13th IEA Heat Pump Conference
April 26-29, 2021 Jeju, Korea

Assessment of Standardised Test and Performance Evaluation Methods for Fuel Driven Sorption Heat Pumps

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Abstract

Space and DHW heating appliances play a major role in increasing energy efficiency and reducing greenhouse gas emissions. A number of recent publications identified fuel driven sorption heat pumps (FSHP) as a promising technology which can considerably contribute to these goals, compared with current state-of-the-art gas appliances. The EU Ecodesign Regulation and the Implementing Regulations for different groups of energy-related products have highlighted the need for unbiased and transparent testing and performance evaluation methods. Although the technology is not new, the market is still developing and the current standards have yet to be evaluated regarding their applicability, unambiguousness and comprehensiveness. Within the IEA HPT Annex 43 and the EcoTest Projects round robin tests on gas driven sorption heat pumps have been performed based on the current European standards. In this paper, the results of the test will be presented with an emphasis on the assessment of the test and evaluation methods and their comparison. As one of the results, shortcomings of the methods and possible improvements have been detected and provided to the relevant CEN Technical Committees for further consideration.

Keywords: gas heat pump; test methods; quality assurance; energy label

1. Introduction

A proclaimed goal of the EU energy policy is to reduce the greenhouse emissions to 80-95 % below the levels of 1990 by 2050. As around 40 % of the final energy consumption in the EU countries can be attributed to the building sector (85 % thereof for space heating and domestic hot water (DHW) preparation), a fast deployment of energy-efficient solutions is crucial to reach this target. The EU addressed this issue in a number of directives regulations, most notably within the Ecodesign and EPBD directives, in which the standards for the energy efficiency of the buildings and HVAC equipment are defined.

The energy consumption for space heating per square meter heated area has been decreasing steadily in the EU countries since 2000. As new dwellings are being built at a rate of about 1,1 % of the total dwelling stock annually, the main contribution to the decrease of specific energy consumption can be attributed to the boiler retrofit and energy efficiency measurements on building envelope. This shows that the retrofit market is the main key to reaching the goals in the given time frames under current market development in the building sector. Therefore, efficient and affordable technologies targeting this market are needed to meet the proclaimed targets of the environmental policy. A number of recent publications (e.g. [1], [2]) on future energy market see fuel driven sorption heat pumps (FSHP) as a promising technology in that respect. The technology is seen by many as the next step in the development of fossil fuel heating systems. It can considerably increase the energy efficiency and usage of renewable energy sources while decreasing greenhouse gas emissions, compared with current state-of-the-art fossil fuel boilers. With expected net decarbonisation of gas grid by increasing biogas

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production, development of power-to-gas concepts and evolution towards the usage of hydrogen, the FSHP, especially gas-fired heat pumps, may further gain in importance.

Calculations to identify the optimal technology mixtures both on the energy production and demand sides in terms of overall annual costs until 2050 were reported in [1]. The simulations were based on a comprehensive model of the overall German energy sector which takes into account the geographical, political, social, economic and technological characteristics of the location and forecasts their development in the upcoming decades. Having the minimum cumulative cost of the transition from the current energy system to an energy system with a substantial reduction of CO_2 emissions as the target function, the simulations yielded the optimal technology mix for a number of different target values.

Figure 1 shows the projected development of the share of heating systems for the buildings by 2050 for the assumed 85 % CO_2 emission reduction compared to 1990 values. This scenario seems to be slightly optimistic since the proclaimed policy of the German government sees an emission reduction of 80 % for the same time period. However, it shows the potential of the heat pump not only as a highly efficient technology, but also as the most cost-effective one in the decades to come. According to the scenario, most of the electricity will be produced by solar and wind power plants by 2050. Fluctuating electricity production will require considerable storage capacities to ensure a reliable energy supply. In that context, production of combustibles by power-to-gas processes and usage of current gas grid and its storage potentials will play a very important role in the future. This means that, even in an electricity-dominated energy system, the need for efficient gas fired energy conversion appliances using existing gas infrastructure will most probably exist.

