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European Heat Pump NEWS

ehpa european heat pump association

Special edition: Heat pump efficiency

The world asks for action on climate change – heat pumps can cut GHG-emissions by half!

In the light of the current discussions in Copenhagen to deliver a reduction in greenhouse gas emissions, the heat pump industry is ready to deliver its promise.

Heat pumps provide a triple dividend to the world: they use renewable energy, they reduce the demand for non-renewable energy sources and consequently they also reduce the emission of greenhouse gases (GHG). Even with today's technology, on average a heat pump installation saves 50 % of GHG compared to the emission of an average replaced heating system.

editorial

Systems efficiency is the key to improve this value. This is taken into account in several areas of discussion. On the EU legislation level, the Directive on the Ecodesign of Energy Using Products (EuP) is currently in its final stages. It covers heat pump units and foresees an efficiency measurement including climatic variations thus enabling the comparison of the product across Europe.

In the field of norming and standardisation stakeholders are about to present a new standard to measure heat pump unit efficiency. This EN 14825 is based on and enhances the coverage of the existing standard EN 14511 and may also be used for the calculations in the EuP-Directive.

Both results are important for the verification of the product performance data by an independent body: This is in the best interest of the consumer to save operating costs, of the producer of quality products to honour innovation and of the energy policy to reach goals set.

The existing EHPA (former D-A-CH) quality label is based on third party measurements of performancedata but goes one step further: it obligates the producer to provide for proper installation documentation, a spare part guarantee and after-sales support. The Quality label is at this moment developped further to integrate the mentioned new developments.

At the end of this process, the foundations for high quality heat pump systems are established. To fully use their potential, it is then to the policy makers to provide institutional and financial support and to treat the technology fair and equal.

In my opinion, it is heat pumps - alone or in hybrid systems - that will contribute the largest share towards the goal of the climate change agenda for both the use of renewables and the reduction of greenhouse gas emissions.

Karl Ochsner (Chairman)

content

The importance of unit quality for heat pump efficiency

Heat pumps are highly efficient devices for heat production from renewable sources. They represent a proven and available technology to increase the renewable share rapidly. To use this potential at a maximum devices have to work with a high efficiency over the entire operating range.

The COP is the critical size to assess the efficiency of a heat pump. The COP is the ratio of usable heat output to the input energy needed. It is a key figure, both for the comparison of equipment as well as for calculating of the savings potential. A high COP is a clear competitive advantage.

Looking at the efficiency of the devices, there are major differences. Since there are no statutory requirements for certification of specified values, the door for arbitrariness is open wide. In particular, manufacturers that do not have the capacity for sophisticated measuring equipment, often declare a theoretically calculated, or even estimated COP. Often this is far away from the measured COP as effects of non optimal construction are not regarded.

Experience shows that by promising to high performace, the image of the heat pump often is harmed when the promises made in advance are not fulfilled afterwards. This is a loss for the entire industry. Therefore for both consumers and fair competition among producers it is of great importance that the specified COP corresponds to reality. To assure this is a main task of the independent quality label for heat pumps. With this a manufacturer can prove that the main technical data is verified and reliable.

To obtain this “EHPA Quality Label for heatpumps” among other requirements the performance figures for different operating conditions have to be measured by an independent test laboratory. This ensures that the technical data of certified devices are reliable, and correspond to the reality. The measurement of the COP is based on EN14511. It is strongly influenced by the operating conditions. It is measured at defined stationary conditions on a test rig. To get reproducable results with low uncertainty, the test has to be performed under precisely defined conditions within a narrow tolerance range. The complete test is described in EHPA testing rules.

The test may be carried out at any EHPA recognized test laboratory. Recognized testing laboratories are:

- AIT (Wien, AT)
- HLK (Universität Stuttgart, DE)
- SP (Boras, SE)
- TÜV Süd (München, DE)
- TÜV Rheinland (Köln, DE)
- VDE (Offenbach, DE)
- WPZ (Buchs, CH)

All testing laboratories demonstrate their quality and independency by an accreditation according to EN ISO 17025.

The results of the tests performed in any of the mentioned laboratories will be accepted in all other member countries. As there is a high testing capacity available in the meantime it is usually possible to carry out the tests in a short term. The following seven countries have introduced the label: Austria, Sweden, Belgium, Finland, Switzerland, France, Germany.

Currently available is the certification of electrically driven air/water-, brine/water, water/water and direct-evaporation/ water heat pumps for space or water heating.

Another aspect of the quality label is to proof that for the devices there is a reliable service network. This must be proofen for every country. Therefore the label is only valid in the country for which this has been demonstrated.

Especially in Switzerland, the label has a very high priority, since public funding for heat pumps is coupled to the label. Thus there is a certain compulsion to carry out the certification. A further strengthening of the label in the other countries would be desirable. This can only be done by the manufacturers using the label aggressively as a marketing tool and working towards coupling of public funding to the label. This would be a benefit the entire industry as rogue providers could be pushed back and only high quality technology will come to market.

Bernd Klein, University of Stuttgart, HLK

Interview with AIT's Heinrich Huber

Long term experiences with heat pump tests

Mr. Huber, arsenal research, today the Austrian Institute of technology (www.ait.ac.at) has one of the longest histories in heat pump testing. When did you start and what were the main reasons to establish testing operations?
We started to deal with heat pump tests in 1998. At that time, only one test institute for heat pump test existed which was also the only institute to perform test according to the newly established D-A-CH quality label. Töss was only equipped to test air-water, water-water and brine-water units. With the high importance of direct evaporation (DX) units at that time, we started with testing of DX units and were the first test house bing able to perform these.

Did you perform tests before the creation of the DACH quality label?
No. In my opinion, the newly established D-A-CH quality label showed increasing interest for heat pumps and the quality of these units. Production quality requires testing, and testing requires independent test houses. Voila – arsenal research picked up this trend and established our labs.

How many units did you test in the past?
Huber: We tested 119 units, 54 of these being brine-water, 38 water-water and 27 DX units. Not all of these were tested for compliance with the D-A-CH quality label, though.

Do you believe that the demand for testing will increase in the future?
Yes certainly. The growing markets for heat pumps make independent third party testing more important. Increasing markets will bring more players into the market and consumers are interested in trustworthy performance data of the unit they want to purchase. Additional drivers are the widerspread use of the EHPA quality label (ex D-A-CH) and political requirements as set in the European Directives on the promotion of use of renewable energy sources and the Directive on the Ecodesign of energy using products.

What are key influencing factors?
In Austria the quality label is required in several areas to receive local or regional subsidies. This is also true for Switzerland. Even though both countries are not part of the EU top 3 markets, they influence testing of units, as the heat pump market is European and very few manufacturers make products for national markets. The implementation of the Directives mentioned before will further increase the demand for testing.

