SEPEMO-BUILD - A EUROPEAN PROJECT ON SEASONAL PERFORMANCE FACTOR AND MONITORING FOR HEAT PUMP SYSTEMS IN THE BUILDING SECTOR

Roger Nordman – SP Technical Research Institute of Sweden, P.O Box 857, 50115 Borås, Sweden

Abstract: The SEPEMO project aims at overcoming market barriers to a wider application of heat pumps, namely the lack of robust data on t he conditions “in real installations” influencing reliability and seasonal efficiency, i.e. the seasonal performance f actor (SPF) of heat pump systems across Europe. The objective is a broader acceptance of heat pump systems and improved quality assurance for heat pump systems in the building sector.
The project focuses on the deployment of all types of heat pumps (air, water and ground) in residential buildings. One key requirement to achieve awareness about real life performance is a universal methodology for field measurement of heat pump systems SPF. Such methodology requires a systems perspective including not only the efficiency of the heat pump unit/system but also the respective regional building standards and climate conditions.

Key Words: Calculation, Seasonal Performance Factor, SPF, Renewable heating and cooling, Field measurements, Heat pump

1 INTRODUCTION AND OBJECTIVES OF THE PROJECT

This paper presents activities and results to date from the IEE project SEPEMO-Build. The project was started in June 2009 and will run for 36 months.
Heat pumps (HP) have an enormous potential for saving energy, reducing the CO_2-emissions using renewable energy as source for making heat for space heating, water heating in buildings, greenhouses and process industries. Heat pumps can cut global CO_2 emissions by nearly 8% (IEA 2008). They are an essential technology for reaching the EU targets for renewable energy and energy efficiency. This potential can be realised on short term at low costs, as the technology is available. However, the awareness at policy level and in the market must increase.
The current European market is around 450 000 sold units in 2006, and in 2008 about 580 000 heat pumps were sold in eight European countries (EHPA 2008). The market growth has been an average 30% per year since 2003. It is of outmost importance that the heat pumps installed are performing optimally, since bad installations could ruin much of the energy saving potential, and also the damage the reputation of heat pumps. Today heat pump units in themselves are very efficient (high COP), but installed in a building this efficiency may be ruined by poor system design and bad installations. As a consequence systems based on heat pumps with the same certified efficiency level are reported with HP system SPF between 2.0 and 5.5 (Fraunhofer 2010).
Standardisation of technology and performance testing procedures laid down in CEN-regulation and quality labels (e.g. DACH and the EU-flower) increase heat pump quality and performance. The performance of heat pump’s (COP) is characterised at single operation conditions and full capacity, in stabilised conditions according to EN14511. These conditions do not always reflect the real performance of heat pump’s in operation in heating systems. Heat pumps operate mainly at reduced capacity in climatic conditions that differ from the standard rating conditions. It is therefore important to study the seasonal performance factor (SPF) based on a number of operation conditions. The influence of reduced capacity operation on SPF is not fully covered by existing methods for calculation of SPF.

There is hence a need for both;

- A harmonised method for calculation of heat pump system SPF based on repeatability and reliable test data from laboratory measurements. This can be divided into two methods:

a) One, used in the design stage, need detailed data about load, outdoor climate, heating system etc.
b) The second, used for labelling purposes, can use a more general approach.

- A harmonised field method for determining heat pump system SPF in real installations.

It is important to have a fair method for comparison which is reliable, mainly to provide end-users a support for decisions of new investment. This method can also be used for policy decisions. The field measurement method is vital in order to learn more about how heat pump systems can be improved, and to find explanations to the reasons why the systems are not so good always as it could be. There is a lack in both a common method to define the heat pump system SPF and also in a common method for field measurement of heat pump systems.

The actual performance of the heat pump system is influenced by the design of the heat pump system taking into account:

- Temperature of the heat source (depend on type of heat source and outdoor conditions).
- Building energy demand (depends on the building standard and behaviour of the people)
- Temperature of the heat sink (depend on type of distribution system in the building).