The scenario sees a domination of heat pumps as heating systems in buildings by 2035 and a complete takeover by late 2040s. GHPs would reach a share of around a quarter of the total market. The technology should experience its first major break-through around 2026-2027 when a threshold of 1 million installed units should be reached. Although this estimation seems to be rather enthusiastic considering just a couple of thousands of currently installed units and not more than a handful of products available on the market, it shows the potential of the technology if the presumed cost and efficiency targets are met and a decarbonisation of energy system is pushed at projected pace. Needless to say, this estimation is highly dependable on a number of factors, including further technology development and acceptance, future energy system configuration, development of energy prices, incentive policy and development of competing technologies, among many others.

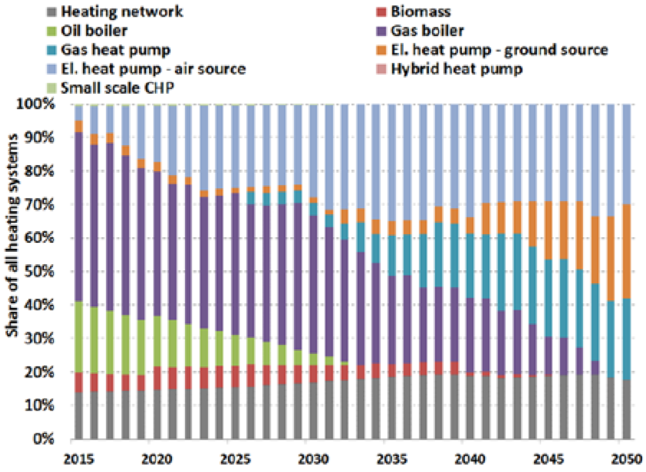


Figure 1. Development of heat supply technologies in buildings until 2050. Source: [1]

2. Market and appliances

Since its market entry in the mid-2000s and until 2010, only one manufacturer (Robur S.p.A.) of gas driven heat pumps was active on the European market. With heating capacities of around 40 kW the appliances were used mainly in small commercial installations. From 2010 onwards, a number of products aiming at single family house market – both new and retrofit – were introduced by major heating equipment manufacturers. All available products were built using sorption technologies. However, almost all these products have been removed from the market in the last 2-3 years leaving Robur to be the sole provider of this technology once again.

Two main concepts were being pursued by the manufacturers: bivalent appliances with an adsorption heat pump using water as refrigerant supported by a modulating condensing boiler. These units need a heat source above 0 °C to avoid freezing – a ground heat source or solar collectors are needed. The adsorption heat pumps were sized to cover only one part of the nominal load up to ca. 4-5 kW. The concept did not prove to be interesting for the market and these appliances were withdrawn by the manufacturers. Absorption appliances are monovalent machines and run with ammonia-water working pair. Due to a lower freezing point of ammonia, they can operate with ambient air as heat source at temperatures well below 0 °C. These units can modulate their output capacities in the range of ca. 30 to 100 % of nominal thermal power.

Manufacturer	Viessmann		Vaillant		Robur			Bosch Thermotechnik	BoostHeat
Model	Vitosorp 200-F D2RA 001|002	Vitosorp 200-F D2RA 003|004	zeoTHERM VAS 106/4	zeoTHERM VAS 156/4	GAHP - GS | WS [5]	GAHP - A [6]	K18	Junkers Supraeco 9000i-G Buderus Logatherm GWPS(L)192-18 i	BOOSTHEAT.20
Nom. Capacity [kW] [1]	11.00	16.70	10.20	15.00	42.61 | 43.90	41.00	17.6	18.00 [3]	20 kW
Technology	adsorption		adsorption		absorption			absorption	mechanical compression
Working pair	water/zeolite		water/zeolite		ammonia/water			ammonia/water	carbon dioxide
Heat source	geothermal | solar		solar		borehole | ground water	air	air	borehole | air	air | borehole | ground water
Aux. heat source	condensing gas boiler		condensing gas boiler		-	-	-	-	condensing gas boiler
Annual GUE [%] [1]	1.38 | 1.39	1.31 | 1.35	1.31	1.22	1.58 | 1.53	1.36	-	> 1,25	1.95 | 1.65 [7]
Nominal GUE [%]							1.69 [2]	1.70 [4]	2.29 [8]
Market entry	2013	2013	2010	2012	2004	2004	2016	2016 (planned)	2019
Not available since	2017	2017	2016	2016	-	-	-	2018 (abandoned)	-

