SEASONAL PERFORMANCE FACTOR AND MONITORING FOR HEAT PUMP SYSTEMS IN THE BUILDING SECTOR

SEPEMO-BUILD

EU heat pump system quality: well on its way, but roadworks ahead

D5.5. Position paper on heat pump system quality.

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1 Introduction

The large-scale application of renewable energy installations in the building sector will require a significant number of highly qualified installers capable of integrating renewables in both new and existing buildings. It will also be necessary to ensure the good operation of these systems after installation and to make sure that they are well adapted to the individual requirements of each customer. Furthermore, life-cycle considerations will have to be taken into account.

SEPEMO-Build was launched in anticipation of the Directive on the promotion of the use of energy from renewable sources (2009/28/EC). This Directive obliges amongst others to reach a minimum level of SPF with heat pump systems to be acknowledged as renewable. Furthermore, Member States have to develop and mutually recognize certification or equivalent qualification schemes for installers of small-scale renewable energy systems (e.g. biomass boilers and stoves, solar photovoltaic and solar thermal systems, shallow geothermal systems and heat pumps) by December 2012.

The aim of SEPEMO is a broader acceptance of heat pump systems and an improved quality assurance for heat pump systems in the building sector. Important activities in SEPEMO include developing a common methodology and field measurements of “real life” heat pump performance.

On analysing the performance of heat pump systems the SEPEMO project has identified a number of key success criteria that should be taken into account when designing and maintaining heat pump systems. Providing heat pump system quality is a more complex matter than the installation of other renewable energy technologies as the optimal performance is dependent not only on the quality of the heat pump itself and the heating and/or cooling distribution system in the building. The design in relation to the quality of the building envelope, the quality of the source design, installation and operation, user characteristics and behaviour, all play an important role.

2 Quality and Certification

The European Directive on Renewable Energy states that: “Member States shall ensure that certification schemes or equivalent qualification schemes become or are available by 31 December 2012 for installers of small-scale biomass boilers and stoves, solar photovoltaic and solar thermal systems, shallow geothermal systems and heat pumps. Those schemes may take into account existing schemes and structures as appropriate, and shall be based on the criteria laid down in Annex IV. Each Member State shall recognise certification awarded by other Member States in accordance with those criteria.”

As heat pump systems consist of the energy source, heat pump and heat distribution and occur in various concepts it is not easy to develop a straightforward performance certification of systems. The optimal performance is dependent on:

- the quality of the heat pump itself;
- the heating and/or cooling distribution system in the building;
- the design of the heat pump system in relation to the quality of the building envelope;
- the quality of the source design;
- the quality of installation, and
- user characteristics and behaviour.
On top of the aforementioned, the designers of the heat pump and the heat source and the installer of the system are usually not the same persons. Often they do not even work in the same company. Figure 2-1 illustrates the complexity of the heat pump systems and different existing labels. Legislative acts exist or are under construction that govern several aspects of the installation addressing both product performance as well as environmental and safety aspects (pressure vessels, F-gases, ground sources, Ecodesign). Some of them even require certified personnel already (F-Gas Directive, Requirements on maintenance for air conditioning systems under the EPBD).

In various countries legislation, certification and registration drilling of ground sources is being developed or existing. This is often mandatory certification as part of environmental legislation to protect ground water aquifers.

The installer (person and company) need to consider the requirements of the legal framework and the peculiarities of heat pump systems in order to provide quality systems in line with regulation.

It becomes obvious, that different training and competence requirements exist that need to be catered for by individual training programs. Today's reality is, that at least six certification schemes exist throughout the EU. Certification can be done according to an identical scheme for all heat pump and small RES installers.
Figure 2-2: Today, at least six different certification schemes for heat pumps exist on the EU market (Ulla Lindberg, SP, European heat pump summit, Nürnberg, Germany, November 2011)

2.1 Heat Pump Quality

EHPA Quality label

The EHPA quality label for heat pumps originates in activities of the heat pump associations of Austria, Germany and Switzerland to create a common set of requirements to ensure product and service quality for heat pumps (named D-A-CH quality label after the countries’ international codes). The idea has been developed further within the European Heat Pump Association. The country scope is currently extending. In order to reflect this development, the name D-A-CH quality label has been replaced by EHPA quality label. In addition to the founding countries the EHPA quality label was introduced in Sweden (2007), Finland (2008), Belgium and France (2010). Its use in more countries is under preparation.