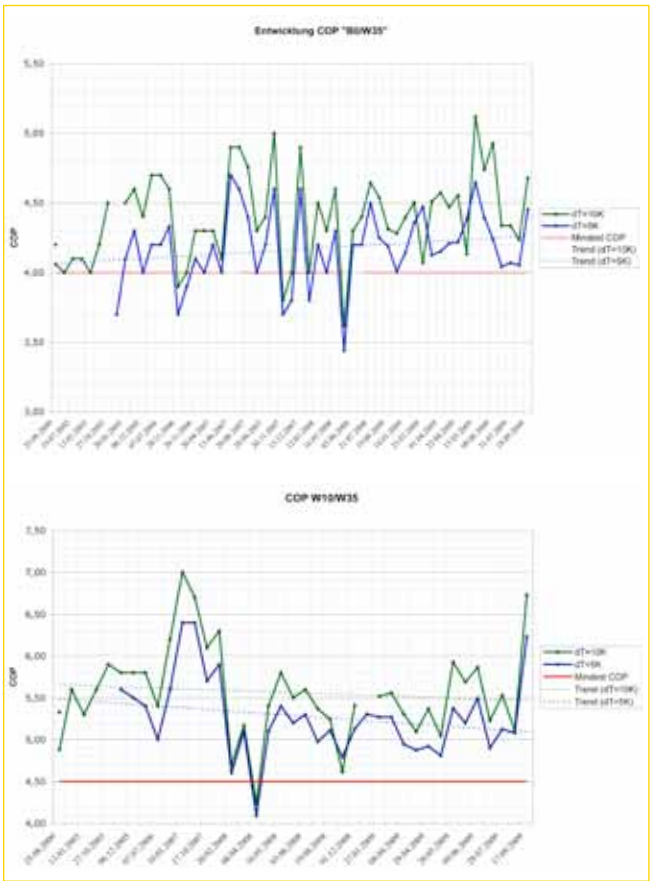
In your perspective: does third party testing like the one offered by AIT puts pressure on the manufacturers to improve the efficiency of their units?
This is difficult to answer: what was there first? The hen or the egg? In other words: does the existances of test houses push manufacturers to further develop their units efficiency or is this an independant development, that is merely observed via measurements?
In Austria, independant third party tests are highly valued in public. Such test results are perceived trustworthy. As measurements are comparable on an international level, the test from all European Institutes gives a market overview and provides information on their relative performance to competing manufactures. This creates competition and most probably is an incentive for a steady increase in unit efficieny.

Can you proof this with measured data?
We have evaluated our measurements over the past years and for direct expansion and brine-water the trends show a slight increase in COP development When measuring water-water systems, however COP values are more or less stagnating over the past 9 years.

Are test like that performed by your insitute required for public subsidy schemes in the future?
In Austria, COP is not a sufficient criterion to show the fullfillment of government subsidies. A trend exists towards using a calculated seasonal performance factor (calculated SPF). Such value has the advantage that climate variations are included. The Austrian seasonal COP is calculated according to the industry norm VDI 4650. Test data is a valuable input to these calculations.

Where do you see the future of heat pumps in terms of market penetration and in terms of efficiency?
An increase in market share of heat pump systems is expected due to increasing energy cost in general and a widening of the gap between one unit of heat provided by traditional burner system and that provided by a heat pump. In terms of improvements of efficiency, I do not expect major improvements. One reason for this is that test houses are not prepared yet to accomodate for new technologial developments such as capacity modulating compressors. In the future, this requires modifications of the test benches to test new technological developments to appropriately match test and reality.

Mr. Huber, we thank you for your answers.



COP developments for B-W systems

History of the European quality label for heat pumps:

From DACH to EHPA

The first heat pumps for heating purposes where sketched in the early 1900's. While the principle of the refrigeration cycle was developed even earlier, it took additional decades until one of the first real installations was build: Since 1938 the mayor's house of Zurich, Switzerland is heated with a heat pump using energy from lake water.

The technology developed further and saw a first major development phase in the 1980's. At this time, a heat pump market started to develop in central Europe. Consumers bought heat pumps for heating as well as domestic hot water units, but growth was not strong enough for heat pumps to gain a significant market share. Due to quality issues, mainly lack of operating security, low reliability and low efficiency, the heat pump lost its positive image quickly and in 1985 the market came to a near complete halt in most countries.

From an large number of manufactures only a handful was left and sales were extremely low. Switzerland was an exemption, as it maintained a small heat pump market, not hit as strongly as the rest of Europe by the quality issues. Still, stakeholders felt that the trust in the technology needed to be re-established as a prerequisite for market development. In 1993, a small group of stakeholders – among them the Swiss utility Nordostschweizer Kraftwerke (NOK) , the Swiss energy agency BFE and several players from the Swiss heat pump industry took on the challenge to develop a system for quality assurance. At its core, the system focussed on testing a heat pump unit in standard operation by an independent test house. As no such institution existed, the testing institute Toess was established in Winterthur, Switzerland in the process. It was funded by the government program "Energie 2000". The label set minimum requirements for the efficiency of the heat pump (COP). The test procedure included measuring unit efficiency at standard testing points, safety checks of the operating range and sound tests. The latter was particularly important for air-water heat pumps. As each tested unit had to be accompanied by a detailed component list, it was also possible to control the identity of the heat pump unit tested with units later brought to market - modifications could easily be spotted. In addition the existence of a service infrastructure, the availability of spare parts and the availability of a proper installation manual in the local language (in Switzerland, this means German, Italian and French) was mandatory. The fulfilment of all requirements was checked by the quality label commission of the Swiss heat pump association (FWS), who is also the body to grant the quality label to the product (it must be noted, that the label is not given to a company!).
The label focuses on checking those requirements necessary to guarantee a reliable and efficient product. Its widespread use was expected to result in satisfied consumers. The participants in the quality system shared the belief that any failure of the installed unit would have to be repaired as soon as possible, in order not to risk consumer trust. The first quality labels for heat pumps in serial production was granted in 1998. From this date onwards, the approach proofed successful, as consumers understood that only high quality manufacturers were able to fulfil these requirements. The quality label for heat pumps was unique in the heating industry. Sales increased and the technology was saved. On top of this measurement results from the lab in Toess helped to improve heat pump units in terms of efficiency and reliability.

Granting the quality label for heat pumps

Each distributor or manufacturer (in case the manufacturer and the distributor are identical) can apply for the label an individual heat pump unit or a product range. A product range can vary in capacity, but must be build with identical components From the subset of tested units the efficiency of the range will be interpolated.
The label is valid for three years and the applicant can apply for renewal for an additional three years. Successful renewal of the label requires that no changes were made to the main components of the units and that the operating boundaries are maintained. At the time of initial application and of renewable, the unit must fulfil the currently valid requirements. While the renewal procedure relies mainly on self declaration, the quality label commission can perform spot checks on labelled units in the field.