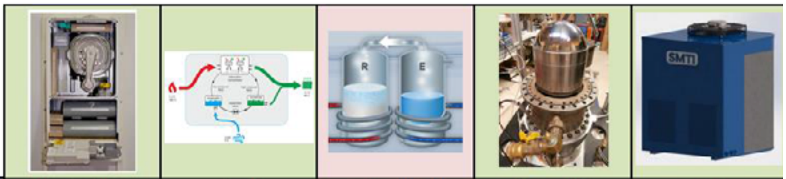
[1] According to VDI4650-2 for supply and return temperatures 35-28°C, except values for Robur K18 and Bosch Thermotechnik. Source: www.bafa.de
[2] According to EN12309-2 for air inlet temperature 7 °C and water supply temperature 35 °C. Source: www.robur.it
[3] According to the manufacturer for brine inlet temperature at heat source 0 °C and supply temperature of 65 °C. Source: www.junkers.com
[4] Test conditions not known. Source: www.junkers.com
[5] Products with same specifications available from Bosch Thermotechnik (Logatherm GWPS/GWPW 41), and OERTLI-ROHLEDER (GAWP 40 SW)
[6] Products with same specifications available from Bosch Thermotechnik (Logatherm GWPL 41), OERTLI-ROHLEDER (GAWP 35 LW) and Remeha (GAS HP 35 A)
[7] According to VDI4650-2 for supply and return temperatures 35-28°C
[8] According to VDI4650-2 for supply and return temperatures 55-45°C

Figure 2. Overview of available and withdrawn GHPs in the European market with main characteristics

In 2019, a start-up company BOOSTHEAT SA brought up their heat pump to the market after eight years of development. Unlike all other gas driven appliances for heating, it is not based on sorption technology but uses an own-developed mechanical compression system.

It is expected that the main market, due to its size, availability of gas mains and technology characteristics will be boiler replacement, especially in countries which are traditionally dominated by this fuel. Figure 2 gives an overview of currently available and withdrawn products with their main characteristics.

Despite a rather slow market development, a number of development activities have been reported in the recent years, both in the EU and in the USA. The main driver in Europe is to find an efficient solution for retrofit for heating in countries with well-developed gas grid. In the USA, the legislation on the minimum efficiency of sanitary water heaters created a need for more efficient gas-fired appliances. Figure 3 gives an overview of some of the reported appliances / concepts under development.



Manufacturer	Sorption Energy	Cooll	ClimateWell	ThermoLift	SMTI
Model	-	-	HeatBoost	TCHP	-
Nom. Capacity [kW]	7.00	?	?	?	40.00
Technology	adsorption	adsorption	absorption	Vuilleumier	absorption
Working pair/fluid	ammonia/active carbon	ammonia/active carbon	water/salt	helium (?)	ammonia/water
Heat source	air	air	-	-	air
Aux. heat source	-	-	-	-	-
Status	laboratory tests	laboratory tests	halted	laboratory tests	field testing

Figure 3. A non-exhaustive selection of reported GHP appliances / concepts under development

3. Standardised test methods and quality assurance

The Ecodesign Regulation and the corresponding Implementing Regulations for different groups of energy-related products have highlighted the need for unbiased and transparent testing and performance evaluation methods for all technologies. In the Communication of the European Commission 2014/C 207/02 [3], a list of harmonised standards for testing and performance evaluation of different heating appliances is provided. For gas fired sorption heat pumps EN 12309 [4] is referred to as the reference document for space heating application. The current version of EN 12309, Parts 1 and 3 to 7 have been published in December 2014. Part 2 "Safety" was published a year later in April 2016. The standard has been developed to be compatible with the corresponding methodologies used for electrically driven heat pumps in EN 14511 [5] and EN 14825 [6] and, thus, uses the same basic methodology for the testing and calculation of the seasonal performance figures. A basic description of the methodology can be found e.g. in [7]. For non-sorption units, no standards are currently available on the European level.

