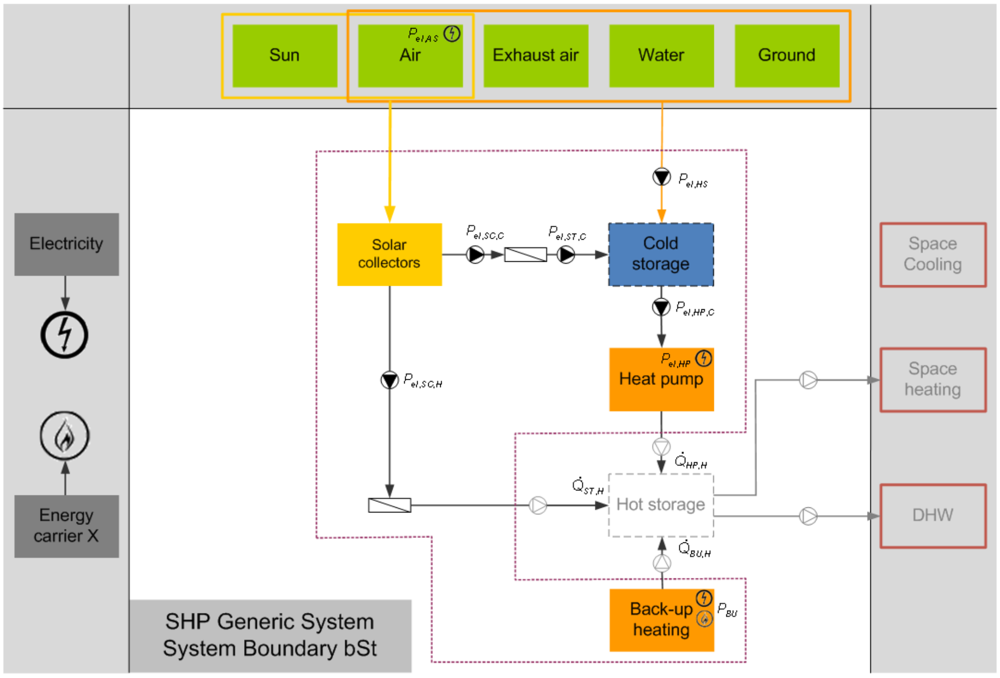

Figure 9: System boundary bSt

SPF$_{H,bSt}$: This SPF gives the gross efficiency of the delivered heat, including the back-up unit:

$$SPF_{H,bSt-BU} = \frac{\int \left(\dot{Q}_{HP,H} + \dot{Q}_{ST,H} + \dot{Q}_{BU,H}\right) \cdot dt}{\int \left(P_{el,HP} + P_{el,AS} + P_{el,SC,C} + P_{el,SC,H} + P_{el,ST,C} + P_{el,HP,C} + P_{el,HS} + P_{el,BU}\right) \cdot dt} \quad (13)$$

Using this system boundary, the fractions of different subsystems to the storage (or directly to the end user) can be calculated, e.g. heat pump fraction, direct solar fraction or back-up fraction. This can be interesting for system dimensioning, control analysis etc.

System boundary SHP – SHP system

In addition to the previous boundary, the losses from the hot storage are taken into account. This system represents the overall SHP system without the energy distribution.

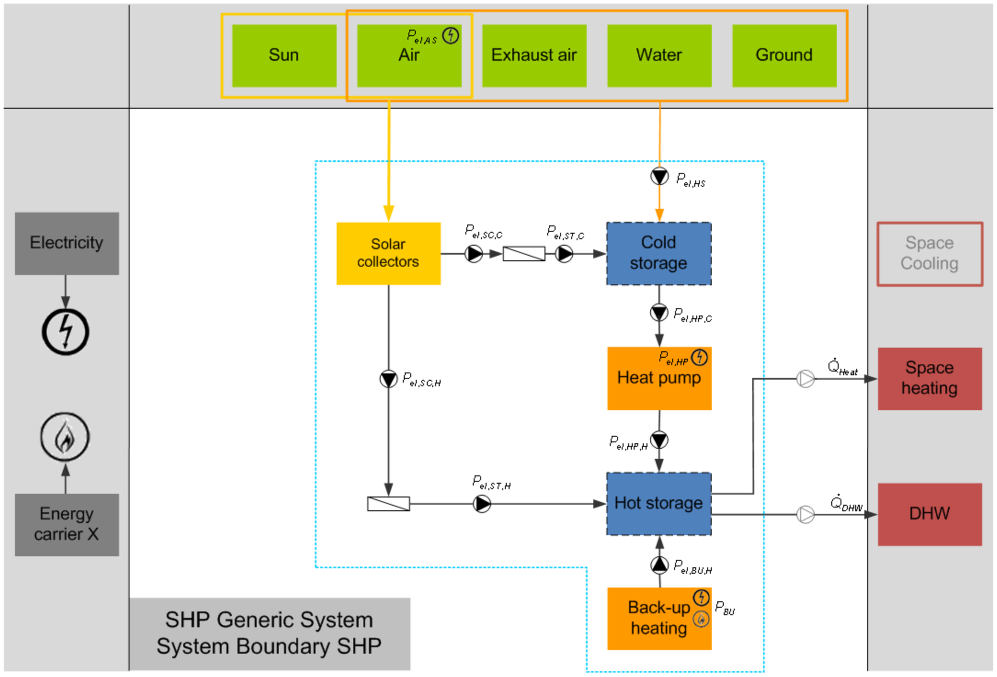

Figure 10: System boundary SHP

$SPF_{H,SHP}$: Unlike the overall SPF_H, it does not include the energy consumption of the heating and DHW distribution systems. Basically, it corresponds to the system boundaries used for performance evaluation and labelling of products from a number of other technologies, including electrically driven heat pumps (however without storage for heating), solar combi systems, thermally driven heat pumps, oil, gas or biomass boilers (however without storage and electricity consumption).

