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Authors: D. van Beek & M.S. Godschalk (IF Technology)

Database Handbook

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Preliminary remarks

List of main abbreviations and acronyms used in the project

Technical:

ATES	Aquifer Thermal Energy Storage
BHE	Borehole Heat Exchangers
BTES	Borehole Thermal Energy Storage
COP	Coefficient of Performance
GIS	Geographical Information System
GSHP	Ground Source Heat Pump
GW	Groundwater
H&C	Heating and Cooling
HVAC	Heating, Ventilating, and Air Conditioning
RES	Renewable Energy Sources
SGE	Shallow Geothermal Energy
SPF	Seasonal Performance Factor
TRT	Thermal Response Test
UTES	Underground Thermal Energy Storage

Administrative (general or on European level):

EED	Energy Efficiency Directive
EPBD	European Performance of Building Directive
LCC	Life Cycle Cost
NREAPs	National Renewable Energy Action Plans
PCM	Project Cycle Management
RES Directive	Renewable Energy Sources Directive on the promotion of the use of energy from renewable sources
SEAPs	Sustainable Energy Action Plans (for cities)
WFD	Water Framework Directive

Note: The general term for all technologies addressed by the project is "shallow geothermal energy". Geothermal Energy is defined in article 2 (c) of directive 2009/28/EC, and "shallow" refers normally to a depth until 400 m (in most practical cases about 100 m or less). The technologies included under this general term are open and closed loops systems geothermal heat pump (GSHP)s, and Underground Thermal Energy Storage (UTES). Both technologies do not have a clear boundary when large installations are concerned (IEA ECES Annex 8 tried to establish a demarcation in 1998). UTES can be further divided into ATES (aquifer), BTES (boreholes), and possible other variations. For GSHP, several heat/cold sources are possible. In the project, shallow geothermal energy is used when referring to the technology in general, and GSHP or UTES when these distinct technologies are considered.

1. Introduction

This database is created to provide a common European registration method for Shallow Geothermal Energy (SGE) installations. Firstly, this database should be adopted by the committed cities as a tool for the common methodology. Moreover, thanks to the effort done in Covenant of Mayors (CoM), other cities could join the initiative.

1.1 Goal of the database

What is the goal of this database?

With this database the local or regional administrations have a tool for registering all the systems and obtaining the following information:

- the total number of systems in operation and total installed capacity;
- the location and dimensions of each system;
- the technical details of each system.

The information regarding the location and dimensions of the systems can be used to evaluate the interaction with nearby installations and environment. This information can be used by the municipalities in urban and spatial planning, in order to prevent systems having a negative influence on the surrounding systems and environment.

The information regarding the technical aspects of the systems, such as characteristics of heat pumps, installed capacity, heating and/or cooling demand of the buildings, can be used for calculations of the potential energy savings and CO_2 emission reductions that are obtained by using these systems.

Who will use the information from the database?

The information for database will be used primarily by the local/regional administration in charge of environmental monitoring, urban planning and energy policies for understanding the main impacts resulting from the installation of SGE systems.

They need to compile the information about the installations performed in the region in order to quantify the installed capacity in their region, to develop urban planning considerations based on the presence of underground infrastructure and achieve the compromise of energy efficiency and savings marked by the Horizon 2020 targets.

Depending on the country, the local/regional administration has to provide the information to the national administration in order to make national calculations of the energy savings. The national information will be used for comparison on European level and form an integral part of the European statistics on the installed capacity and performance of SGE systems.

Who will fill in the database?

The data needed should be input by the person who is the owner of the SGE system as a part of the permit. To fill in the form, information from an installation/drilling advisor or contractor can be used. However, the owner of the installation is responsible for the data that is included in this database.

1.2 How does the database work?

The database has been developed as an Excel spreadsheet with drop down menu options. This structure is selected in order to facilitate the use in existing GIS or spatial management systems that are already used at local/regional administration level. Figure 1 shows a snapshot of the database.