The label can be granted to standardized space heating electrically driven heat pumps, with or without domestic hot water heating capability, with a capacity of up to 100 kW from air, geothermal or water heat sources. In order to qualify for the EHPA quality label, the heat pump in question must comply with EHPA heat pump test criteria and the distributor must provide a defined level of service. The key requirements are (list not exhaustive):

- Conformity of all main components and compliance with the national rules and regulation (CE marking)
- Minimum efficiency values defined as follows (operating points - required COP), tested in labs accredited to ISO 17025 to perform heat pump test according to EN 14511/EN 16147/EN 15879:
- Brine to water B0/W35 - 4.30
- Water to water W10/W35 - 5.10
- Air to water A2/W35 - 3.10
- Direct exchange ground coupled to water E4/W35 - 4.30
- Hot water heat pump (currently under revision)

- Declaration of sound power level.
- Existence of sales & distribution, planning, service and operating documents in the local language of the country where the heat pump is distributed.
- Existence of a functioning customer service network in the sales area that allows for a 24h reaction time to consumer complaints.
- A two year full warranty which shall include a declaration stating that the heat pump spare parts inventory will be available for at least ten years.

The full set of requirements and/or further information can be obtained from EHPA’s quality label committee or the associations’ websites (www.ehpa.org).

ECO Label

The European ECO-Label is a voluntary scheme. It can be used in all European member countries. It has been built to encourage the market of products and services that are kind to the environment. The heat pumps are in the group “Household Appliances”. Criteria on efficiency are given but the aim is not only to reduce environmental impacts but also to reduce or prevent the use of hazardous substances. The market share for ECOLabel product aimed is 20% by product categories, in order to identify the most efficient and ecologic products. The criteria could be revised within 3 to 5 years.

Concerning Heat Pumps, the ECO-Label is established for “electrically driven, gas driven or gas absorption heat pumps” with a maximum heating capacity of 100 kW. Levels are established for COP and EER and PER (Primary Energy Ratio) for specified source and output temperature (see Table 2-1).

2.2 System Quality and EUCERT

The European Certified Heat Pump Installer programme (EUCERT) is the response of manufacturers and industry stakeholders to setting minimum requirements for heat pump installers that are necessary for high quality, efficient and reliable installations. It focuses on implementing a training program for heat pump installers, establishing a certification programme for this target group and disseminating the trademark “certified heat pump installer”. A key element of the programme is the provision of identical training material (in the local language) for all EUCERT training courses throughout Europe to enable the development of a comparable qualification and mutual acceptance of certificates by various participating countries.
<table>
<thead>
<tr>
<th>Heat source /heat sink</th>
<th>Outdoor unit (°C)</th>
<th>Indoor unit (°C)</th>
<th>Min. COP</th>
<th>Min. COP</th>
<th>Min. PER</th>
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<td>Outlet temp.: 45</td>
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<tr>
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<td>Outlet temp.: 45</td>
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<td>2,04</td>
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<td>Inlet wet bulb: 15 max</td>
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<td>Outlet temp.: 45</td>
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<tr>
<td>Brine/water</td>
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<td>Inlet dry bulb: 20</td>
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<td>Outlet temp.: 45</td>
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<td>2,24</td>
<td>2,04</td>
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<td>Water/air</td>
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Table 2-1: ECOlabel COP criteria for various heat pumps

The core training manual addresses relevant aspects of an efficient heat pump installation from a technical and a sales perspective. The technical part covers: technical operating principles of a heat pump, factors influencing efficiency, planning and installation of the heat source, heat distribution systems and hydronic systems, environmental impact, energy efficiency in buildings, conducting a site assessment, installing HP and auxiliary components, operation modes and control, performing a system check, failure detection and maintenance of a HP system, electrical basics, frequent mistakes and practical experiences. The economic part covers marketing and sales, cost calculation, customer education and warranty, compliance with legal standards.

Each training course consists of 36 hours manufacturer independent education including eight hours of hands-on, practical training. It is completed by an examination. EUCERT training does not replace manufacturer-specific product training but supports it by providing a broad foundation for future learning. Participants who successfully pass the examination and provide proof of active experience as an installer can then opt for a certification which – if successful – grants the title “European Certified Heat Pump Installer”. The certificate is valid for three years and can be renewed. The renewal procedure requires proof of active work as a HP installer as well as participation in additional education activities.
Experience from the EUCERT program shows that the success of the programme strongly relies on support from the industry (manufacturers/heat pump associations offering a brand independent education scheme) and governments (certified installers as a prerequisite for subsidies, acknowledgement of an increasing share of RES systems in heating and cooling and appropriately adjusting the curricula of education and training). Agreement on one education system supported by relevant industry actors seems to be of particular importance, especially since the RES Directive asks for mutual acceptance of the certificate across Member States. A rapid uptake of education and training programmes, as well as of certification options in the workforce seems to strongly rely on the abovementioned elements.

As a lack of sufficiently educated installers can severely limit market development, it is in the interest of Member States as well as of industry to establish training and certification options at the same time encouraging (new) installers to enrol in them. The number of trainees is small compared the portential requirements in Europe.