$$SPF_{H,SHP} = \frac{\int \dot{Q}_{HP,H} \cdot dt}{\int P_{el,tot} \cdot dt} \tag{14}$$

with

$$P_{el,tot} = P_{el,HP} + P_{el,AS} + P_{el,SC,C} + P_{el,SC,H} + P_{el,ST,C} + P_{el,ST,H} +$$
$$+ P_{el,HP,C} + P_{el,HP,H} + P_{el,HS} + P_{el,BU,H} + P_{BU} \tag{15}$$

If the back-up heating system uses a different fuel instead of electricity (e.g. biomass, gas), only the electricity consumption of the unit is considered. The consumption of any other fuels should be given separately or through the primary energy ration PER, as described later.

This system boundary gives the possibility of an economic and ecological evaluation of the energy producing system, without the energy distribution system, which is different for every application. It is the most suitable for SHP system intercomparisons, as well as comparisons of the SHP systems with other technologies. It is therefore the most important boundary Interesting for product quality assurance, labelling, manufacturers, comparison between different systems and technologies regarding primary energy, emissions (if system extended to the primary energy sources) etc.

System boundary H – Heating, overall system

Finally, this system boundary includes all energy consumptions of the entire system, including the energy distribution (e.g. electricity for fan coils, circulation pumps etc.).

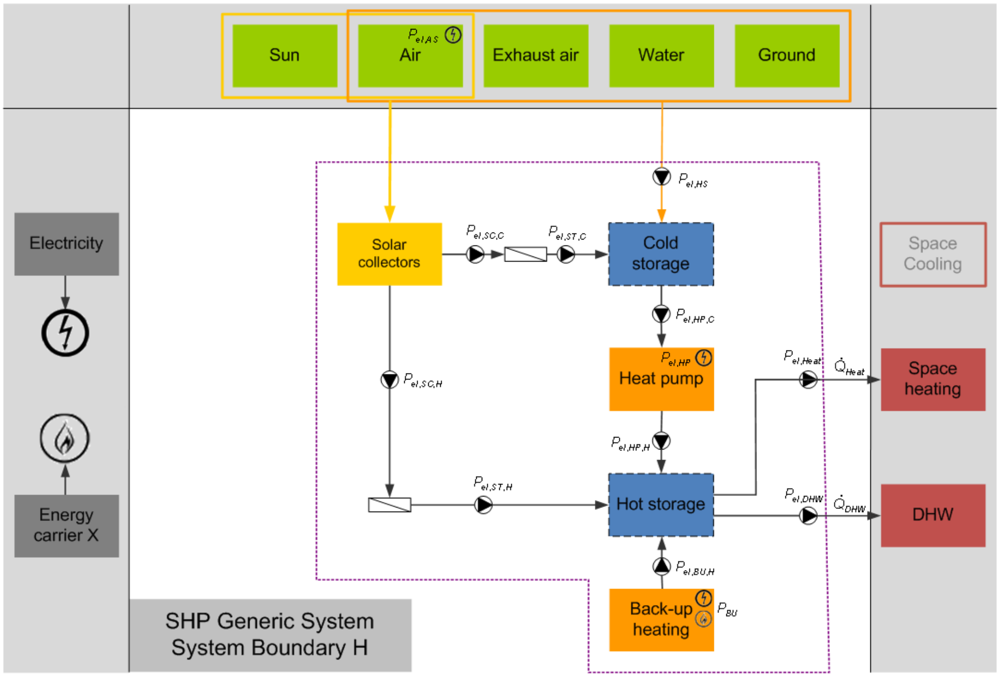

Figure 11: System boundary H

SPF$_H$ represents the efficiency of the whole system including all energy inputs for the heating and DHW distribution (including electric heat-ribbons for DHW distribution pipes, circulation etc.). If a supplementary fuel is used for the back-up unit, the same applies as for SPF$_{H,SHP}$.

5 Comparison of performance figures for different heat pump applications

As mentioned above, one of the goals when developing system boundaries was the comparability of SHP systems with other heat pump and solar thermal applications. Table 1 gives an overview of comparable performance figures for heat pumps and systems including heat pumps from three on-going international projects, which aim at setting standardised procedures for the calculation of system performance. Further development and harmonisation can be expected within follow-up activities.

Table 1: Corresponding SPFs for different heat pump applications, as defined in relevant projects

IEE SEPEMO	IEE QAiST / IEA SHC T44,HPP A38	IEA HPP Annex 34[9]
SPF_{H1}	$SPF_{H,HP}$	SPF Level 2a
SPF_{H2}	$SPF_{H,bSt\text{-}BU}$	SPF Level 2b
SPF_{H3}	$SPF_{H,bSt}$	-
SPF_{H4}	SPF_{H}	SPF Level 1

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[9] In Chapter 2.2, an example for indirect fired cooling system is shown and the corresponding performance figures apply for the cooling application. However, the methodology remains the same also for the heating application, as well as the class of the performance figure.

References

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