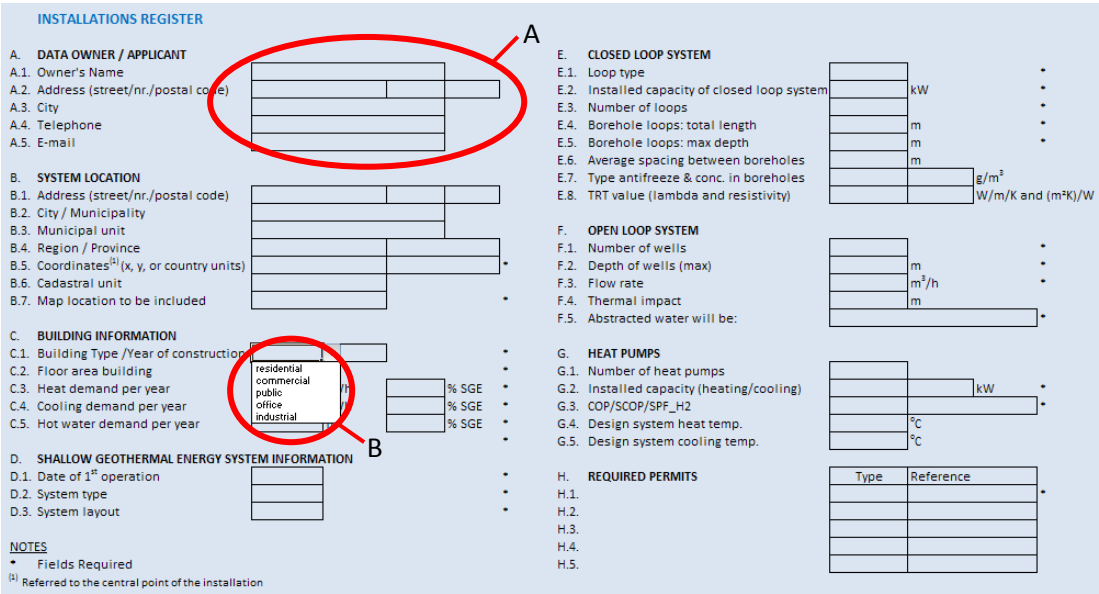

Figure 1: the database

The database has different sections (A to H). Each section contains several questions that cover one subject.

Each question has an answering field. There are 'open' fields and 'multiple choice' fields. In 'open fields' you have to define your own answer. An example of the fields that have to define your own answer is circled as (A) in figure 1. There are also 'multiple choice' fields, where you have to choose your answer between several options. In these fields a drop down menu appears when you click on them, such as is represented in circle (B) of figure 1. From the drop down menu you can choose one option.

The fields marked with an asterisk (*) are appointed as obligatory as they are considered to be the basic information required in order to be able to achieve to goals of this database:

1. facilitate the calculation of the energy saving obtained from SGE installations;
2. use system specific information for urban and spatial planning, and
3. better understand the environmental impact of systems and to prevent negative influence.

The optional fields provide information needed for communication with the owner of the system and some extra information about the local situation and system.

NB. The local/regional administration has the possibility to add extra information to the database, if the local situation or policy requires this (for example different permitting procedures or policies).

1.3 Questions/helpdesk

The local/regional administration operates a helpdesk office for help and/or question regarding the filling or implementation of the database.

2. Explanation per field

This chapter describes per question what information is exactly needed in every field of the database.

Section A: Data Owner / Applicant

This section includes the contact data of the owner of the system. The local/regional administration will use this information for contacting the owner of the system (if necessary).

A1. Owner's Name
A2. Address (street/number/postal code)
A3. City
A4. Telephone
A5. E-mail
All fields are optional.

Section B: System Location

This section identifies the location of a system. The information on the location is used for urban and subsurface spatial planning.

B1. Address (street/number/postal code)
B2. City
The address and city of the location of the system.
These are optional fields.

