Technology Collaboration Programme on
Heat Pumping Technologies (HPT TCP)

IEA OECD

Annex 39

A Common Method for Testing and Rating of Residential HP and AC Annual/Seasonal Performance

Executive Summary

Operating Agent: Sweden

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HPT-AN39-SUM

iea Energy Technology Network

EXECUTIVE SUMMARY

It is important to have reliable information on both the heat pump itself, and how it is influenced by the surrounding system and the climatic conditions under which it operates. This annex focuses on lab methods and related standards, in order to improve them, harmonize and create a better understanding of differences between these. As Figure 1 shows, there could be large deviations between lab tested performance and real performance.

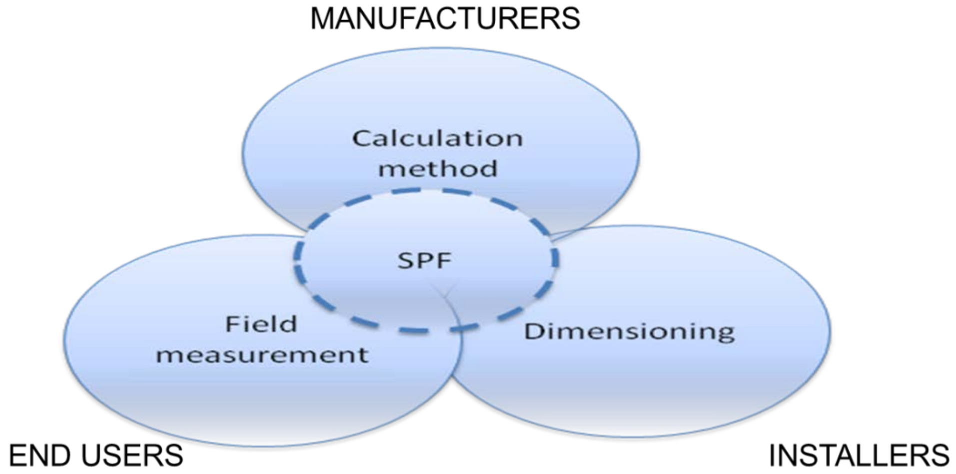
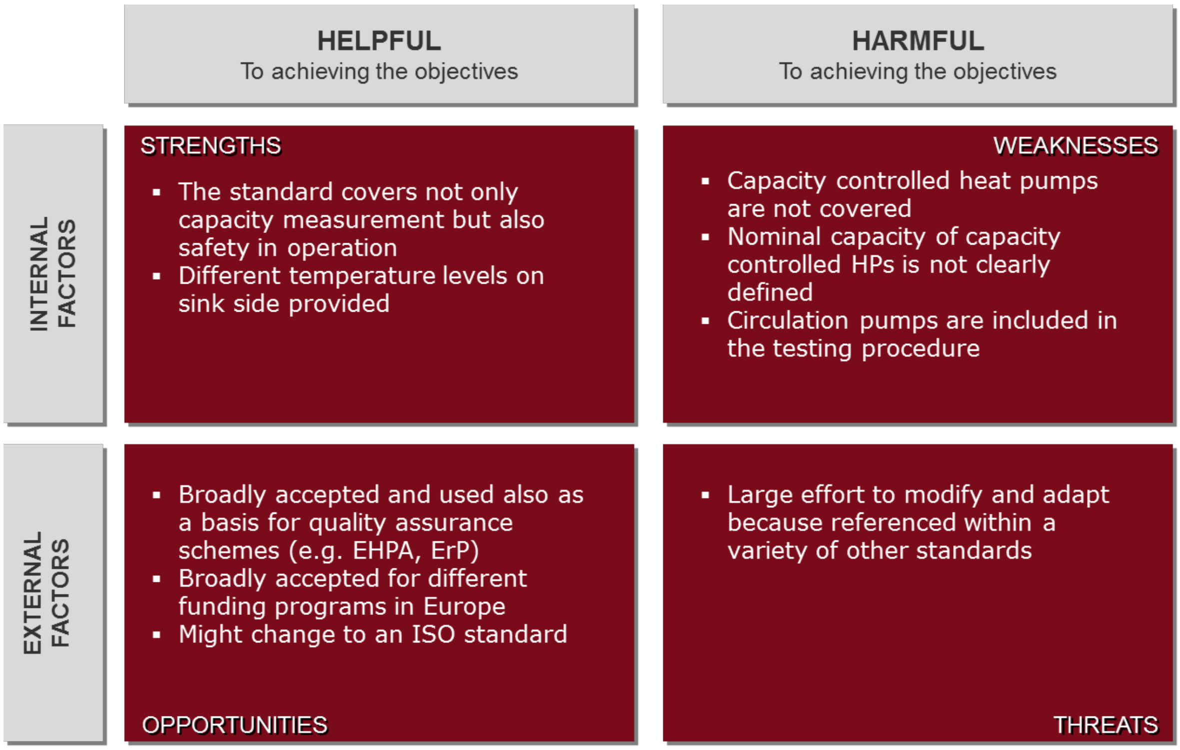