Also the installation procedures and the skills of the installers are important factors for the final reliability and efficiency of the heat pump system. The market development of heat pumps in general is thus hampering because the performance of HP systems is not always as expected.
Field experience cannot offer repeatability and fair comparison in the same way as controlled measurement performed in a laboratory according to a harmonised standard but it can offer new knowledge about important parameters/factors influencing the efficiency of the whole heat pump system, hence the need for deeper insight necessary in real life systems.

In earlier projects, such as Groundreach and Groundhit, information about performance of ground source domestic HP's was gathered. Generally, communication and marketing from these projects was built upon best practice projects showing how good heat pumps can be. Although information from these projects is valuable it doesn't give a deeper insight in the parameters of real life system performance. We must acknowledge that the heat pump is very sensitive in its operation and that bad examples also exist. The difference between a good and a bad project often lies in the system installation and operation.

In the southern part of Europe more and more air source heat pumps are installed. With a need for heating, cooling and domestic hot water, there is an enormous potential market for heat pump system which can offer both heating and cooling with the same system. In modern air conditioning in commercial buildings advanced heat pumps with high COP's are already installed with a high share of renewable energy. These concepts compete in a market which on other hand is overrun by cheaper, less effective split units for cooling, inaccurately installed, thus increasing the energy demand of the building sector in summertime significantly. Therefore there is a broad opposition against accepting air source heat pump systems as renewable.

SEPEMO-Build is the natural follow up of earlier projects and extend the scope to all heat sources (ground, air) covering the complete product range of heat pumps.

The knowledge about parameters influencing the efficiency of the heat pump is relatively high. There is however a lack of information about real installations. The knowledge about how those parameters influence the design and installation in real systems needs to be improved. The aim is to improve insight in and better understand how the system design and installation influence the parameters which are critical to achieve a high performance and reliability of heat pumps in heating and cooling systems.

- Increase the ability of the supply side of the market, installers, designers and energy service companies to build high performance and reliable HP systems.
- Increase the acceptance of the market at end users level with private building owners and housing corporations thus increasing the market share of HPs.
- Lay down guidelines for the further development of quality assurance and certification of systems and installers in order to give guarantees on performance and to increase the acceptance in the market.
- Increase the market share of HPs in the building sector in order to create a mature self sustaining market situation by increasing the awareness by policy makers and the market of the possibilities and the acceptance in de market of a wide range of HP systems for domestic buildings.

2 TARGET GROUPS

As the development of the heat pump market in Europe is complex and not solely dependent on one market group the project aims to reach out for several target groups where the main components of the project are deeper insight through structural monitoring and quality for HP systems.