Subsidies for labelled products

Recently support for GHG reducing products has increased. However, governments, utilities, banks or private bodies are obliged to use their available funds most efficiently and as such they aim at supporting only high quality, efficient units with a positive image. Supporting bodies have realized the positive impact of asking for high quality for themselves. Apparently, the consumer perceives this as a positive aspect of corporate culture or corporate quality orientation. FWS managed successfully to convince several supporting bodies to combine the established quality system for heat pumps with the established support processes. An interim peak success was reached in 2009 when the Swiss government started wide-spread action to replace electric direct heating with heat pumps and made the quality label a mandatory requirement to receive government funding. It is estimated, that this approach increased turnover by approx. 5%. With additional government funds available for 2010, it this trend is thought to increase.

The quality label for heat pumps in international perspective.
Triggered by former FWS president Gabriela Brugger (daughter of Ernst Brugge, former member of the federal government), representatives from German (D), Austrian (A) and Swiss (CH) industry and associations met to discuss an enlarged quality

Companies using the former DACH quality label on their heat pumps in 2002.

label. They agreed to develop a joint approach based on mutual quality standards with the aim of a label to be accepted in all German speaking countries. After its implementation it became obvious, that consumers followed the quality philosophy. Not only did they request the label as a proof, but also did the image and sales number of heat pumps increase in the participating countries. The fact that heat pumps are manufactured for a European market made an even wider approach seem appropriate.

This second phase in the internationalisation of the label was started in 2005 by Artur Rodecker (D), Frido Flade (D), Andreas Bangheri (A) und Stephan Peterhans (CH). They presented the concept of the quality label within a meeting of the European Heat Pump Association (EHPA) and offered it for further development and use to the assocation. The board of the EHPA accepted the proposal and established a technical committee for the D-A-CH quality label. Sweden was the first country to join this group. This step not only proofed the acceptance of such a label in the European market place, but also enlarged the scope by an non-German speaking member resulting in the need for further adaption. Sweden was followed by Finland and France and Belgium is the latest new member to the quality label.

It is only appropriate to re-name the label from D-A-CH quality label to EHPA quality label to reflect its European scope. For manufacturers and consumers alike it is beneficial to work with only one label in as many European countries as possible. Consumers benefit from trust and wider spread acceptance, industry profits from an easier handling of the scheme.

The advantages of a European label

Labels and certificates help consumers to make a decision according to their needs. In the building sector, criteria can be sustainability, eco-friendlyness and effiency in choosing a long-term beneficial solution. Quiet often it is still simple investment cost that are taken. Independent of this choice consumers can not all details of a product and must rely on external information – namely transferred via labels. This general trend towards lables must be met by the market. As manufacturers are used to labelling their products, they are most often supporting this development as they see labels as a tool to avoid loss of trust and negative impact on market development. Labels should however be manageable in cost efficient, transparent and simple way. Experience shows that a quality based label is also an effective tool against low quality, inefficient competition.

The quality label for heat pumps – a future perspective

The evaluation of heat pump measurements enables the testing institutes to assess the technologies (and manufacturers) state of the art rather accurately. With increasing demand in terms environmental friendlyness, the development of new application fields and the development of new heat pumps to meet these demand, it is also necessary to develop the quality label even further.

The members of the EHPA quality label committee are deeply rooted in industry and maintain good relations to government agencies. Consequently they are able to assess upcoming new developments and to start a modification process of scope and requirements of the quality label very early. At the moment next steps include air-air units, and heat pumps with capacity modulation. With new developments in increasing heat pump performance, future adaption steps will be necessary. The established process is prepared to keep the quality label at par with technology developments and to maintain the high quality of the label.

With expected growth, more players will enter the market for heat pumps. A strong system for quality assurance including a quality label for the unit will remain an important prerequisite for continued success of the technology.

Stephan Peterhans,
Swiss heat pump association (FWS)

Efficiency measurement of heat pumps

A European Perspective

Seasonal performance factor and monitoring for heat pump systems in the building sector (SEPEMO Build)

The SEPEMO Build project is a response to an increasing demand for reliable and easy to compare data on the efficiency of heat pump systems across Europe. The lack of such data has repeatedly been identified as a major obstacle to an increased market development. It can be used as a benchmark for requirements on heat pump performance, for the execution of subsidy schemes and for the calculation of the renewables contribution of heat pumps in national and European statistics. Main factors influencing systems efficiency are:

1. Efficiency of the heat pump unit
2. Quality of installation (influencing the efficiency „in situ“)
3. Design of the system,
4. emperature level of the heat distribution system
5. Heat losses of the building envelope
   Climatic condition where heat pump is employed.

These factors are incorporated to different degrees in existing calculation and measurment approaches towards heat pump (system) efficiency (see table).

The SEPEMO project focuses on developing a universally applicable methodology for the determination of the seasonal performance factor for all EU countries. This approach is the most accurate, yet most complicated. The usability of existing data suffers largely from the fact that measurement approaches chosen in existing studies where not the same, in particular systems boundaries, number, position and accuracy of sensors as well as reporting schemes are different. As a consequence, the comparison of existing data does not provide exact results.

The SEPEMO project partners aim at overcoming this issue by developing a common methodology for field measurement of heat pump systems and calculation of SPF. This method will be based on and incorporate – as much as possible – on existing approaches. It will try to normalize their results trying to make them comparable according to a single approach. The result of this work will be tested in some 40 new field measurements incorporating all types of heat pumps located in the different European climate zones.

Results will be disseminated continuously throughout the project to decision makers in commission, Parliament and Council to make sure that they are recognised in the current preparation of Directives related to the Energy use of products and buildings:

- Directive on the promotion of use of energy from renewable sources (2009/28/EC, RES-Directive)
- Energy performance of buildings Directive (EPBD)
- Framework Directive on the Ecodesign of energy using products (2009/125/EC, EuP)

Resulting data from measurements and experience made while applying the common methodology will form the basis to enhance existing guidelines for heat pump installations even further. A strong focus will be given on parameters influencing the efficiency of the system taking into account regional variations in building standards, legislation and climate. These parameters will then be included into the training guidelines of the EUCERT training.

Similarly, experiences from defining the measurmenet scheme and identifying factors influencing the performance of heat pump systems shall form the foundation for a a reference guide describing presently available system concepts with their applications and users experience with a set of standardized high performance concepts as a basis for quality assurance of heat pumps.

Overall the project aims at providing background information on the keyparameters influencing efficient heat pump systems in design, installation and evaluation to decision makers from all stages of the products value chain. The project was successfully started in June 2009 when the ten partners from seven countries met in Borås, Sweden for the kick-off meeting.

Current activities are geared towards the preparation of the website (which is already online) and at the evaluation of existing SPF measurement schemes. More information can be found at: *www.sepemo.eu*.

Thomas Nowak

Categories of heat pump efficiency (source: own).