Figure 1. SPF can be obtained in many different ways.

The matrix in Table 3 below is a summary of the most important standards studied in the project. It is divided into different categories trying to sort out the content of the different standards.

Strengths and weaknesses with current methods have been analysed and SWOT analysis of existing standards have been done. It was shown for example that the standard EN 14511 covers not only capacity measurement but also safety in operation and different temperature levels on sink side. EN 14511 is broadly accepted and used also as a basis for quality assurance schemes (e.g. EHPA, ErP) and different funding programmes in Europe. The Standard is not covering capacity controlled heat pumps and the Nominal capacity of capacity controlled HPs is not clearly defined. In EN 14511 circulation pumps are included in the testing procedure only a small amount is integrated in the calculation. After the closing of this annex, updates to the EN14511 standard have occurred.



Comparisons on how different calculation methods predict the seasonal performance have been performed in the Annex, showing that the calculation almost always underestimates the real performance of the heat pumps, but that they are very close to real performance.

A comparison was made for one field monitored site, where monitored SPF was used as a benchmark. As can be seen from Figure 18 below, all calculation methods have underestimated the SPF compared to the monitored value (messung).

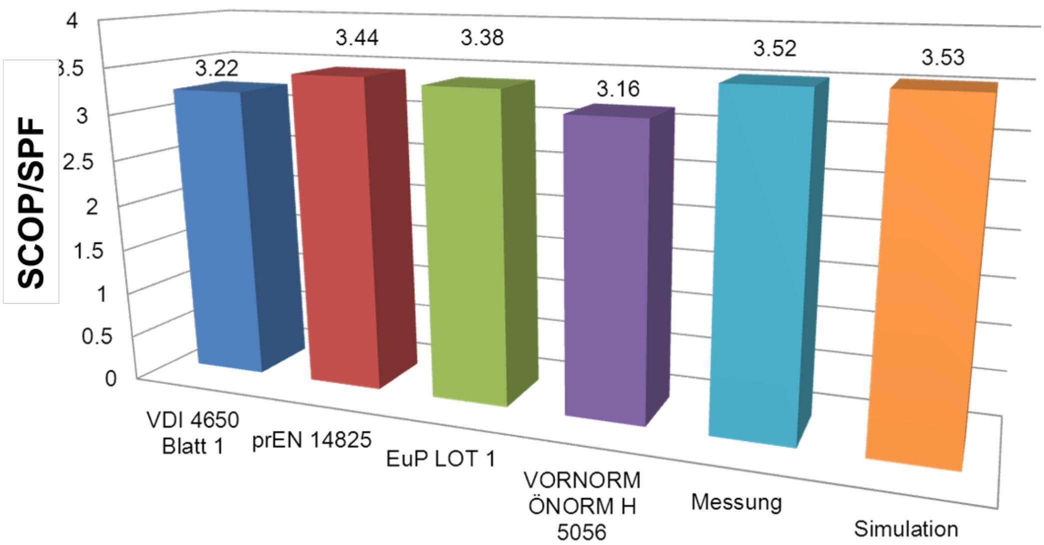


Figure 2. Comparison of different calculation methods with one field monitoring site.