B3. Municipal unit
B4. Region/Province
These options can only be filled when relevant for your country.
These are optional fields.

B5. Coordinates (x,y, or national grid reference units)
These are the coordinates that refer to the location of the system[1]. In the case of a system with multiple wells/loops, the central point of these wells/loops should be used. The coordinates can be implemented in the local coordinate system.

This is an obligatory field.

[1] In this handbook the term 'system' refers to the subsurface part of an SGE system, that is the wells or loops that collect the energy from the ground(water). The different types of SGE systems are explained in more detail in section D.

B6. Cadastral unit

Additional to the address and coordinates, specific cadastral data relating to the location of the system can be added to the application. The input of cadastral data will be dependent on the country. The local/regional administration has to give instructions on this topic.
This is an optional field.

B7. Map location

The map has to show the location of the system. This can be either the location of each well/loop, or the central point in case of a multiple well/loop system (see also B5). Each location marked on the map has to include its coordinates. A scale bar in the map is required.

The map can be uploaded during the application. The uploaded file can have different formats: *.doc*, *.pdf*, *.tiff*, *.jpg*, etc...

It is obligatory to include the map in the application.

Section C: Building Information

This section refers to the information of the building that will be heated and/or cooled by the SGE-installation. It also includes information about how much heat/cold is distributed through the building. All fields are obligatory.

C1. Building type and year of construction

This field describes the type of building that is heated and/or cooled by the SGE system. The following building types can be chosen:

- residential: residential building
- commercial: any kind of shops, shopping centers, etc.
- public: any building that belongs to the (local) government and buildings that have a public function, like train stations, libraries, hospitals, schools, universities, etc.
- office: office buildings, where people work
- industrial: buildings where goods are produced or elaborated, like factories

C2. Floor area building [m^2]

This is the total floor area of the building. If a building has several storeys, the floor area of these storeys also has to be included.

C3. Heat demands per year [kWh] and [% SGE]

C4. Cooling demands per year [kWh] and [% SGE]

C5. Hot water demand per year [liter] and [% SGE]

These fields identify the amount of heating, cooling and hot (sanitary) water that the SGE system provides to the building per year. The first box identifies the absolute amount per function (in kWh or

liter), the second box identifies what percentage of this demand is met by the SGE system. If the system is not used for one (or two) of these functions, fill in '0' in both boxes.

Section D: Shallow Geothermal Energy System Information

This section identifies the general characteristics of the system. All fields are obligatory.

D1. Date of first operation

This field asks about the date of first operation. This is the date when the system is switched on or commissioned and thus **not** the date of installation.

D2. System type

In this field the type of system that is used has to be described. The options are:

- open: an open loop system, or ATES system, uses energy that is stored in aquifers from 20 to 250 m below the surface. In a cold period, water is extracted from an aquifer, heat is extracted from this water and relatively cold water is re-infiltrated through another well in the same aquifer. In a warm period, cold is extracted from the groundwater and relatively warm water is re-infiltrated. Figure 2 shows the principal of an open system.
- closed: a closed loop system, or BTES system, uses a closed circuit of piping in the subsurface. A number of tubes are placed into the ground to a depth of between 50 and 200 m. The tubes are filled with a fluid to exchange heat with the ground volume around it. These vertical heat exchangers exchange heat with the earth to heat or cool the building. Figure 3 shows the principal of a closed system.

