IEA HPP ANNEX 37
DEMONSTRATION OF FIELD MEASUREMENTS OF HEAT PUMP SYSTEMS IN BUILDINGS
- GOOD EXAMPLES WITH MODERN TECHNOLOGY

Pia Tiljander, Researcher, SP Technical Research Institute of Sweden, P.O Box 857, S-50115 Borås, Sweden
Andreas Zottl, Researcher, Austrian Institute of Technology, Vienna, Austria
Ivan Malenković, Researcher, Austrian Institute of Technology, Vienna, Austria

Abstract:
Annex 37 aims to expand acceptance of heat pumping technology and to increase take-up in new markets. The intention is to demonstrate energy and environmental potentials of heat pumping technology, using existing field performance measurements, and with the emphasis on best available technology. It should be possible to predict the most suitable heat source and heat pump system for particular applications.

In order to ensure reliable results, it is most important that the quality of the measurements should be assured, and so the criteria for good and assured quality will be defined in the Annex. As the results will also be used to compare given heat pump systems with alternative heating systems, it is therefore important to define measuring conditions such as measuring points and system boundaries that influence energy savings and CO_2 reduction.

An important outcome of Annex 37 will be a data base of existing field measurements, using a common method to express performance values such as seasonal efficiency and energy savings. The data base will be linked to the IEA Heat Pump Centre's website.

Key Words: heat pumps system, field measurements, renewable heating, CO_2-reduction

1 INTRODUCTION

There is a need to be able to demonstrate the potential for energy savings and CO_2 reduction with heat pump technology. There is also a need for increased knowledge of the efficiency of heat pumps in real installations, especially concerning heat pump systems for combined operation including heating, cooling and domestic hot water production.

Demonstration of heat pump systems would be an efficient way of communicating the potential of the technology, promoting top-of-the-line [state of the art] heat pump systems and also improving existing guidelines for selection, design and installation of systems. Demonstration of best available heat pump technology is a way to achieve further acceptance for the technology and, in that way, to increase take-up in new markets. It is important that information about different heat pump systems should be accessible, analysed and presented in a harmonised way.

The operational performance of heat pumps (COP) is often given as that measured under steady-state operating conditions and at full capacity. These conditions do not always reflect the performance of heat pumps operating in real heating systems. The efficiency of a heat pump system is influenced by how the heat pump is connected to the system, by the system design and by the operating temperature of the heating system. This means that the design of the heat pump system, and the quality of the installation, will strongly influence the final efficiency of the heat pump system.

The aim of Annex 37 is to demonstrate and disseminate the economic, energetic and environmental potentials of heat pumping technology. The focus will be on best available technology, and results from existing field measurements will be used to calculate energy savings and CO_2 reduction. It should be possible to predict the most suitable heat source and heat pump system for particular applications. In order to draw the right conclusions, it is most important that the quality of the measurements should be assured. The criteria for good and assured quality will be defined in the Annex.

The results from existing field measurements will also be used to calculate the electricity consumption and energy savings, compared to alternative ways of heating, for a given heat pump system.

An important outcome of Annex 37 is a database from existing field measurements, using a common method to express performance values such as seasonal efficiency and energy savings. The database will be connected to the IEA Heat Pump Centre’s website, and will be continuously updated with new information after conclusion of the Annex.

In November 2010 the Executive Committee of the Heat Pump Programme approved Annex 37 and it started with an initial meeting on February 24th, 2011 in Sweden. Annex 37 is an "Annex lite", which implies limitations in time and meetings, Confirmed participants of the Annex are Austria, Switzerland, the United Kingdom and Sweden (Operating Agent). Other countries are invited to join the Annex.

2 OBJECTIVE AND SCOPE

The objective is to demonstrate the potential with heat pumping technology for all types of buildings from existing field measurements. There is no limitation of type and size of heat pumps. The focus will be on the best available technique in order to achieve further acceptance for heat pumping technology.

A goal in this project is to ensure the quality of the performed field measurements in terms of such factors as system boundaries, measured parameters, sampling intervals, accuracy of measurements etc.

Another goal is to establish a database connected to the Heat Pump Centre´s website where data from this and other field measurements can be presented.

An additional objective of this annex is to improve the understanding of key parameters influencing the reliability and efficiency of heat pump systems.

2 TIME SCHEDULE

The project period is planned to be 20 month and started with the initial meeting in February 24, 2011. At the meeting the participants discussed the work and established a timeframe for the work, figure 1.