Table 1. Main features and differences between EN 12309-7 and VDI 4650-2

EN 12309	VDI 4650-2
Part load conditions related to the declared heating/cooling load	Part load conditions related to the declared HP capacity
Electrical and thermal energies are consequently separated, PER is used for an overall energy consumption	Electrical and thermal energies are put together in some figures; electrical efficiency not provided as a separate figure
Data for three different climates available, adaption to other climates possible	Part load data based on only one climate, adaption to other climates rather difficult
Performance evaluation for bivalent (hybrid) units possible (gas boiler and solar thermal)	Calculation of bivalent operation possible (only solar)
Heating and cooling considered, DHW is missing	Cooling not considered
Electrical power input during idle time considered for the calculation of seasonal performance	Electrical power input in standby mode not considered in performance figures

Due to a lack of suitable EN standards at the time, a VDI guideline for calculation of the seasonal efficiency of gas driven heat pumps was developed – the VDI 4650-2 [8] for the purpose of granting subsidies for the appliances in Germany. Similarly to the corresponding EN standards, the calculation method is strongly based on the VDI 4650-1 [9] which applies to electrically driven units. It inherited the operating conditions, including the part load rations, but was extended with new features to suit the needs of the products. These extensions include solar thermal collectors as heat source, direct solar DHW production, a performance figure to take into account dual driving energy and so forth. An overview of the main features of both standards is given in Table 1. Despite the availability of the EN 12309 and its current harmonisation with the EU Ecodesign and Energy label Directives, the VDI 4650-2 is still used for product assessment within the German federal subsidy program for heating with renewable energies.

In 2018, a new standard (EN 13203-6 [10]) for the energy consumption evaluation of sorption gas heat pumps for sanitary hot water production was introduced as part of a series of similar standards for a variety of gas driven appliances, including hybrid heat pumps (combination of a gas boiler and an electrically driven heat pump).

Both the EN 12309 and the EN 13203-6 have been scrutinised in round robin tests organised within the IEA HPT Annex 43 [11] and the EcoTest [12] projects. The findings have been reported to the relevant Technical Committees (TCs) and will be considered within the current revision processes which aim to harmonise these standards with the Ecodesign and Energy Labelling Directives.

The main European independent and voluntary certification mark, the Heat Pump Keymark, has added gas driven heat pumps to its scope in 2019.

4. Round Robin Test on a hybrid adsorption heat pump (IEA HPT Annex 43)

The project IEA HPP Annex 43, among other objectives, aimed at investigating the applicability, unambiguousness and comprehensiveness of the relevant existing standards used for assessing fuel sorption heat pumps. For the purpose, a round robin test on a gas-driven hybrid heat pump was carried out according to the standard EN 12309:2014.

The choice to test this kind of appliance was dictated mainly by its operational complexity. In hybrid heat pumps, the combination of two technologies in one appliance, such as a condensing boiler for the peak load and a sorption module for the base load, generates a discontinuous operation of the appliance.

In this specific case, the tested machine was a geothermal hybrid heat pump consisting of a condensing boiler and a zeolite (adsorption) heat pump module. The presence of the adsorption module caused a cyclical machine's operation.

The tests were carried out at two different temperature applications: low temperature application (28 °C - 35 °C) and medium temperature application (35°C – 45 °C), both for "average" climate conditions. The method used was the "inlet temperature method" while, for results' reproducibility reasons, water was employed as heat transfer medium at the outdoor heat exchanger.

Analysing an operation cycle (see Figure 4), it's possible to distinguish four different phases: adsorption phase, during which only the sorption module is working; adsorption plus boiler phase, where both the condensing boiler and the sorption module are working; boiler phase, where only the condensing boiler is working and, finally, desorption phase, where only the sorption module is working and no heating energy is delivered.