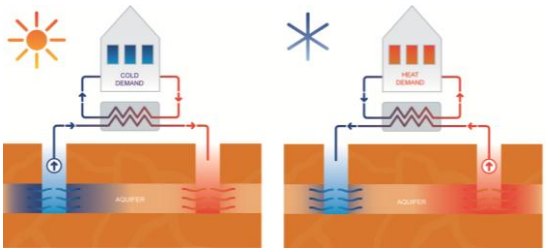

Figure 2: open loop system / ATES

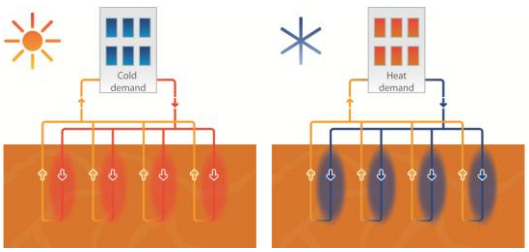

Figure 3: closed loop system / BTES

D3. System layout

This field describes the orientation of the wells/loops of the SGE system. The options are:

- vertical (Figure 2 and 3)
- horizontal (Figure 4)
- inclined (Figure 5)
- other, for example a closed basket system (Figure 6).

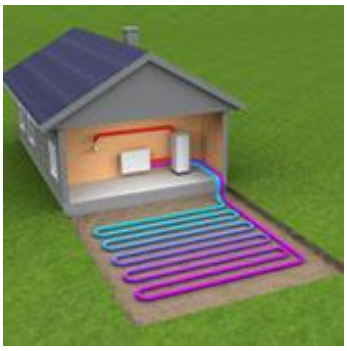

Figure 4: horizontal

Figure 5: inclined

Figure 6: other, closed basket

Section E: Closed loop system

This section describes the characteristics of the closed loop system. This section should only be completed if a closed loop system is installed.

E1. Loop type

This field describes the type of loop that is used for the system. This is an obligatory field.

The options are (Figure 7, 8, 9):

- single U loop: this is a single pipe loop;
- double U loop: this loop type is the combination of two single U loops;
- coaxial or concentric loop: in this loop type, the fluid is going down in the centre of the loop and is coming up at the border of the loop, outside of the downward part;
- other: other type of tubing, for example a closed basket (Figure 6).

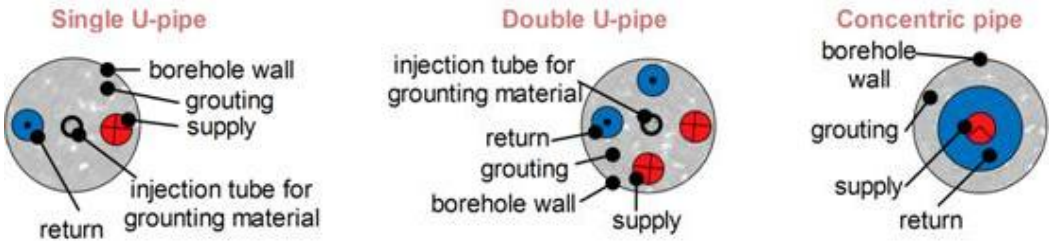

Figure 7: loop types

Figure 8: end of U loop

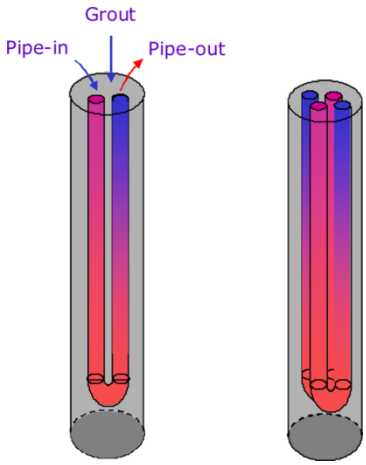

Figure 9: single (left), double (right)

E2. Installed capacity of closed loop system [kW]

The installed capacity is the amount of energy (power) the system can generate per hour. In this database the theoretical maximum installed capacity of the system should be input. The theoretical installed capacity is not necessarily equal to the actual capacity of the system.

This is an obligatory field.

E3. Number of loops

This is the number of boreholes completed for the loops installed in the subsurface. For each loop, one borehole is made. A double U loop counts as one loop.

This is an obligatory field.