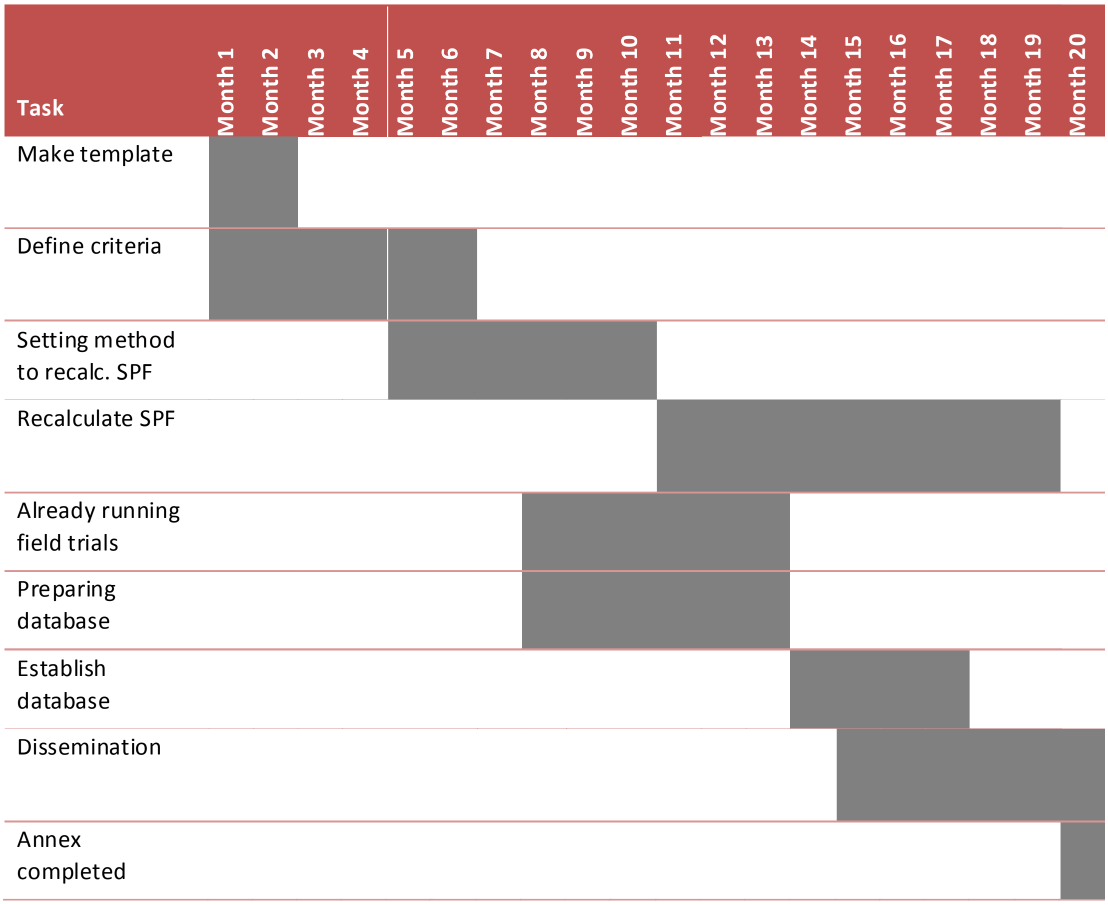

Figure 1: Timeframe of the work in Annex 37.

Most face to face meetings will be replaced with mail and telephone. The participants will have telephone meeting once a month with start in April. The participants will also meet in May 2011 in conjunction with IEA HPC in Tokyo.

3 WORK PROGRAMME

The objectives shall be achieved by the following task-sharing activities:

Task 1
Make a common template of what should be communicated.

Task 2
Define criteria for good quality of field measurements (e.g. boundaries of the measured systems, number of and placement of measuring points, measurement uncertainty, time increments etc.) and decide what parameters are important for assured quality. In this Annex the system boundaries defined in SEPEMO-build will be applied.

Task 3
Collection and evaluation of current and concluded field measurements on heat pump systems. The focus is on the best available technique.

Task 4
Agree how to recalculate the chosen annual performance figures, such as seasonal performance factor (SPF), energy savings and carbon footprints. Calculation of SPF, electricity consumption, energy savings and CO_2 reductions from the collected measurements. These parameters will be compared with those for other heating systems. For thermally driven heat pumps, the current SPF definition from HPP Annex 34 will be applied. Regarding systems with heat pumps combined with solar thermal, the results from the ongoing work in Task 44 of the IEA Solar Heating and Cooling Programme / Annex 38 of the IEA Heat Pump Programme, will be considered.

Task 5
Establish a database connected to HPC website with data from field measurements, using a common template.