	Type of efficiency determination	Required norm, usage example	Includes factors
Unit efficiency „Coefficient of performance“ | COP	laboratory measurement of energy output over auxiliary energy input at defined rating points	• EN 14511 • EN 255 • Ecolabel for heat pumps • EHPA quality label	1, 4
Unit efficiency including climate data input „seasonal COP“ | SCOP	laboratory measurement of energy output over auxiliary energy input at defined rating points Weighting of results according to existing climate data	• prEN 14825 (temp. bin) • Implementing measure Ecodesign of heat pumps as energy using products.	1, 4, 6
Systems efficiency including energy losses of the building „calculated Systems performance factor“ | cSPF	Calculation of efficiency based on input data from unit measurements (COP), building and climate data	VDI 4650 EN 15316	1, 3, 4, 5, 6
measured systems performance „Seasonal performance Factor“ | SPF	Field measurement of energy output over total energy input. Different systems boundaries are used.	Fraunhofer ISE studies, Germany, FAVA study, Switzerland, Sweden Some EHPA best practise database examples	1, 2, 3 4, 5, 6

Impact of wide spread testing of heat pumps for market development

Heat pump testing in Switzerland is a success. Since 1993, more than 500 heat pump types from all European Countries were tested on unit efficiency in the labs of Toess and Buchs. Measurements were done both for prototypes and for serial products. The results of these markets are of high importance not only to the Swiss but also to the European market. They are used by public administration to decide on the inclusion of heat pumps in public subsidy programs or on the acceptance to market and they are also the basis for granting European quality labels. Inter alia, date from these measurements is used to grant the Quality label of the European Heat Pump Association (EHPA quality label, ex. DACH label) and the Ecolable for heat pumps.

The Swiss heat pump test center (Wärmepumpenzentrum – WPZ) was established in 1993 in Winterthur-Töss to speed up the efficiency and quality of heat pump units. As a result, heat pump efficiency has increased and a positive market impact became visible. Third party tests were an important aspect of trust in the quality of the technology, of the individual product and the production process. Their existence strongly influenced the development of the heat pump market in Switzerland in the 1990s. In 2004 the heat pump test center was relocated from Winterthur-Töss to Buchs, where the success story continued.

Over the last 5 years, 150 heat pump types of all variants (Air-Water, brine-water, water-water and domestic hot water) were tested at the new location. In cooperation with the Swiss federal agency for Energy (Bundesamt für Energie, BFE) the heat pump test center is evaluating the measurement results in order to better understand progress in technology development and the impact of new technological developments on heat pump quality. One factor that is permanently evaluated is the efficiency of the heat pump unit, the so called coefficient of performance (COP). This factor is measured at a rated measurement point which depends on the type of energy source used by heat pumps.

For brine-water heat pumps, the rated point measured at a heat source temperature (brine – B) of 0 °C and a heat sink temperature (water – W) of 35 °C. The short notation for this relation is B 0/W35. For Water-Water units, it is measured at W 10/W 35 and for Air-Water units, it is measured at A2/W35–25, meaning that the return temperature of the heat distribution is approx. 25 °C.

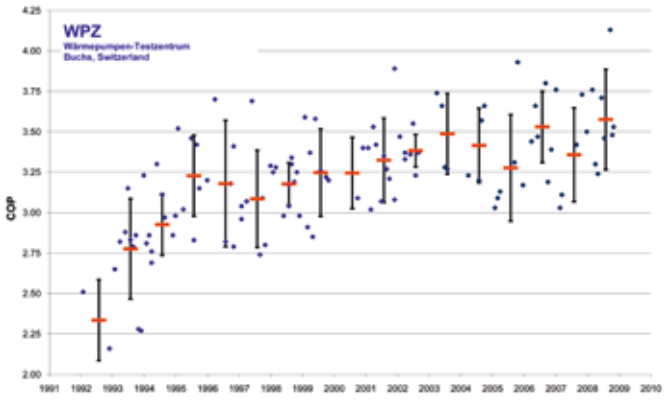


Figure 1: Measured COP values of all Air-Water heat pumps at A2 / W35–25, 1993 to 2009.

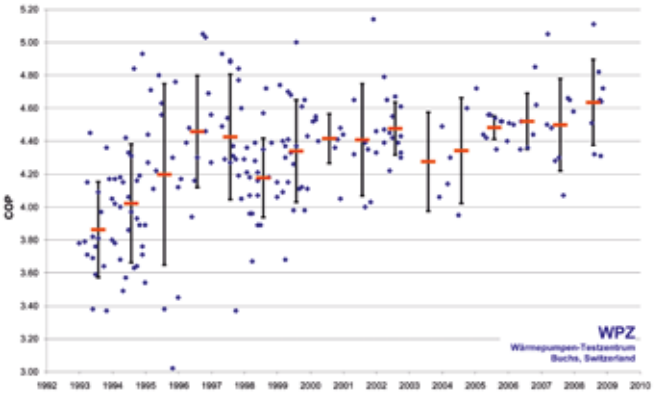


Figure 2: Development of measured COP of Brine-Water heat pumps at Bo / W35–25: 1993 to 2009.

The development of the measurements of Air-Water units over time is illustrated in figure 1. The mean of all measured COP values has increased until 2004. Starting at an averags of 2,3, efficiency has increased by mor than 50 %. Since then the average COP was measured at a level of approx. 3,5. Latest technological developments show that also for Air-Water heat pumps COPs above 4 are possible. While the all measured COP values since 2000 were above 3,0, a detailled evaluation does also show that approx. 1/3 of all results are in the range from 3,0 to 3,2. It is assumed that strong competition in this market segement had a "stabilizing" effect on unit performance as manufactures focussed more on cost improvements. The graph shows that the general development follows a wave form with technological advancement and consolidation phases. The fact that no heat pump in 2009 was measured with a COP lower than 3,2 could be an indication for another wave of technological progress based on an optimzed price-performance ratio of components used.

When focussing on Brine-Water heat pumps as similar trend as observed for Air-Water units is recognizable (See Figure 2). COP values have improved continuously until 2000. However the increase is less impressive than that for Air / Water units. Starting at an COP of 3,9 in 1993, the value increased by roughly 10 % to 4,4. This development stopped between 2000 and 2005, when COP values fluctuated by +–0,1 (from 4,3 to 4,5).

In 2004, measurements were no longer performed according to the established EN 255, but according to the new EN 14511. Due to changes in the measurment approach, the average measured value dropped by 7 %. However the required efficiency to be eligible for the EHPA quality label remained constant, putting pressure on those manufacturers that delivered products with efficiencies at the lower end of the range. The step in efficiency observed in 2005 and 2006 can be considered a reaction of the manufacturers on improved requirements. Further improvements in the vast majority of products lead to the case that today only a minority of units shows efficiencies lower than 4,3.

This cause-effect relation can result in requests towards constant further increase in requirements. Only this may be the conclusion – will meaningfully encourage manufacturers to improve the quality and the efficiency of their products in the long run.

Michael Eschmann, Wärmepumpen-Testzentrum WPZ

Country in focus:
Field measurements in Germany

Measurement of efficiency: Fraunhofer results from 100 new and 100 used buildings.