E4. Borehole loops: total length [m]

This is the combined total (borehole) length of the individual loops combined in one system. In case of vertical or inclined loops, the length of the loop is defined as the distance from the top of the borehole to the bend (or connection) at the lowest point in the borehole; for double-U-loop, this value is taken only once. For example, if one system has three borehole loops, you have to add the length of the three loops. For horizontal loops, the total length of pipe in the ground should be given.

This is an obligatory field.

E5. Borehole loops: maximum depth [m]

This is the maximum drilled depth the loops are installed.

This is an obligatory field.

E6. Average spacing between loops [m]

This is the space between the loops of one system. If the space between the loops differs throughout the field, the average space can be chosen. Figure 10 gives an example of a field of loops.

This is an optional field.

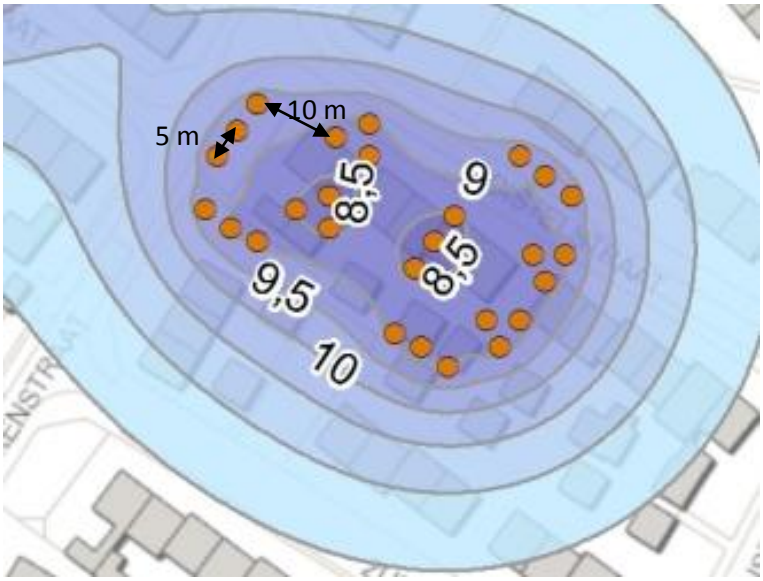

Figure 10: field of loops with an average distance of 7,5 m between the loops

E7. Type antifreeze & concentration in loops [g/m^3]

The first box identifies the type of antifreeze that is used in the closed loop. The options are:

- water: in this case no antifreeze is added
- water + antifreeze: in this case antifreeze is added to the water, but the type of antifreeze is not known
- alcohol: alcohol is added to the water
- glycol: glycol is added to the water

The second box is for filling in the concentration of antifreeze that is used in the closed loops. If only water is used, fill in '0'.

These fields are optional, since it is not always known what fluid is used in the loops.

E8. TRT value (thermal conductivity (λ) and borehole thermal resistance (R))

A Thermal response test (TRT) is used to determine the real effective thermal properties of the ground. If a TRT is carried out, the results of the test can be filled in these boxes.

The information compiled from this field, give a better understanding of the subsurface properties. The thermal conductivity (λ) is in [W/m/K], the thermal resistance (R) is in [(m^2K)/W].

This is an optional field.

Section F: Open loop system

This section describes the characteristics of the open loop system. This section is only relevant if an open well system is installed.

F1. Number of wells

This describes the number of wells that are completed for production and/or re-injection.

This is an obligatory field.

F2. Maximum depth of the wells [m]

This describes the maximum depth of the wells that are completed as part of the system.

This is an obligatory field.

F3. Flow rate [m^3/h]

This describes the installed flow rate of the wells, i.e. how many cubic metres of water are pumped in one hour. In this database the theoretical maximum installed flow rate of the system should be input. The theoretical installed flow rate is not necessarily equal to the actual flow rate of the system.

This is an obligatory field.

F4. Thermal impact [m]

This is the zone of thermal influence that a well creates. This field is optional.