Task 6
Information dissemination

- Good examples of "state of the art", showing the potential for heat pump systems based on reliable data from field measurements
- Case studies to be used as input data for improved statistics on heat pump systems
- Using the outcome to improve and extend existing guidelines, to include all types of heat pumps, for installation of energy-efficient and reliable heat pump systems, taking into account regional constraints as well as building standards.

The following issues were, among other things, discussed at the initial meeting:

3.1.1 Information in database and to installers.

Good examples will be published in the database. The details are not decided yet but the following information should be given:

- Information about the building (year of construction, year of installation, type of building, application area, geographical location, climate, heated area etc).
- Photo of the building.
- Information about the heat pump (heating capacity, type, purpose, type of heat source, type of heat sink, heat source system, distribution system, alternative / complementary heating system etc).
- System scheme.
- Key parameters of the control (e.g. heating curve). See final report "FAWA" of 2004 at the Swiss Federal Office of Energy (Rognon 2004)
- Information about measurements (number of measuring points, location of measuring, sampling interval, system boundaries etc).
- Results (curves and key figures). Savings should be expressed in both energy and terms of carbon savings/carbon footprint

Information to installer and manufacturers shall contain good examples but it could also contain bad examples with mistakes that are often made and should be avoided. This information should support a further development of training documentation (e.g. EU Certified Heat Pump Installer) and also installation manuals and regulations supplied by the manufacturers.

3.1.2 Location of measuring points

The results are influenced by the location of the monitoring sites, and on the placement of the monitoring equipment in the system. For example, the declared seasonal efficiency and savings depends on where in the system the heat meters are located.

For example: Figure 2 is a schematic figure of a heat pump system. The heat can be measured either before (alternative A in figure 2) or after (alternative B in figure 2) the accumulator tank and the domestic water heater (alternative A in the figure). Due to heat losses from the accumulator tank and the water heater, these two measurements will give different results for SPF, energy savings and carbon savings. When results from different field measurements are analyzed and compared it is, therefore, very important to know what has been measured, how it was measured and where the measuring points were located in the heat pump system.

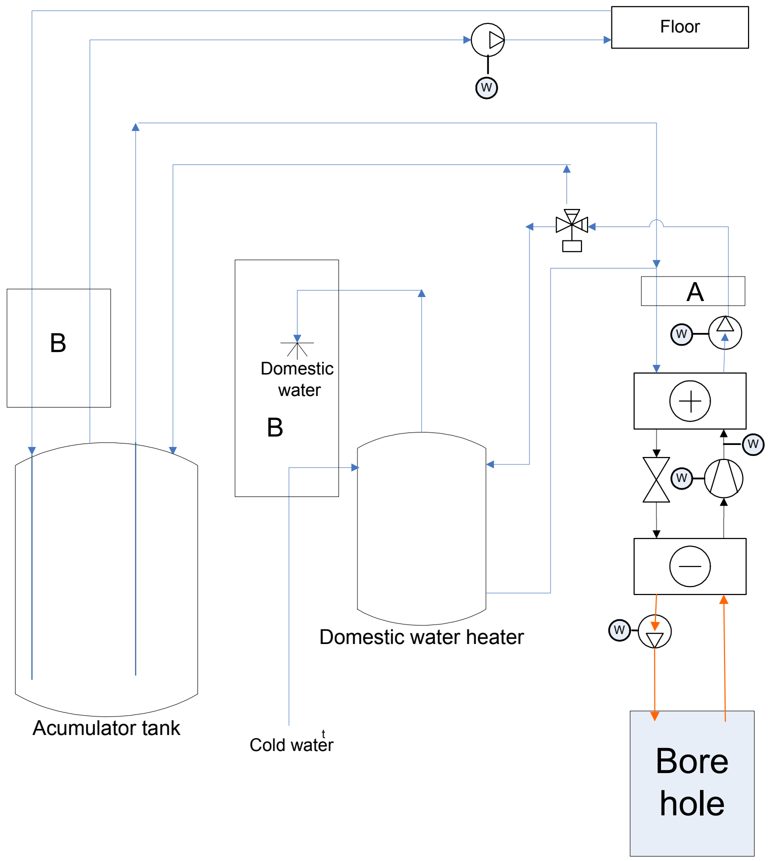

Figure 2: Schematic figure of a heat pump system

3.1.3 System boundaries

The definition of the system boundaries influences the results of the SPF due to the impact of the auxiliary drives. Therefore it is important to define the boundary systems and the SPF should be calculated according to different system boundaries. In this Annex the system boundaries defined in the IEE project SEPEMO-Build will be applied for electrically driven heat pumps.