The fact that there are numerous methods for calculating SPF, taking into consideration different national geographic conditions and other special conditions, there was a quite clear view that calculation methods for different climates may need to be local, but considering the test points for lab test standards (Table 8), there is not that many points that differ. It would therefore be of interest to make a thorough evaluation of the consequences of harmonizing the test point parameters for lab testing.

Table 1. Comparison of main standards in three geographic regions of the world.

	APF (Year-round performance factor)	EN14825 SPF	ANSI/AHRI210/240 SEER
Building load	Load=0 : Outdoor tem. at 17 ℃ Load=82% of rated capacity at outdoor temp. of 0 ℃ in heating	Load=0 : Outdoor tem. at 16 ℃ Load=100%: Outdoor tem. at -10℃	Load=0 : Outdoor tem. at 18.3 ℃ Load=100%: Outdoor tem. at -5℃
Estimated load appearance hours	Heating period: Oct 28 – Apr 14 Heating hours: 6:00 – 24:00 Total heating hour: 3042 hrs	Heating hours of standard region is 4910 hours.	750 ~ 2,750 hours depends on regions.
How to calculate device performance	Performance level of products in every outdoor temperature degree can be calculated by measuring rated and intermediate capacities at 7 ℃ outdoor temperature and maximum capacity at 2 ℃.	Can estimate device performance curve by measuring 4 points between 88 % and 15 % on load curve in relation to outdoor temperature	1.Max capacity line; connect 2 points, measured at 1.7 ℃ & -8.3 ℃ 2.Min. capacity line; connect 2 points, measured at 8.3 ℃ & 16.7 ℃ 3. Intermediate capacity line: Measuring at 1.7 ℃ then make a line.
Measuring points	Total: 3 points; 2 from rated and intermediate capacities at 7 ℃, 1 from max. capacity at 2 ℃.	3 -5 points in 3 regions (basically measured at full rated capacity or 75%, 50% and 25 % of rated capacity.	5 points; 2 at max. compressor rotating speed, 1 at intermediate capacity and 2 at min. capacity
Conditions of Measuring points	Rating and intermediate capacities at 7℃, and max. capacity at 2 ℃	-7.0℃:88% 2℃:54% 7℃:35% 12℃:15%	-8.3℃:Max 1.7℃:Mid. 8.3℃:Max.Min. 16.7℃:Min.
	Outdoor temp. is fixed at rated condition of 7℃ & 2℃	4 measuring points. Part loads are measured at different temps.	5 measuring points at 4 different temps. Part loads are measured at different temps.
Remarks about capacity range	Low capacities are not measured due to lacking fairness considering large measuring errors in low capacities.	Measuring error is large at 15% of rated capacity.	Measuring error is large at 25% of rated capacity.
Frost	Considered in every load between max. and intermediate.		Considered only in performance curve of max. load not in other loads.
How to measure a intermittent operation for majority	Degradation Coefficient Cd is not used. As the lower limit of variable width of heating capacity is rarely below the intermediate operation in Japan, they do not calculate by using Degradation Coefficient Cd.	Degradation Coefficient Cd=0.25 is used. Same as the ARI210/240	Degradation Coefficient Cd=0.25
Stand-by power consumption	Not considered	Suggested that stand-by power consumption should be considered	

By looking into the development of products, the complexity of different building traditions and climatic conditions, we have developed a set of requirements that a completely new test/calculation method should be able to handle. Some of the most important are listed below, but all are presented in the report:

It should be possible to decide the energy demand of the house in the model, either by given reference loads, or by choosing a specific energy demand of the house. This should be separated into space heating and domestic hot water. When the model itself calculates the losses of the house it can be misleading and not sufficient for the actual house. This can be one boundary requirement of the project.

To take into account for the climate at the installation, local climate data, for example Meteonorm climatic data could be a part of the model.