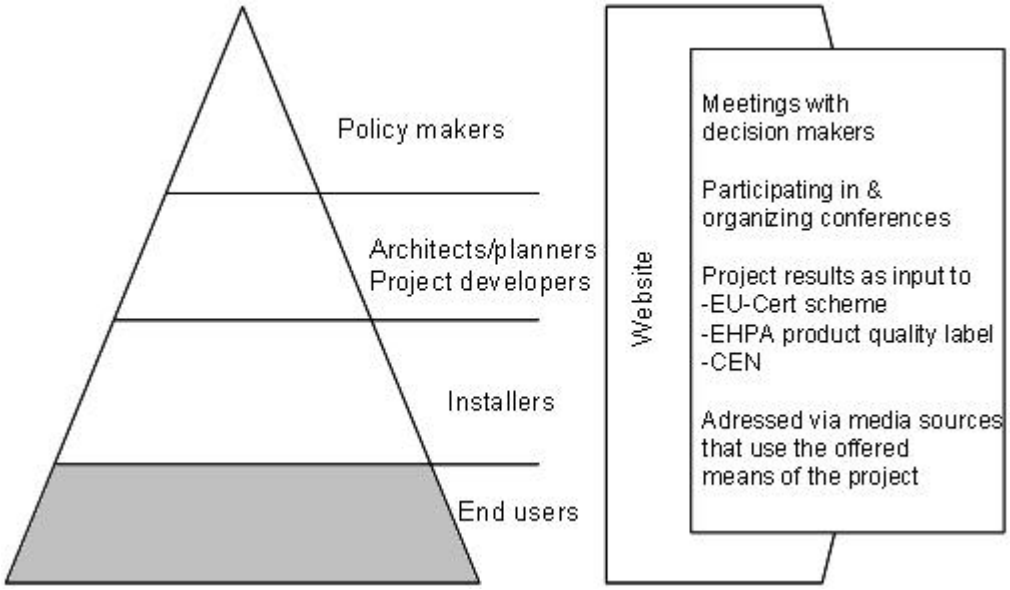

Figure 1. Approach for dissemination.

Specific professional groups are crucial for the market development, as they represent a grey area between supply and demand: installers, heating engineers, architects. New players in the market are Energy Service Companies. These groups are key influencers of the decisions of the end users. At the same time they can have a stake in the supply side, as the added value of their services usually tends to increase if they offer renewable heating and cooling. In a positive environment, they can contribute to the market penetration of heat pumps. To do so, they need first to acquire skills and experience with HP systems. As at the

same time their domain can be threatened by the introduction of new technologies, they can become an obstacle for market transition.
The project aims to develop measurement methods and basic system quality guide lines as a basis for certified installation quality to increase the performance of systems and optimal installation. These instruments can be used by supply side parties, after training and education, to increase their market volume. The project thus stimulates new market players. Learning more about real field experience SPF of heat pumps will lead to quality improvement of the systems and to a reliable higher performance which the end-user can 'trust'.
A top-down approach has been chosen in this project. Focus is to disseminate project results to policy makers and public authorities, architects/ planners/ project developers and installers.

3 WORK PROGRAMME

Figure 2 illustrates the workflow in the project. Management and dissemination activities are ongoing activities during the project life.

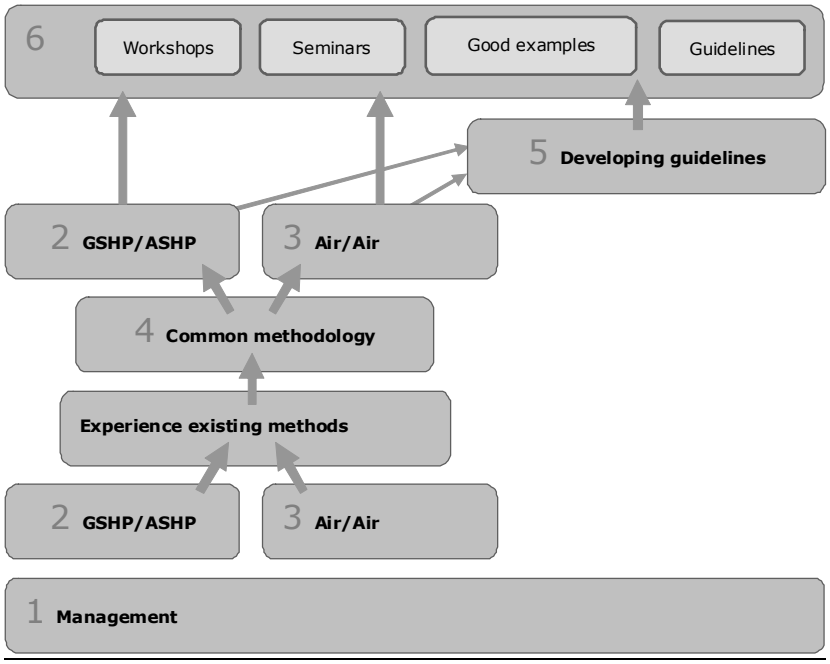

Figure 2. Workflow in the SEPEMO project.

In the work packages WP2 and WP3, information on existing and new field measurements will give input to a common methodology in WP4 and to the development of guidelines in WP5. This methodology and the guidelines will then be used to evaluate field measurements in WP 2 and 3, and the experiences will be collected and evaluated.