SEPEMO-build defines four system boundaries and they are described as follows (Zottl 2010):

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

SPF_{H2}:
This system contains of the heat pump unit and the equipment to make the source energy available for the heat pump. SPF_{H2} evaluate the performance of the HP operation, and this level of system boundary responds to $SCOP_{NET}$ in prEN 14825 and the RES-Directive requirements.
Note: The boundaries of COP in EN 14511 and $SCOP_{NET}$ in prEN 14825 are more or less between SPF_{H1} and SPF_{H2}

SPF_{H3}:
This system contains of 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,…). This system boundary is similar to the SPF in VDI 4650-1, EN 15316-4-2 and the $SCOP_{ON}$ in prEN 14825.

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

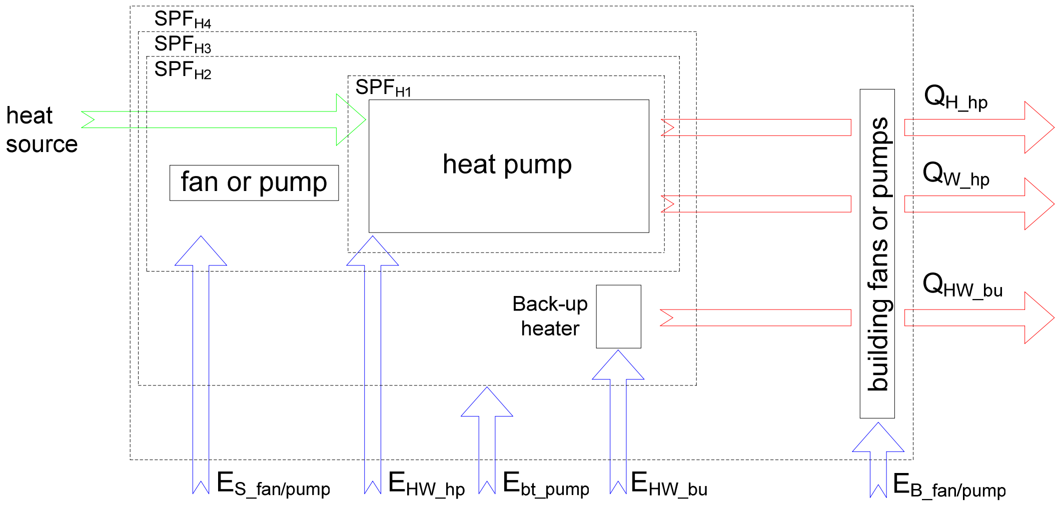

Figure 3: System boundaries for electrically driven heat pump systems applied in this Annex.

In Annex 34, system boundaries for the definition of the performance figures for thermally driven heat pumps have been proposed, Figure 4. Most of the boundaries are equal to the ones from Figure 3. However, the SPF for boundary 3 in Figure 4 takes into account the storage losses. TDHP systems need generally both thermal (e.g. solar, gas) and electrical energy. For an in-depth analysis of the system and its components, it is thus necessary to consider one thermal (SPF_{th}) and one electrical (SPF_{el}) performance factor. They are defined as the total useful energy output divided by the total respective energy input for the system or part of the system.

Further, for an economic evaluation of the system and its comparison to other technologies, a primary energy ratio (PER) is given. The current definition of the PER takes into account the overall primary energy input over the primary energy coefficients for different energy sources. The PER is also the basis for the calculation of the emissions and operation costs of the systems. It is currently discussed to include also the energy of for the water treatment in case of wet or hybrid cooling towers, which would be proportional to the water consumption.