The dynamics of the house/building can be a part of the model. The perceived temperature of the house is not fully consistent with the actual outdoor temperature. At colder temperature dips of for example -15°C, the house will not experience the real outdoor temperature, but experiences a temperature of e.g. -12°C instead (due to internal heat gains). Even the irradiance of the sun differs between the seasons (and different spots). The energy demand of the house is affected from those variances over the year, why it might be an idea to calculate the SPF over monthly periods. For simulations, also the use of a fictive outdoor temperature would be an alternative. The climate data can be adjusted (flattened out) depending on a number of inputs, but a temperature dip is still needed in order to make a proper effect dimensioning (this is dimensioning the entire system such as deep wells etc.).

The model should contain a radiator heat curve where required supply temperature is calculated, an example of this can be found in the thesis of Fredrik Karlsson [6]. At a colder outdoor temperature, the supply temperature should peak; this makes the test scheme tables in EN 14511 deficient. Also other heat distribution systems, such as underfloor heating, heating ventilation air and mixed systems should be included in the model.

Part load performance of the heat pump must be properly taken into account.

Back up heaters is sometimes necessary to complete the energy demand of the house. Back up heaters should be included in the calculation model. Supplementary heating should be possible to choose between different sources of supplementary heat, e.g. electricity, solar or biomass heating.

The possibility to include the production of domestic hot water to the SPF calculations would be an advantage. It should also be described how this shall be measured in tests alternatively, how the amount of produced domestic hot water shall be estimated. Today there are two main ways how to do the measurements, including the losses or not (one can measure the amount of energy that is obtained by tappings or the amount of tap water the heat pump is producing).

Accumulators should be possible to include in the model.

A model must contain clear system boundaries for what is to be included in the calculations and how measurements are performed.

An outcome of the results should be to see that a properly sized heat pump is the best alternative to install. An oversized heat pump will result in on/off cycling losses etc.

The model must be transparent so it is possible to follow and understand the calculations. The studied models all contain parts that are more or less transparent. For example how the estimation of the number of equivalent heating hours is performed is not shown in any method.

For the calculation, either BIN methods or hour by hour calculations should be possible to be used. The existing calculation models based on heat pump performance testing according to standards are all using BIN models. Therefore, to keep a clear connection to existing test standards, it is the easiest to base a new model on BIN models.
The drawback with this approach might be that dynamic effects, especially in cases with large or well stratified accumulators are not treated in a way that the full potential of these units are revealed. Likewise, solar irradiation gains might not be treated properly.

To better compare heat pumps’ benefits with other heating technologies, but also to better understand performance of heat pump, a number of other measures could be used to understand:

a. The improvement potential of heat pumps and heat pump systems
b. The competitiveness of heat pumps in environmental performance compared to other competing technologies

Figure 3 below shows the different boundaries for characteristic factors for benchmarking the systems according to primary energy, final energy, usable energy, SPF, PEF and PER. The needed parameters for calculating PEF, AE and0020PER are described.