The thermal effects can be calculated with a thermal model (Figure 11). If no model is available, the following formula can be used to calculate the global thermal radius (Figure 12):

$$r_{th} = \sqrt{\frac{Q * C_w}{H * \pi * C_a}} \qquad \textit{(Eq. 1)}$$

where:

r_{th} thermal radius of the stored cold or heat [m]

Q amount of water that is pumped per season from one well to the other well [m^3]

H filter length of the well [m]

C_w volumetric heat capacity of water [MJ/(m^3K)] = 4.19

C_a volumetric heat capacity of the aquifer [MJ/(m^3K)] =

$$C_a = n * C_w + (1 - n) * C_s \qquad \textit{(Eq. 1a)}$$

where:

n porosity [-]

C_w volumetric heat capacity of water [MJ/(m^3K)] = 4.19

C_s volumetric heat capacity of the solid [MJ/(m^3K)]

Soil type*	C_s	Soil type*	C_s
Chalk	2.2 - 2.7	Sandstone	1.6 - 2.8
Limestone	2.1 - 2.4	Sand	2.2 - 2.9
		Clay/silt	1.6 - 3.4

* More soil types are available on VDI 4640 Blatt 1 (Berichtigung).

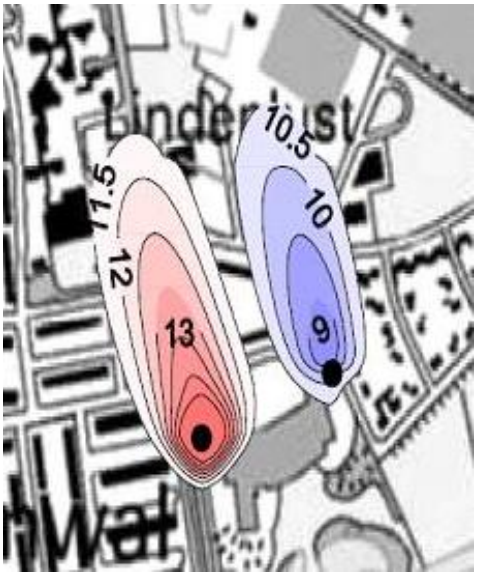

Figure 11: thermal effects calculated with a model

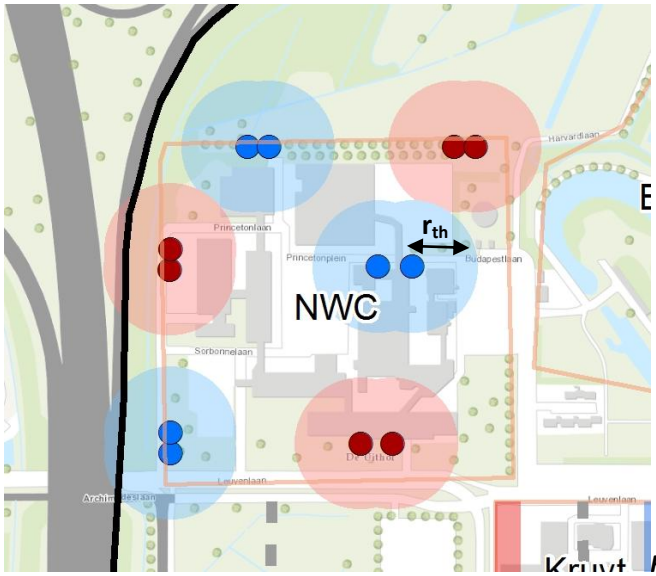

Figure 12: thermal radii calculated with equation 1

F5. Abstracted water will be:

This question identifies what is done with the abstracted water. The options are:

- re-injected: this is the case in a storage system
- discharged to sewer
- discharged to surface water

This is an obligatory field.

Section G: Heat pumps

This section includes the technical information of the heat pump.

G1. Number of heat pumps

This question identifies the number of heat pumps that are installed in one system. It is for example possible that one pair of wells or one closed loop field is used for the heating and/or cooling of several apartments that each has their own heat pump.

This field is optional.