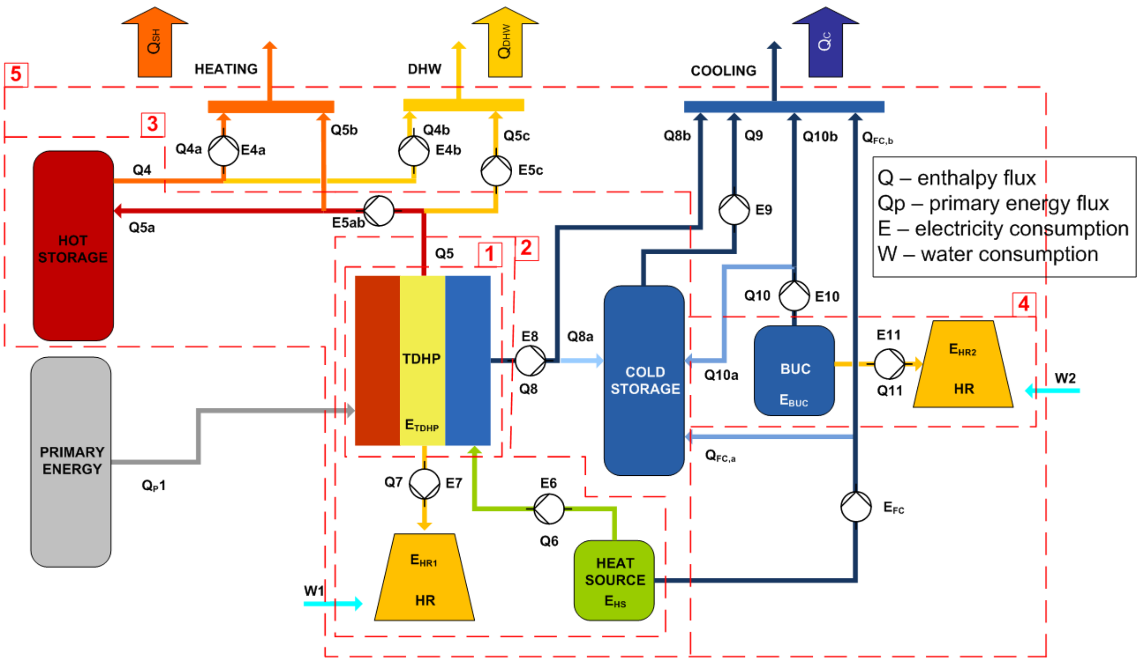

Figure 4: System boundaries proposal for TDHP systems – example for direct fired combined heating and cooling. Source: Annex 34

For heat pump systems in combination with solar thermal, a concept analogous to the definitions of the SEPEMO Project and Annex 34, taking into account the specific features of this combination, will be developed within the IEE QAiST Project and SHC Task 44 / HPP Annex 38.

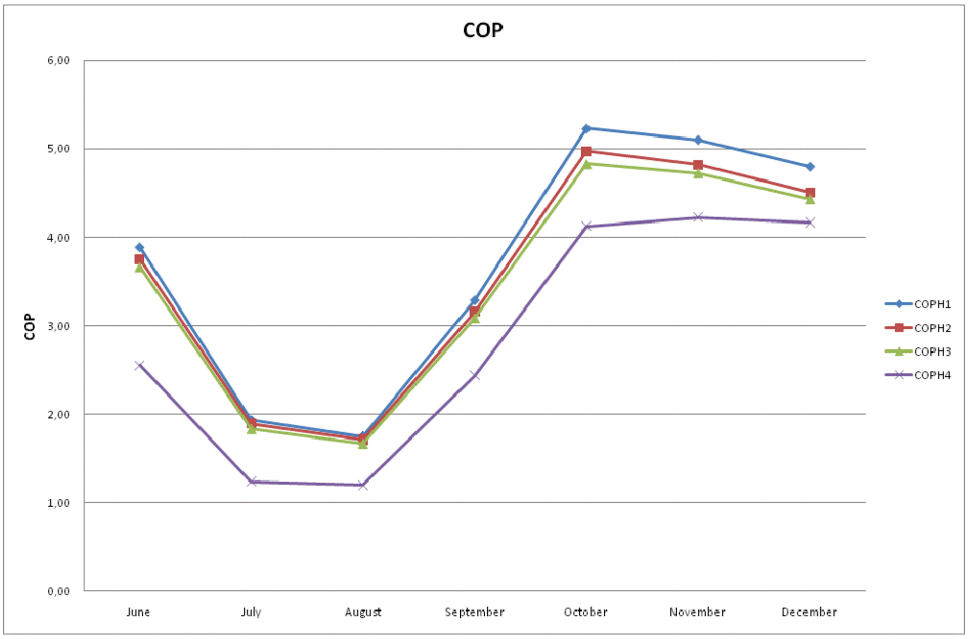

Figure 4: Monthly mean values of COP for a heat pump system according to the four system boundaries defined in SEPEMO-build.

Figure 4 shows the coefficient of performance, COP, for one site from field measurements performed at SP Technical Research Institute of Sweden (Tiljander 2010) The four different system boundaries defined in SEPEMO.build. In this case it is clear that the auxiliaries of the heat sink system decrease the COP values significantly. By calculating COP for different system boundaries it is possible to analyse which components that are energy efficient and which are not. It is important to use a good system solution, energy efficient components and a good installation.

When declaring COP or SPF for a heat pump system it is of importance to communicate the system boundaries valid for the figures.

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