In many countries heat pumps are experiencing renewed popularity. Although heat pumps have been used to heat buildings for more than 50 years, the technology first boomed in the 1980s and since then, much has changed. Today the technology is very advanced and modern heat pumps matched to the heating demand and equipped with efficient controls can offer both economical as well as environmental advantages over a system supplied by fossil fuels. Primarily the fact of increasing clean power contributes to last-mentioned issue.

In comparison to conventional technologies, the heat pump is a much-debated technology with respect to its primary energy consumption and impact on the climate; some aspects of air-to-water heat pumps are environmentally controversial. Nonetheless, the increasing number of heat pump systems sold for use in new as well as existing buildings indicates the increasing popularity of this technology.

In a bid to resolve the issue of whether heat pumps are a sustainable alternative to fossil fuels, under the direction of the Fraunhofer ISE, two large field tests of newly installed heat pumps were started in 2006. In each project, measurements of a large number of heat pumps were carried out under real operating conditions in single-family dwellings.

Description of the projects

The field test takes place within the framework of 2 different projects. The first one is called "Heat pump efficiency". The subject of this project is the evaluation of heat pumps with a small output capacity of 5 – 10 kW thermal, with outdoor air (air-to-water HP), earth (ground-to-water HP) and groundwater (water-to-water HP) heat sources. Currently, the study deals with more then 100 heat pump units installed primarily in Low Energy Houses up to KfW-60 standard. The aim of the project is to assess their efficiency under varying operating conditions and in different system configurations and the results will be used to aid in further developing concepts. The characteristics of the assessed heat pump systems are shown in Figure 1. The majority (68 units) use ground as heat source. In addition, approximately 70 % of the systems use bore holes and 30 % use ground collectors. Air as the heat source is used in 26 systems. The remaining seven systems (9 %) are water-to-water heat pumps. Considering the heat distribution system, the predominance of the favored system is evident as 92 systems (93 %) are equipped with a floor heating and only nine use either only radiators or radiators in combination with floor heating (combined systems).

The project is funded by the federal German Ministry of Economics and Technology and seven producers, as well as by the utility companies EnBW and E.ON. The heat pumps assessed in the projects are from a wide range of suppliers: Alpha-InnoTec, Bosch Thermotechnik, Hautec, NIBE, Stiebel Eltron, Vaillant and Viessmann.

The second project, "Heat pump in existing buildings", deals with 75 heat pump units from major producers which are measured under real operating conditions in existing buildings. Due to their high supply flow temperatures, these heat pumps are particularly suitable for the use in older buildings. Here the focus was on comparing heat pump systems with alternative central oil-heating boilers with respect to the economics and greenhouse gas emissions. The project was commissioned by E.ON Energie AG, although the results will be made widely available. Concerning the characteristics of the assessed heat pump systems, this project differs from the one described before. It includes 38 heat pumps using ground, 35 using air, and two using water as heat source. Radiators are used as the heat distribution system for 97 % of the units used. This fact determines the higher system inlet temperatures of the heating system than in case of floor heating.

Efficiency figures

There are primarily two factors to describe the efficiency of heat pumps. First, the coefficient of performance (COP), is determined in the test stand with standard conditions for a

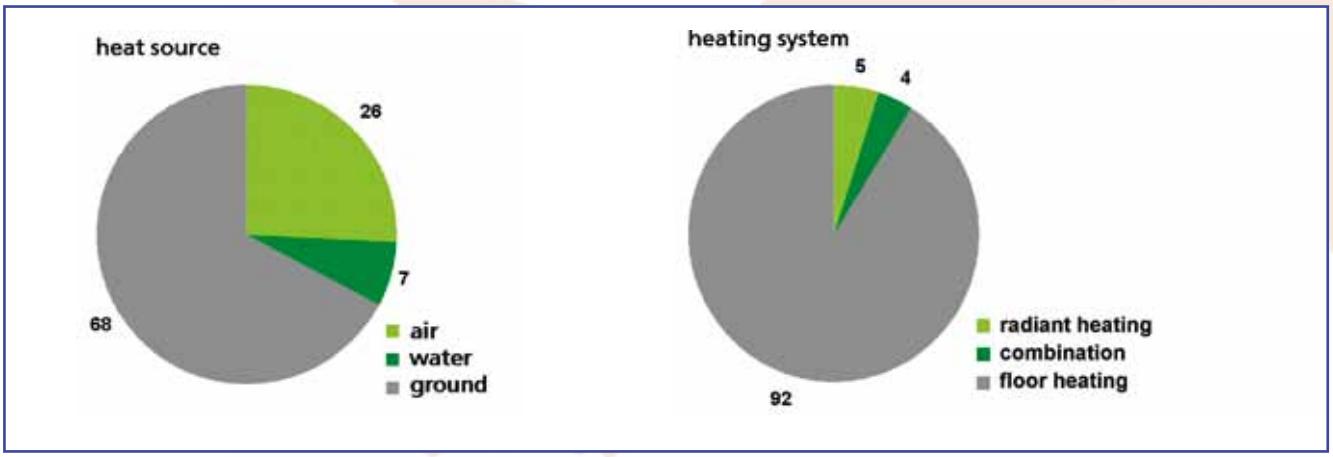


Figure 1: Distribution of the participating heat pump types (according to heat source and heat distribution system) in the project "Heat pump efficiency".

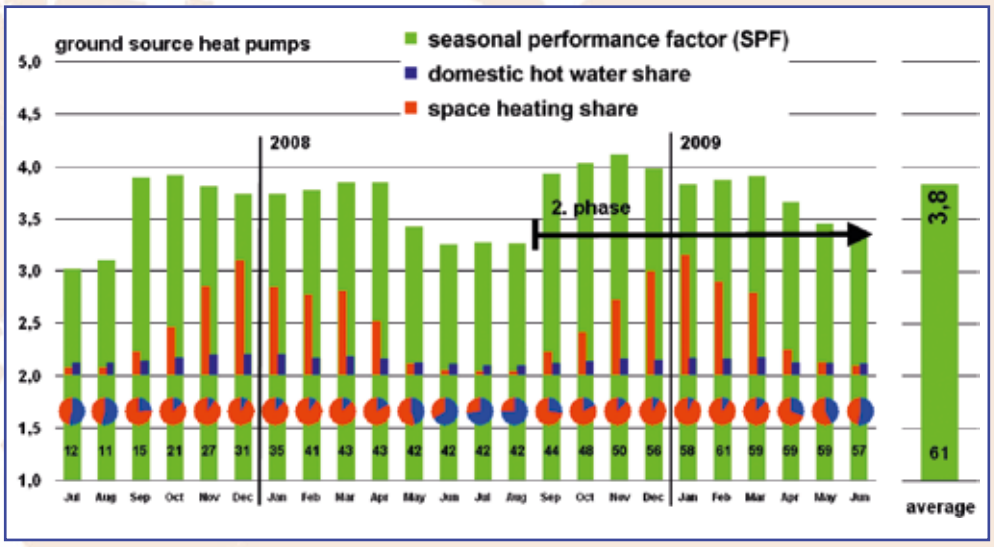


Figure 2: Seasonal performance factor (SPF) of the ground source heat pumps, including back-up electrical heater in the project "Heat pump efficiency".

certain operating point and/or for a number of typical operating points. Second, the seasonal performance factor (SPF), describes the efficiency of the heat pump system under real conditions during a certain period, for example for one year. It should be noted that the SPF does not describe all aspects of heat pumps and therefore their evaluation may not be reduced exclusively to the seasonal performance factors.