G2. Installed capacity (heating & cooling)

This is the maximum amount of heating and cooling power the heat pump can produce in kW. In the case that more than one heat pump is installed in one installation, the combined total amount of heating and cooling should be input.

This is an obligatory field.

G3. COP / SCOP / SPF_{H2}

These are the Coefficient Of Performance for heating (COP), the Seasonal Coefficient Of Performance for heating and cooling (SCOP) and the average Seasonal Performance Factor (SPF).

The COP of a heat pump is the ratio of the heating or cooling provided over the electrical energy consumed. The COP provides a measure of performance for heat pumps that is analogous to thermal efficiency for power cycles.

In the database you can choose between the following options to provide the system's performance:

1. COP Declaration of the coefficient of performance according to EN 14511.
2. $SCOP_{net}$ Declaration of the seasonal coefficient of performance ($SCOP_{net}$) calculated according to EN 14825:2012.
3. SPF_{H2} Calculation of SPF_{H2} from data from field measurements. Use equation 3 to calculate the SPF_{H2} and use field measurement data as input. (Please note that SPF_{H2} requires measured system performance data, typically from one year of operation, and cannot be applied in the initial or early design stages of a project.)

1. COP

$$COP_h = \frac{Q_{heating}}{W} \quad \text{and} \quad COP_c = \frac{Q_{cooling}}{W} \qquad \textit{(Eq. 2)}$$

where:

$Q_{heating}$ amount of heat produced by the heat pump (in kWh)

$Q_{cooling}$ amount of cold produced by the heat pump (in kWh)

W amount of energy (electricity) consumed by the heat pump (in kWh)

Heat pumps have a rating plate where a COP at a standard rating condition according to EN14511 is given. That COP is only valid for space heating at the specified condition. For example, the COP for a low temperature system is given at 0/35. That is, at a heat source temperature of 0 °C and a heat pump outlet temperature of 35 °C.

2. $SCOP_{net}$

The $SCOP_{net}$ means the net Seasonal Coefficient Of Performance in active mode. This value should be calculated according to EN 14825:2012 and is valid for space heating mode without a backup heater. Sanitary hot water heating is not included.

In $SCOP_{net}$ the COP for several operating conditions are weighted to represent a seasonal performance during a year. Taking into account the heat demand of a fictive house that matches the heat pump capacity. Different ambient temperatures and their duration during a typical year are considered. The $SCOP_{net}$ value is derived from the system's implementation study and based on the installer's design assumptions.

3. SPF_{H2}

When stating the SPF value one should follow the system boundaries in Figure 13 which is according to the European Commission's decision of 1 March 2013 (2013/114/EU).

Using this system boundary, the SPF_{H2} is calculated by:

$$SPF_{H2} = \frac{Q_{H\_hp} + Q_{W\_hp}}{E_{S\_fan/pump} + E_{HW\_hp}} \qquad \textit{(Eq. 3)}$$

where:

Q_{H_hp} quantity of heat of the HP in space heating operation [kWh]

Q_{W_hp} quantity of heat of the HP in domestic hot water operation [kWh]

$E_{S\_fan/pump}$ electrical energy use of the HP source: fan or brine/well pump for space heating and domestic hot water [kWh]

E_{HW_hp} electrical energy use of the HP for space heating and domestic hot water [kWh]

This is an obligatory field.