The solution could be to make proof of training or even certification mandatory, due to cost and time constraints for the training of all installers. A pragmatic approach is needed to allow a fair number of installers to be trained without posing too big a burden on the installer trade.

The necessary next steps are:

- To establish understanding in the administration of Member States on the compliance of EUCERT with the requirements of Annex IV of the RES Directive and seek official acknowledgement of the programme as an option to fulfil the Directive’s requirements.
- To get the certification in line with the local building codes.
- Find partners in the remaining European Member States to execute the programme.
- Encourage more installers to participate in the training courses and in certification.
- Financial incentives and tax reduction schemes dependent on installations made by certified installers.
- Manufacturers, members of EHPA, or the various national manufacturers’ associations in the various counties, should only deliver to certified installers.

2.3 Ground sources

Ground Source Heat Pumps (GSHP) systems consist of three main components: the ground source, the heat pump itself, and the distribution system in the building. Many problems with heat pump systems could have been avoided if there would have been no errors with source design. A good design must take into account the whole system, matching the components in such a way that the most effective operation and the highest comfort can be achieved.

Today, a certification for the heat pump installers exists which only covers the heat pump and the heat distribution system. Planning and installing the geothermal system (the ground part), is currently only covered by a few schemes in Europe, for instance the “DACH certificate for ground heat exchanger drilling companies”.

Geotrainet
The IEE project “GEOTRAINET” has set up and tested a concept for training and certification of drillers and designers. The project was finalised in February 2011, but the partners collaborate further in an education committee, located at EGEC / EFG (European Geothermal Energy Council / European Federation of Geologists).

The theoretical part of the shallow geothermal installer training covers all of the following: geothermal resources and ground source temperatures of different regions, soil and rock identification for thermal conductivity, regulations on using geothermal resources, basics in determining the most suitable geothermal heat pump system and system layout, drilling technologies, installation of borehole heat exchangers, well construction, pressure testing, logistics, building laws, and safety.

The training also provides good knowledge of the standards for shallow geothermal, and of relevant national legislation. The trained installer will have gained the following key competences:

- basic geographical and hydrogeological knowledge and understanding geological and geothermal parameters of the underground and knowing their determination, nomenclature and identification of soil and rock types, preparing borehole reports including lithology, groundwater, etc.;
- familiarity with different drilling and digging technologies, choice of the optimum drilling method, ensuring protection of the environment (in particular groundwater) while drilling;
- skills for welding of plastic pipes and other connection methods and ability to install borehole heat exchangers, to grout, backfill or otherwise complete the ground source system, and to perform pressure tests; ability to construct groundwater wells, to install the relevant pipes, pumps and control systems;
- ability to perform the relevant documentation including identification and drawing up of drilling locations.

It should be noted that existing DACH certification scheme typically concerns the companies. However, the GEOTRAINET scheme is for certification of trained persons.

The following issues are important for further implementation of ground source certification schemes:

- the certification of installers and designers of ground sources should be organised on a European level;
- the number of countries actively participating in the certification scheme should increase;
- the certification of installers and designers of ground sources and the certification of heat pump installers should be matching;
- quality certificates of materials for ground sources (grouting, pipes, connections) should not be forgotten for optimal efficiency and longevity.

According to QualiCert, one of the barriers to a sustainable and growing shallow geothermal market is the lack of appropriate skilled personnel, of quality of design and dissatisfactory results of existing installations.

There are two big needs:

- train the GSHP designers to teach them to link ground potential and building energy needs and thus achieve a correct sizing.
- train the drillers to have the necessary knowledge of the installation of borehole heat exchangers, to be sure they interpret the design correctly, and drill the boreholes according to the good practice.

Certified planners, manufacturers and installers (including drillers) are necessary to ensure high
efficiency and longevity of a GSHP system. Also for the certification of drilling companies, joint basic rules should be developed in order to facilitate cross-border service.

The certification of drillers, installers, and, more generally, of all specialists that contribute to the design, installation and maintenance of GSHP systems is a very important issue in order to guarantee the proper operation of the system. Concerning the certification of specialists for GSHP applications, e.g. drillers, installers etc., common requirements for this procedure have to be established in the framework of a common European norm. Moreover, heat pumps and materials (grouting, pipes, and connections) used for these systems have to be certified in order to ensure the quality and long-life operation of the GSHP system.

2.4 Building Quality

The EPBD (Energy Performance of Buildings Directive) obliges EU countries to do the following:

- Adapt to the EPBD general framework calculations
- Set minimum requirements for energy efficiency of new buildings
- Set minimum requirements for the renovation of large buildings
- Set up a system of energy certification of buildings
- Regular testing of heating and cooling equipment, above a specific size, and testing of equipment older than 15 years.