The SPFs in this case are the ratio of the heat energy produced by the heat pump and the back-up heater and the corresponding energy requirement of the heat pump, back-up heater and source fans in case of the air-to-water heat pump, brine pump in case of the brine-water heat pump and well pump in case of water-to-water heat pump.

Ground source heat pumps

The SPF for individual months and an average value for the period of July 2007 until June 2009 for ground source heat pumps are shown below in Figure 2. The share of the produced heat energy of the heat pump in space heating operation and domestic hot water operation is shown by the circles in the diagram. The columns right above the circles represent the same share in total value. The numbers in the bars indicate the number of analyzed heat pumps for each month. The arrow indicates the 2nd phase of the project, which includes the installation of additional heat pumps. The shown SPFs indicate both heating and domestic hot water supply.

The assessment of this 2-years measurement data for ground-source heat pumps in the new buildings project reveals a SPF of 3.8. The SPF of individual systems with a minimum measurement period of 12 months was within the range of 2.9 – 4.6. The share of the produced heat energy in domestic hot water operation with supply temperatures about 52 °C was 21% and 79% for the space heating operation, with supply temperatures in the range 28 – 46 °C.

Heat pumps within the second project, "Heat pump in existing buildings", score slightly lower on the scale. The SPF for the 2-years period of measurement averages 3.3. The range of the individual systems reaches from 2.1 to 4.2. However, the share of the produced heat energy in domestic hot water operations with average supply temperatures of about 52 °C was significantly smaller than in new buildings and amounts to 12%. The supply temperatures for the space heating operation were considerably higher than in the new buildings and similar to the average supply temperature in domestic hot water modes.

In both projects, the significant share of space heating in the summer months indicates that the control systems of the heat pump systems are not operating correctly, for example by not optimally loading the buffer storage.

Air-to-water and water-to-water heat pumps in 2008

Seasonal performance factors for the air-to-water heat pumps in new buildings averages 3.0 although as only six units are considered in this trial the formed average values are less representative than with the ground source heat pumps. The average SPF of the air-to-water heat pumps installed in existing buildings (34 units) amounts to 2.6.

The average seasonal performance factor for water-to-water heat pumps was 3.5. This efficiency value is lower than expected for this type of heat pump. Low heat load of the analyzed systems and high electrical consumption of well pumps may be an explanation for this observation. Additional factors influencing the efficiency of the water-to-water heat pump systems may be a low quality of the ground water resulting in the fouling of the water filter.

High efficiency, real conditions

The preliminary results show that the ground source heat pumps are especially promising when it comes to reaching high efficiencies under real conditions. However, there is still a need for optimization in the integration of the unit in the supply system for the house and for the control strategies of the heat pump. Thus, a poorly integrated heat source or an incorrectly designed heat sink can decrease the seasonal performance factor of the heat pump.

The seasonal performance factor of 3.8 for the brine heat pump system for supplying the space heating as well as for heating the water in residential buildings in the current building standards leads to the expectation that the often-cited SPF of 4 may soon be reached. Several systems already provide evidence of an SPF of over 4 in field tests and show what is achievable. When used solely for heating, the mean value of the SPF is 4.1 (new buildings). The main point to consider is the careful layout of the system as a whole, rather than with respect to single components.

For air heat pump systems there is still room for optimization. In the building stock, air-to-water heat pumps can reach values that exceed the determined seasonal performance factors provided that the layout is well planned and the flow temperatures are below 50 °C.

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In search of the perfect refrigerant

In times when environmental interest groups such as Greenpeace and Friends of the Earth are getting a lot of attention for their numerous attacks on multinational companies responsible for environmental pollution, the refrigeration and heat pump industry are not being left out. It is a strange fact that one of the most promising technologies to reduce green house gas emissions is being accused of careless use of green house gases.

However most of us active in the industry find the accusations unjustified. We believe that industry has taken all precautions necessary to deliver tight and even hermetically sealed systems to minimising refrigerant leakage. Our opponents are nevertheless urging for a shift to refrigerants without any global warming potential (GWP). While this demand seems obvious, it must be assessed in a lifecycle perspective. Such assessment of the environmental impact of a heat pump system is complex, and the refrigerant itself has only a minor role to play in total emissions produced.

Environmental evaluation of technologies needs to take into account direct emissions in production, operation and dismantling as well as indirect emissions related to the generation of the fuel (gas/electricity) that is used to operate the appliance.

With few exceptions, the majority of life cycle assessments carried out on systems for space conditioning or generation of electricity by combustion, confirm that the largest environmental impact is caused by the energy use of the appliance/plant in operation. In the case of heat pumps, direct emissions are caused by refrigerant losses in the different stages mentioned and indirect emissions from electricity/gas production.

A lot of research has been made to establish an integrated method to calculate the contribution of green house gas emissions from refrigeration and heat pump applications. The most well established method, TEWI (Total Equivalent Warming Impact), was developed at Oak Ridge National Laboratory in the early nineties. A TEWI calculation integrates direct and indirect green house gas emissions over the whole lifetime into a single number expressed in terms of CO_2 mass equivalents.

$$TEWI = \underbrace{(n \times L \times m \times GWP)}_{\text{direct emissions due to leakage}} + \underbrace{(n \times E_{annual} \times EF)}_{\text{indirect emissions related to electricity generation}} + \underbrace{(L_{demolition} \times m \times GWP)}_{\text{direct emissions at demolition}}$$

Where

n	*equipment lifetime [year]*
L	*annual leakage rate [%]*
m	*refrigerant charge [kg]*
GWP	*global warming potential [kg CO_2/kg refrigerant]*
E_{annual}	*annual energy use [kWh/year]*
EF	*emission factor driving energy [kg CO_2/kWh]*
$L_{demolition}$	*refrigerant losses during demolition [%]*

TEWI example:

As an example, a closer look is given at a domestic ground source heat pump supporting a single family house with an annual heat load of 24 000 kWhheating. This heat pump will require a total annual electric input, based on a seasonal performance factor (SPF) of 3, of 8 000 kWh. The following assumptions are used:

- Heat pump: NIBE Fighter 1230
- Labelled heat output: 6 kW
- Refrigerant charge: 1.8 kg R-407c
- GWP R-407c: 1530 kg CO_2/kg refrigerant
- Equipment lifetime: 15 years
- Annual leakage rate 2 %
- Refrigerant losses during demolition: 15 %
- Annual electric energy input 8 000 kWh
- Electricity emission factor (av. EU electricity mix): 0.47 kg CO_2/kWhelectricity

$$TEWI = \underbrace{(15 \times 0.02 \times 1.8 \times 1530)}_{826\ kg\ CO_2} + \underbrace{(15 \times 8000 \times 0.47)}_{56\,400\ kg\ CO_2} + \underbrace{(0.15 \times 1.8 \times 1530)}_{413\ kg\ CO_2} = 57639\ [kg\ CO_2]$$

Comments:

Even this example with its rather modest requirements on efficiency and indirect emissions from electricity supports the general conclusion that almost the entire amount of green house gas emissions stems from the indirect emissions related to the use of electricity (97.8 %). 1.4 % are caused by refrigerant losses over the useful life and 0.7 % by the losses from dismantling. In consequence the demand for a shift towards a refrigerant with lower GWP must consider these facts. As many replacement options with low GWP potential can only be realised at the cost of unit or systems efficiency, the overall TEWI value may not be reduced.

It should however be noted that the emission factor related to the generation of electricity may vary in a fairly wide range depending on the source of electricity generation. The example is based on 1992 average emission data for EU-12. There is a general understanding that utilities in Europe are facing a tremendous challenge in becoming less CO_2 intensive and a recent study by the association of European electricity companies (EURELECTRIC) explains that the goal of near zero CO_2 emission from electricity is possible.

In parallel increasing efficiency of heat pump technology may reduce the overall demand for auxiliary energy. Accordingly,

the TEWI impact from energy use will become much smaller and heat pump manufacturers as well as refrigeration industry need to start looking for more environmentally friendly refrigerants now. However large scale shifts towards low GWP refrigerants should be avoided if such shift can only be performed at the cost of the overall emissions (TEWI value) of heat pump systems. Such a step would be short sighted and must be considered a sub optimisation leading in the wrong direction.

Choice of refrigerant

The refrigerant chosen must meet several requirements with the most essential ones being reviewed below:

Chemical stability
- The refrigerant has to be completely stable within the system and ideally quickly decompose to harmless substances in the atmosphere.

Environmental impact, health and safety
- Environmental impact due to direct emissions (leakage) must be kept at minimum level. The use of flammable and toxic refrigerants is limited due to strict regulation and reluctance from the industry.

Thermodynamic properties
- Freezing temperature: well below normal operating conditions
- Critical point and boiling point temperatures have to be appropriate for the application.
- Reasonable operating pressures are preferred in order keep costs at a minimum
- High volumetric refrigeration capacity is beneficial

Practical characteristics
- High oil solubility is in general preferred
- Compatibility with common construction material
- Low cost

The search for a suitable refrigerant really started in the beginning of the twentieth century as the refrigeration industry at that time was restricted to the use of ammonia, carbon dioxide, sulphur dioxide or water. None of these refrigerants were at that time viable for domestic appliances. The lack of an adequate refrigerant was seen as the most important barrier to overcome. In 1928, Thomas Midgley and his associate Albert Henne were assigned to find a non flammable and non toxic refrigerant – global warming potential was not on the criteria list at that time. As being chemical engineers Midgley and Henne went back to their laboratory to look for suitable chemical substances that would fulfil the specified requirements.

Just two years later, at a meeting of the American Chemical Society, Midgley presented the new refrigerant, later known as R-12. The presentation was quite sensational as Midgley proved the desired characteristics by inhaling the refrigerant and then extinguished a candle as he exhaled. The introduction of R-12, which is a chloroflurocarbon (CFC), served as the take off for the refrigeration industry and the vast use of CFCs and later on HCFCs.

In 1973, Sherwood Rowland and Mario Molina presented a theory that CFCs would deplete the ozone layer. Their work was rewarded with the Nobel Prize in 1995 and led to the international agreement to phase out the use of CFCs in the Montreal Protocol 1987 and later on in the amendments to include the reduction of HCFCs.

The European industry has been successful in phasing out the use of CFCs and HCFC in a short time. Nevertheless it is not time yet to sit back and relax, yet. Now is the time to take the next step and look for refrigerants with low GWP that is practical for use and safe guard efficient use of our systems. Right now “old” natural refrigerants are experiencing a small renaissance and extensive studies are performed on new chemical substances with the desired characteristics. We are not likely to find a perfect refrigerant for all types of applications by tomorrow. The future of refrigerant use will most probably a mix of a) heat pumps using HFCs with a much smaller refrigerant charge, b) heat pumps using natural refrigerants and c) heat pumps using a new set of chemical blends that fulfil the required need.

The share of each of the options should be defined by the specific applications need taking into consideration the emission over the life cylce of the product. As explained, a simple ban on the use of HFCs would not only be very difficult to handle for industry but might also jeopardise the ambitious targets for improving energy efficiency and reduction of green house gases.

Martin Forsen

The state of heat pump installations in the Czech Republic

Development of the market

Modern heat pumps have been installed in the Czech Republic since the nineties of the twentieth century.

The number of units were slowly increasing in the nineties and a bigger progress was registered at the beginning of the twenty-first century. Since that time the number of installations have been higher year by year. Today´s state counts about 20,000 units in the region of the Czech Republic. The exact number cannot be given. The number is counted from the available data provided by the companies which agreed to give the information about the installations. The whole number is gained by using the statistical methods. Concerning heat pump types, ground systems prevail but not significantly.

Classification of the market

Heat pump market in the Czech Republic can be divided into three groups. For better understanding it is necessary to describe the development in the Czech Republic, former Czechoslovakia (before 1993). The first units which were installed here at the beginning came from England, Sweden and Germany. Their quality was time-proved as in the above mentioned countries they had been installed and developed very long. These heat pumps were the pioneers of the technology here. Heat pumps were made abroad and imported and installed here at that time.

These heat pumps are classified as high-quality units. They reach very good COP values and they do not show failures. Even their operation time is long thanks to experience and long development in the area.

As the time lapsed other brands came to the Czech market. Some firms also started to make HP units in the Czech Republic. These heat pumps are classified as average quality. They usually do not reach the same COP values as the units in the first group, however they can be still considered good devices. The main reason for it is that their history is quite short and the development is a bit delayed in comparison to e.g. Swedish technology.

In a few last years the Czech market has been flooded by unknown product brands, especially of Chinese production. These heat pumps are mainly air to water systems. A huge problem arose. Such systems show failures shortly after installing and their COP values are not as required. They usually freeze up and the system of defrosting does not work properly. Doubts can be also about their life time. However, their advantage is a very low price which attracts people to buy and install them. A problem the market is facing is that these relatively cheap devices make up the most of the market offer. People then cannot recognize which heat pump is quality, which can fullfil customers´ requirements. Unfortunately there are not many incentives which would help people make differences between good and bad heat pumps.