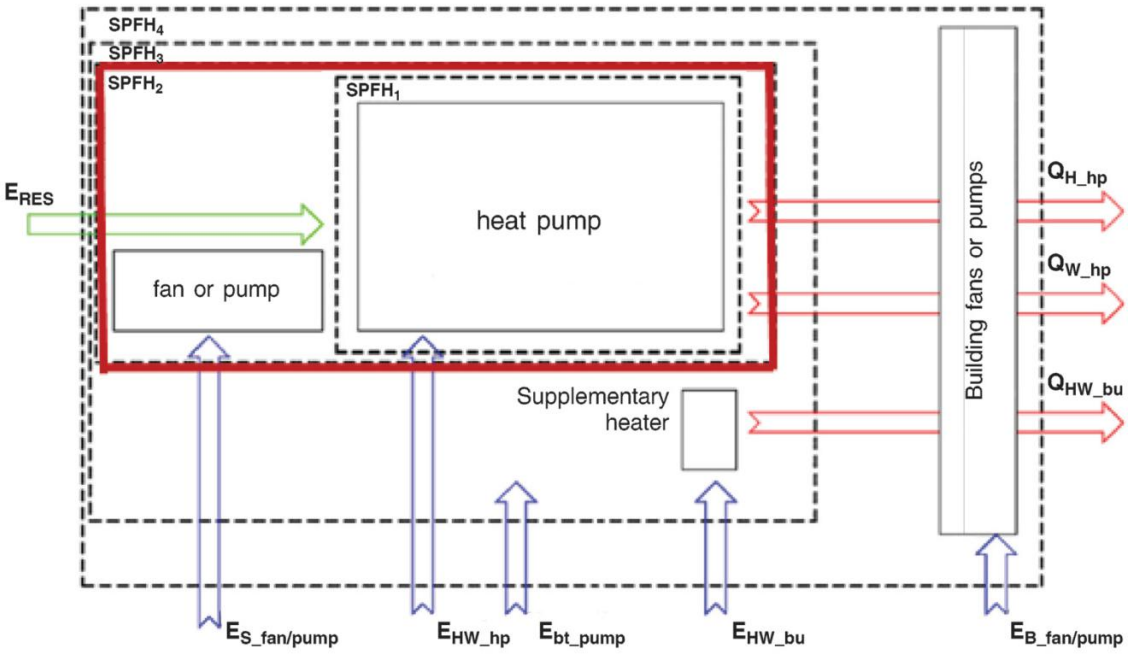

Figure 13: System boundaries for measurement of SPF and Q_{usable}. From the European Commision's decision of 1 March 2013 (2013/114/EU), establishing the guidelines for Member States on calculating renewable energy from heat pumps from different heat pump technologies pursuant to Article 5 of Directive 2009/28/EC of the European Parliament and of the Council.

G4. Design system heating temperature [°C]

This is the theoretical temperature the heat pump will produce for heating. It is the temperature that is designed in advance of the installation, and not the actual temperature. The actual temperature can be higher or lower than the design temperature, due to climatic influence.

This field is optional.

G5. Design system cooling temperature [°C]

This is the theoretical temperature the heat pump will produce for cooling. It is the temperature that is designed in advance of the installation, and not the actual temperature. The actual temperature can be higher or lower than the design temperature, due to climatic influence.

This field is optional.

Section H: Required permits

This section covers all potential permits or declarations and the types (level) of administration involved in the installation of an SGE system. The following data of each permit/declaration should be input:

- the type of the permit; in this field you have to define the relevant permit
- the permit level; which means from which level administration. The options are:
    - national
    - provincial
    - regional
    - municipal
- a reference number and data of issue

Every country has its own legal system, so every country has to add its own permits and declarations. To give an idea of the possible types of permits, the following list of potential permits and declaration has been created:

- Installation permit: a permit required for the installation of the SGE system.
- Production permit: Permit required for the start-up of the system's operation. It follows the commissioning period of the installation and it is usually issued after the installation permit
- Exception: Concerns installations that are excluded from any permitting procedure
- Small scale permit: Alternative permit which might replace either the exception or the installation permit or both depending on the special regulatory provisions of each country.
- Water use permit: a permit needed to be allowed to extract groundwater for an ATES system.
- Discharge permit: a permit can be required for the system water or for the cleaning of an ATES well that needs to be discharged.
- Environmental Terms: a permit needed to be allowed to install or operate a very big system or a system planned in environmentally vulnerable areas.

NOTE: the content of the drop down list can be changed to the local situation.