The objectives are achieved by the work in the seven Work Packages:

WP 1: Management

WP 2: Field measurement of air/water and ground/water based heat pumps
In this WP, in depth information on existing projects with ground source and air source heat pumps in domestic buildings with hydronic distribution systems is gathered and analysed. This information is assessed and structured. Together with the information gained in the field measurements, input is given to WP4 and WP5 as input for the development of a common methodology and guidelines. Field measurements are performed on some 40 sites around

Europe (Austria, Germany, Greece, France, the Netherlands and Sweden), using the common methodology developed in WP4.

WP 3: Field measurement of air/air based heat pumps
In this WP, information is gathered and analysed on existing projects with air/air source heat pumps in domestic buildings. As in WP2, the collected information together with the information gained in the field measurements are used in WP4 and WP5 as input for the development of a common methodology and guidelines. Air/air heat pump field measurements are carried out on about six to eight sites in France and Sweden.

WP 4: Development of monitoring methodology
In this WP a methodology is developed as well as definitions and guidelines for monitoring the Seasonal Performance Factor (SPF) of heat pump systems in buildings. A method to compare heat pumps with other heating sources is also developed. This information will serve as a source for creating a basis on international level for:

- Measurement methodologies
- New demonstration projects
- Increasing the performance of systems.

In a feed-back of these definitions and methodologies to WP2 and 3 the findings of WP4 are tested and evaluated and used to increase the level of awareness through communication under WP6 and to increase the level of system quality under WP5.

WP 5: Development of basic heat pump system quality
In this WP the findings of WP2, WP 3 and WP4 are further analysed and translated into guidelines for the basic quality of high performance systems. These guidelines will be used for training installers and designers, making it able to use the experience for new demonstration projects and monitor the effects. This information will thus serve as a source for creating amongst others a basis on international level for:

- Quality guidelines based upon system performance in line with Annex VII of the RES directive (EU 2009) to fully exploit the potential of heat pump systems with high efficiency in the domestic sector.
- Guidelines for the certification of installers, in line with Annex IV of the RES directive, based upon quality guide lines

WP 6: Communication and Dissemination
Dissemination of all results, measured values, reports and guidelines is communicated in workshops and in standardisation committees, as well as in conferences and in meetings with EU policy makers and stakeholders. In addition, the field measurements can be followed from the project website, where also all deliverables are available for download.
The website of the project is frequently updated on www.sepemo.eu.

WP 7: IEE Dissemination Activities
Common dissemination activities are performed in this work package, mainly towards EU. For example, project results were presented during workshops at the European “Sustainable Energy Week” in both 2010 and 2011.

4 RESULTS

Until now the main body of work have included:

- Collection and evaluation of past and present field measurements on heat pump systems.
- Evaluation of existing methods for field measurement and calculation of heat pump systems SPF.

- Development of a common methodology for field measurement of heat pump systems and calculation of SPF.
- New field measurements on heat pump systems using the common methodology.
- Improve and extend existing guidelines to include all types of heat pumps, for installation of heat pump systems, taking into account regional constraints as well as the building standard.
- Information dissemination.

So far the following deliverables have been published from the website:

- A common methodology for field measurement which can be incorporated in CEN standardization (Zottl 2010).
- A database on heat pump system SPF based on a common methodology for field measurement and calculation of SPF including all types of heat sources (air, water and ground) (SEPEMO 2010).
- A recommendation for a standard method to measure the performance of heat pump systems (Zottl 2011).
- Newsletters in cooperation with EHPA (SEPEMO partners provide material to the EHPA newsletter).
- Workshops and a public website (SEPEMO 2010);

Results to be published during the remaining project period include:

- Proposal to SPF calculation method
- Position paper on SPF measurement
- Report on important factors for improvement of heat pump system performance and quality
- Report on main points for improvement of existing or future legislation on HP systems (including an updated version at the end of the project)
- Concept for evaluation of CO2-reduction potential
- Important parameters influencing heat pump systems efficiency and reliability
- Position paper on heat pump system quality and a Quality fact sheet
- A best practice database with twenty new best practice cases arising from the project (part of the project website)
- A set of guiding principles to develop quality schemes for heat pump systems based upon an SPF
- Report on installer experiences from using heat pump system quality guidelines
- Easy to understand" guidelines for installation of reliable and energy efficient heat pump systems as a basis for courses and certification of installers within the scope of the RES directive, Annex IV
- Easy to understand" guidelines for installation of reliable and energy efficient heat pump systems for architects/planners
- Results from new field measurements
- Report "Overview of the status of heat pump concepts with ground and air as heat source and hydronic heat distribution system (including the economic aspects)

In addition to this, numerous dissemination activities are made via articles, website information and meetings with stakeholders.

5 PARTICIPANTS OF THE CONSORTIUM

The consortium consists of ten research partners from six countries in Europe, see Figure 3. The coordination of the consortium is by SP Technical Research Institute of Sweden (SP) with the author as the coordinator. The other partners of the consortium are: AgentshapNL, Association pour la Recherche et le Développement des Méthodes et Processus Industriels

(ARMINES), Austrian Institute of Technology (AIT), Centre Scientifique et Technique du Bâtiment (CSTB), Centre for Renewable Energy Sources and Saving (CRES), Electricité de France R&D (EDF), European Heat Pump Association (EHPA), Fachinformationszentrum Karlsruhe (FIZ) and Fraunhofer ISE (Fraunhofer).

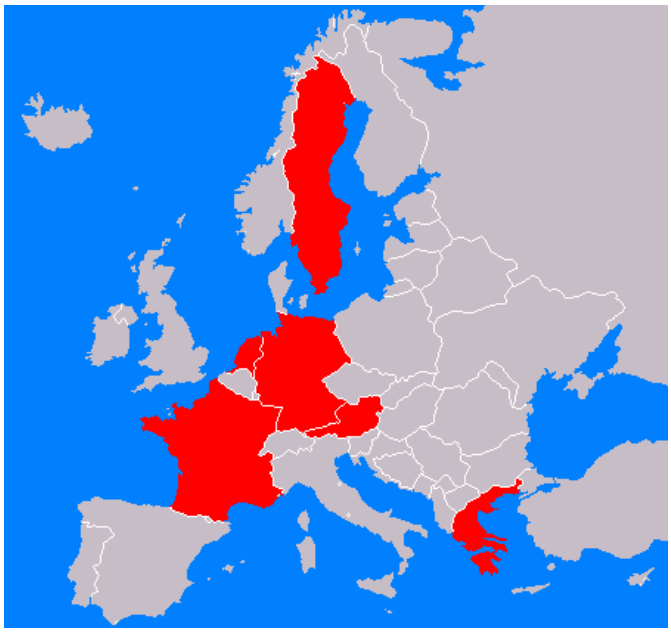

Figure 3. Participating countries in red, in addition EHPA have 89 members in 21 EU countries.

6 REFERENCES

EHPA 2008, “Outlook 2009 – European Heat Pump Statistic”, 2009

EU 2009, “RES Directive, on the promotion of the use of energy from renewable sources DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, April 2009

Fraunhofer 2010, http://wp-effizienz.ise.fraunhofer.de/german/index

IEA 2008, “Heat pumps can cut global CO2 emissions by nearly 8%” HPC-BR6, 2008

SEPEMO 2010, www.sepemo.eu

Zottl, A., Nordman, R. et. al. 2010 ”Concept for evaluation of SPF - Version 1.0, A defined methodology for calculation of the seasonal performance factor and a definition which devices of the system have to be included in this calculation”, SEPEMO-Build Project, Deliverable 4.2, Contract for the European Communities. Contract No.: IEE/08/776/SI2.529222., 2010.

Zottl, A., Nordman, R., et. Al. 2011 ”Guideline for heat pump field measurements” SEPEMO-Build Project, Deliverable 4.1, Contract for the European Communities. Contract No.: IEE/08/776/SI2.529222., 2011.