Support of quality units

Since non-quality products have a bad inflence on the whole heat pump field, the Czech Heat Pump Association made endeavor to recognize quality and non-quality heat pump units. CHPA has achieved the support of quality units in the form of financial subsidies by the Ministry of Industry and Trade of the Czech Republic. Subsidized heat pumps have to reach set COP values otherwise they are not supported. People who install geothermal systems can get as many as 2,900 Euros and air to water systems 1,900 Euros within the programme called Green Savings. It can be said that this is the biggest success at present and the first step how to have only quality units on the market.

It is believed that people will choose mainly subsidized heat pumps and thus heat pump units of lower quality will disappear from the market. However, it is a long-time task which cannot be successful without the help on the European level.

Martina Boehmová, Czech Heat Pump Association

How to join the EHPA quality label – a quick guide for new manufacturers and new countries

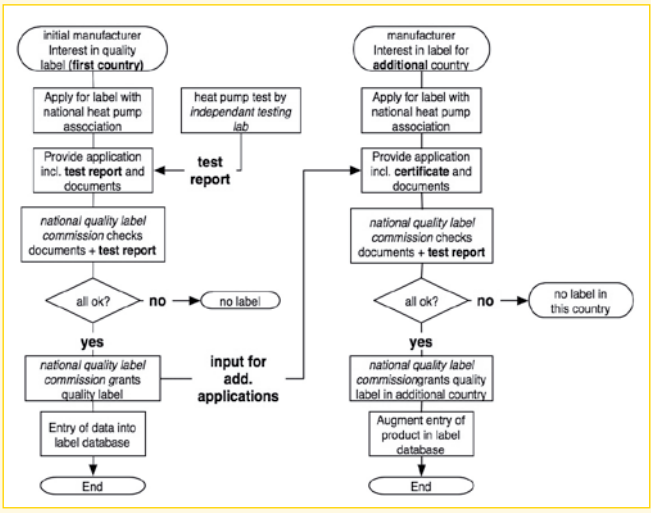
The EHPA quality label is currently valid in six European countries: Germany, Austria and Switzerland (ex D-A-CH), Belgium, Finland, France and Sweden. Acceptance in Belgium is under preparation.

How to obtain the quality label for a product

In order to achieve the right to apply the label to the individual product, a manufacturer or distributor has to comply with a set of criteria that are the same for all European countries:

1. The product must comply with European rules and regulations.
2. The product must meet the efficiency requirements as set in the documents available for the heat pump type (see www.ehpa.org/ehpa-quality-label/ for details).
3. The manufacturer/distributor must have established a service organisation in the country within which he asks for the quality label. Consequently, if the label is applied for in several countries, the existence of this organisation must be prooven for each country.
4. The manufacturer must confirm that he offers a full 2 year warranty.
5. The manufacturer must confirm that he offers spare parts for a period of 10 years.
6. The manufacturer must provide an installation manual in the national language(s).

In order to achieve the right to apply the lable to the individual product, the manufacturer/distributor has to apply with a national heat pump association. The quality label commission of this assocation will check compliance with requirements one to six of the above list and will inform the applicant on the outcome of this procedure. The application can be filed for one or more countrie; in case the use of the label in several countries is asked for by the manufacturer, the application is still only made once, however in this case the applicant indicates the countries that he whishes to obtain the label for on the application form. The involved quality label commissions exchange the necessary documents among each other. Each national commission checks for compliance with items three to six and reports the results. Once all requirements are checked, the commission that received the original application informs the applicant on the outcome of the process and in case of success, provides him with a certificate and a certification number. The number follows the nomenclature Country code - xxxxx. For example AT-00001. The certificate is valid for xx years, validity can be checked on the EHPA website using the label number.



Application process for obtaining the heat pump quality label.

How to join the quality label scheme as a new country

In order to establish the quality label in a new country, some preliminary steps are necessary. It is required that some sort of organisation exists in the country to handle the interests of the heat pump industry. This organisation – upon decision of the national stakeholders – should then establish a national quality label commission to handle all request for the use of the label in the country. It is also obliged to sent a representative to the EHPA quality label committee meeting.

This structure has proven efficient in the past and requires only very little administrative effort.

Development of the quality label in the future

The heat pump industry has established a well working instrument to ensure the quality of its products based on a set of identical requirements checked by third party testing. For the future, the European Heat Pump Association intends to develop the label further by extending it to more countries and by modifying and updating the technical requirements. The association looks forward to the acceptance of its label as the requirement for national quality incentives and quality schemes.

Developments on the Ecolabel for heat pums and the Implementing measure for boilers (Part of the Framework Directive on the Ecodesign of Energy using products) are closely monitored at the quality label is working towards increasing the overlaps of the EHPA quality label with the requirements of these pieces of legislation.

Making quality visible: The label and the product database

In 2006 the EU-CERT.HP project was completed and the EHPA took over the activitites to maintain the education program and to execute a roll-out to additional Member States. After two years of work, the EUCERT program is estalished in 8 European countries recently joined by Finland and a roll-out in Italy about to start.

Part of a working quality scheme is a logo and an option to check on the validity of its use for the individual product. In the process of developping the DACH quality label towards a European label, the EHPA quality label committee has decided on a new logo to be used on the product and in product related marketing material. While the technical requirements are still the same it was the aim to express the new scope of this label – its usability for quality assurance in all European countries. The new logo makes reference to the old one in maintaining a modernized version of the letter Q. It bears the text "European Quality Label for Heat Pumps" in English or the national language of choice and it shows that certification number.

On the website, all interested parties can check which heat pumps have been granted the quality label. The entry for each certificate provides information on the manufacturer and the heat pump unit. It also shows, when the certificate was first applied for, whether or not it has been renewed, the countries in which it is valid and which organisation performend the certification. The certificate is presented as PDF-document.

In addition, a contact address of the manufacturer as well as of the service organisations in the different countries is provided.

For interested parties looking for a specific heat pump, the website provides a full-text seach field as well as selectors to have a look at heat pumps from particular manufacturers, of different types/models and from different countries.

next meetings

EHPA general assembly
19.5.2010 | Brussels, Belgium

3rd EHPA heat pump conference
20.5.2010 | Brussels, Belgium

Executive committee meeting
12.1.2010 | Düsseldorf, Germany

Education committee meeting
9./10.3.2010 | t.b.a., United Kingdom

Quality label committee meeting
12./13.4.2010 | Leuven, Belgium

Norms & Standards committee meeting
12.3.2010 | Brussels, Belgium

PROJECT MEETINGS

Ground-Med second partner meeting
25./26.2.2010 | Athens, Greece

QualiCert meeting
26./27.4.2010 | Brussels, Belgium

SEPEMO project meeting
13./14.1.2010 | Brussels, Belgium

OTHER DATES WITH HEAT PUMP RELEVANCE

General assembly European Technology Platform renewable heating and cooling
23./24.2.2010 | Bilbao, Spain

European Sustainable Energy week
22.–26.3.2010 | Brussels, Belgium