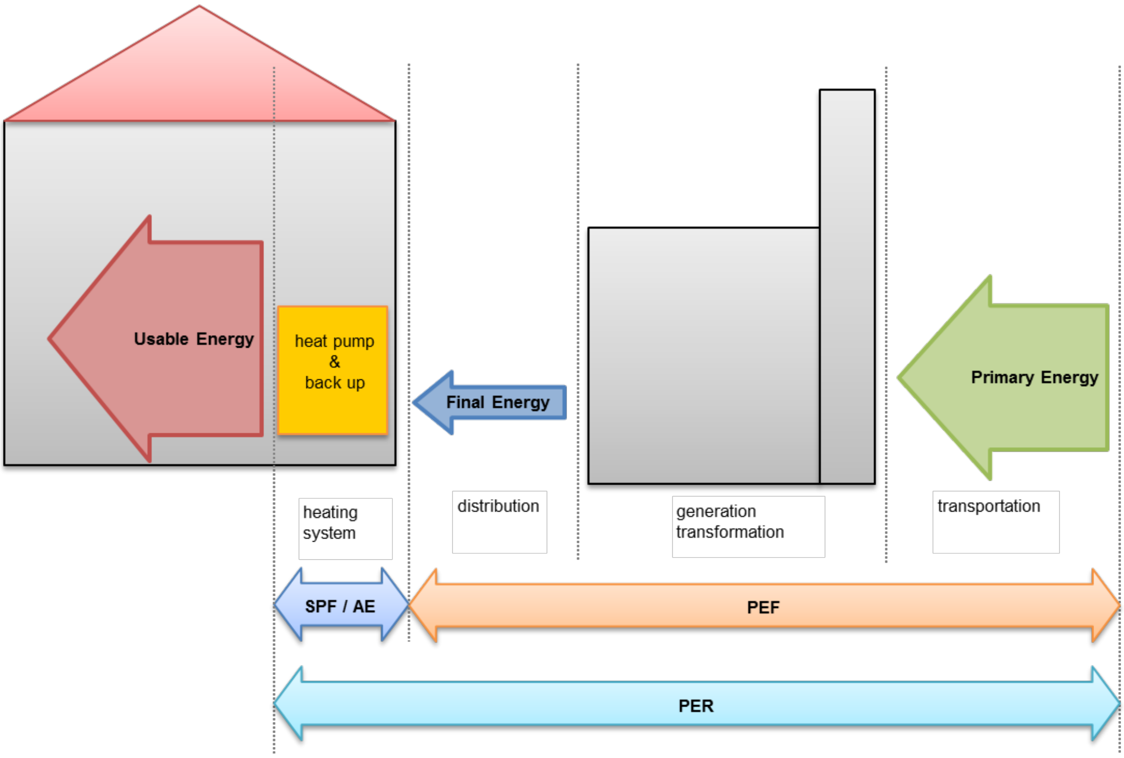


Figure 3. Boundaries for characteristic factors

Conclusions from the Annex work

This annex give proposals for harmonizing test standards, but also extends to give suggestions for building test chambers in an similar way, and propose alternative measures to describe the technical, environmental and financial performance of heat pumps. Much work was carried out in the separate national teams, and the results were presented in workshops. The conclusions from the results are summarized in bullets below, but in order to gain more insight, it is recommended that the conclusions of the national reports are read as well.

- The difference in test points in different regions doesn't differ a lot, why there is the possibility to harmonise many test points. By harmonising the test points, the road is open to come closer with the calculations and certifications that are based on these test points.
- Harmonisation should be made to test points, so that a similar set of test points are tested in the test labs. There must be room for local (national, regional) variations, especially regarding climatic conditions and building demand profiles. Therefore a matrix of test conditions could include the necessary test points, and voluntary test points that should need to be tested for certain markets (e.g. in cold climates, one -15°C point should be included).
- Harmonisation of test standards should happen on ISO level, since this is the global forum for standardisation. Regional/national standards should align with the ISO standards when they are published.

- Timing between revisions of standards is a threshold to harmonisation. Ideally, an agreement should be made between standardisation organisations to make revisions e.g. every five years with a limited revision time, with possibility to harmonise standards at every revision.
- We have reached a conclusion that harmonization of the standards in respective countries is difficult. Even so, we believe that we will be able to create annual performance evaluation standards that seem to be uniform as far as possible.
- Even though this annex have found many possibilities to harmonize standards, we have concluded that a number of new calculation and simulation methods have been developed during this project, which is moving in the opposite direction of the thoughts of this annex.
- As simulation becomes more and more accepted to define building integrated heating performance, there should be very transparent models for both buildings, heating systems and with regards to climatic data. Very clear operating ranges for different relations should be defined etc. There is otherwise the possibility that the final performance numbers are compromised by uncertainties in simulations models.
- To promote heat pump simulation, one IEA HPT annex could be performed, developing a library of annotated and accepted heat pump and building models.
- The IEA HPT could from this annex develop a set of calculation templates for evaluating other performance metrics but SPF, both for installers and for end users. These templates should be Final energy use, Primary energy consumption, CO2 emissions reduction and Cost performance. This makes it much more clear to end consumers to understand the financial and environmental consequences when installing a heat pump

IEA Heat Pump Centre
c/o SP Technical Research Institute of Sweden
PO Box 857
SE-501 15 BORÅS
Sweden
Tel: +46 10 516 5512
E-mail: hpc@heatpumpcentre.org

www.heatpumpingtechnologies.org

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