Tradition has it that the installer installs a larger system than required because he needs a satisfied customer and he expects that the quality of the building envelope does not meet the design.

Concerning the building envelope and domestic hot water demand, setting minimum standards for building quality is one thing, but guaranteeing that all details will be put in place on the building site is another. Another observation is, that energy demand for space heating has decreased considerably over the years. This gives rise to the following issues for heat pump systems:

- The quality of the building envelope has a major impact on heat pump performance. The heat pump should be sized relating to actual energy demand of a building, which implies that the building should have the quality that is expected in the planning.
- Oversizing or undersizing a heat pump will lead to dissatisfied customers. When oversized, the heat pump operates part-load, the investment was too high and the efficiency is disappointing. When undersized, the indoor comfort is insufficient.
- Energy demand for space heating is decreasing, while energy demand for domestic hot water is increasing, with higher comfort demands. This asks for new system designs, where domestic hot water production is the dominant heat demand …
- From national traditions, requirements for avoiding legionella are different across the EU. The required rise of temperature, and its frequency play a role in heat pump water heater efficiencies. Harmonisation would be welcome.
- Building codes calculate a standardised energy use. However, user behaviour can lead to significant differences in heat demand. This is demonstrated in the graph below which presents energy use for space heating and domestic hot water in one building with 76 apartments in the Netherlands. Monitoring was done by IthoDaalderop. The graph shows that nearly identical houses have enormous variations in space heating demands and demands for domestic hot water, largely due to user behaviour. As an example, the thermostat settings for space heating varied between 18-23.5°C in these apartments! This is a more challenging reality than the average model predicts – to which the heat pump system
should then adapt.

Figure 2-3: Measured electricity uses (kWh) for space heating (SH), domestic hot water (DWH) and cooling differ a factor of three for 30 apartments in one apartment block, equipped with identical ground coupled heat pump systems. Setpoint temperatures between 18.5-23.5°C for the same apartments. Measuring period: 25-12-2010 till 11-03-2011.

Financial barriers due to the costs of audits can be overcome by adjusting the number of audits conducted (e.g. random selection).

2.5 F-Gases

Since 1st January 2010, companies in the sector of refrigeration have to comply with the new statutory obligation under the European-style F-Gases decision. According to the F-gases act, certification is required for companies active in the field of installation and / or maintenance of refrigeration equipment (installation, repair, periodic maintenance, commissioning, preventive monitoring and decommissioning) with F-gases or controlled (ozone depleting) substances (e.g. CFCs, HCFCs and HFCs). There are two levels of certification: a first one for personnel (with examination of know-how), and a second one for the company (with proof of certified personnel and necessary tools).
2.6 Air conditioning

The EPBD (Energy Performance of Buildings Directive) also requires regular testing of heating and air-conditioning equipment. It is widely agreed that audits (particularly on-site ones) are an essential part of a quality assurance scheme which can effectively increase the scheme’s credibility.

Article 9 of the EPBD is named “inspection of air-conditioning systems”. It stipulates that “with regard to reducing energy consumption and limiting carbon dioxide emissions, Member States shall lay down the necessary measures to establish a regular inspection of air-conditioning systems of an effective rated output of more than 12 kilowatts”. Moreover, “this inspection shall include an assessment of the air-conditioning efficiency and the sizing compared to the cooling requirements of the building”. Finally, “appropriate advice shall be provided to the users on possible improvement or replacement of the air conditioning system and on alternative solutions”.

Since 2005, most Member States have opted for a voluntary instrument for plant optimization. However with the EPBD-recast discussion those countries become obliged to develop this into a mandatory instrument in line with the F-Gas regulation.

Air-Conditioning falls under the RES-Directive. So the implementation of Article 9 of the EPBD (Energy Performance Building Directive) is of importance for the certification of heat pumping technologies and seems of importance to monitor the effects of Article 9.

3 Conclusions

Proper training for the installation of heat pump systems is a complex task that is not handled uniformly across Europe. The same holds true for installer certification (both for the installer company and the installer personnel). European heat pump industry has taken up the challenge and operates the most refined scheme (of all RES sources) for installer training and certification. Several national approaches coexist and are up and running in a number of European countries, both for heat pump installation and for design and installation of ground sources. However, for a robust Europe-wide heat pump system quality the following needs to be put in place:

- Participation in EUCERT (and GEOTRAINET) and recognition of these schemes should be expanded to all European countries;
- EUCERT needs to be in line with national building codes and manufacturers’ training activities;
- EUCERT needs to be harmonised with other European standards and certification schemes on heat pump related topics.
- EUCERT should be recognized in each country and used to uniform the different labels in order to avoid confusion for customers as for authorities.