These four phases and their alternation affect the applicability of several requirements of the analysed test procedure such as the limits on the permissible deviations of the quantities of interest. For example, the evaporator (i.e. the "outdoor" heat exchanger) and the internal circulation liquid pump, responsible for the circulation of the heat transfer medium between the machine and the geothermal probes, work only when the sorption module is adsorbing. This means that the monitored quantities at this component such as the inlet and outlet temperatures, flow rate and the differential external static pressure will have an unsteady behaviour (see Figure 5). It's easy to understand that it's not possible to respect the limits on permissible deviations prescribed in Table 4 of the standard EN 12309:2014, Part4.

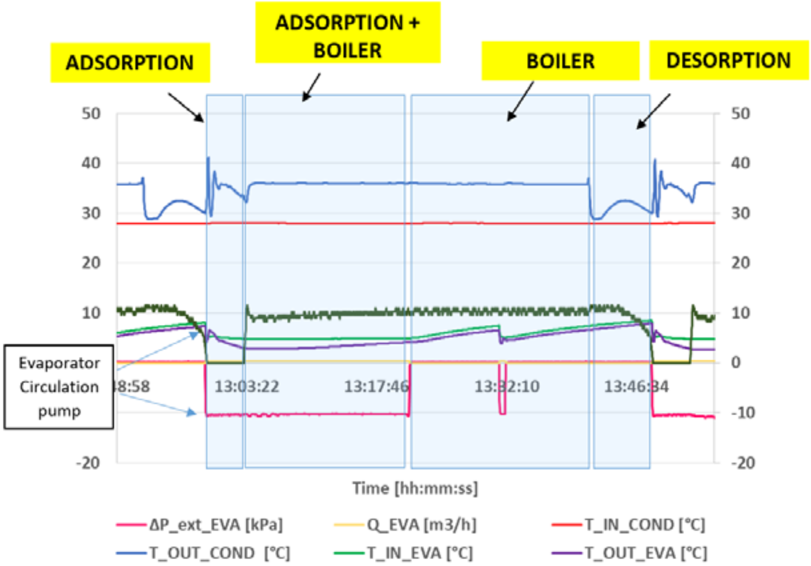


Figure 4. Operation cycle of the hybrid heat pump under test (ΔP_ext_EVA – external pressure difference over the evaporator; T_OUT_COND – outlet water temperature from the condenser; Q_EVA – water volume flow rate through the evaporator; T_IN_EVA – inlet water temperature to the evaporator; T_IN_COND – inlet water temperature to the condenser; T_OUT_EVA – outlet water temperature from the evaporator)

The same can be said for the condenser (i.e. the "indoor" heat exchanger), where the only two parameters that can respect the limits of permissible deviations are the inlet temperature (red line in Figure 5) and the flow rate since, after a certain time, their behaviour depend only on the control of the test rig. The only parameter that, in this case, is influenced by the hybrid heat pump's operation and, therefore, has an unsteady behaviour, is the outlet temperature (see Figure 5, dark blue line). Nevertheless, no requirements are foreseen on this parameter even if it is crucial for the distribution system. With this regard, it could be useful to have a requirement (a permissible deviation) on that.

Concerning the permissible deviations of the inlet temperatures, they vary (the amplitude) based on machine's load: i.e. as the load decreases, the deviation increases. This is not necessary since the fluctuation of the inlet temperatures depend only on the test rig control and not on the machine.

Another remark concerns the duration of the test (equilibrium phase plus data collection phase): From the executed tests, it emerged that some "special" cycles occur (see Figure 5, light red rectangles). This means that the choice of the test duration shall be done in order to consider all operational peculiarities of the hybrid heat pump under test. According to the prescription given in the paragraph 4.5.2.1 of EN 12309-4:2014, the equilibrium period and the data collection period shall be at least 40 minutes and 30 minutes, respectively.

It's clear that, for this kind of machines, the definition of these periods in terms of minutes is not representative but it shall be done in terms of complete operational cycles instead. From the tests carried out, it was concluded that minimum appropriate number of operational cycles that can also allowed to collect a significant number of samples could be eight. This number is also high enough to include all possible strange or peculiar cycles.

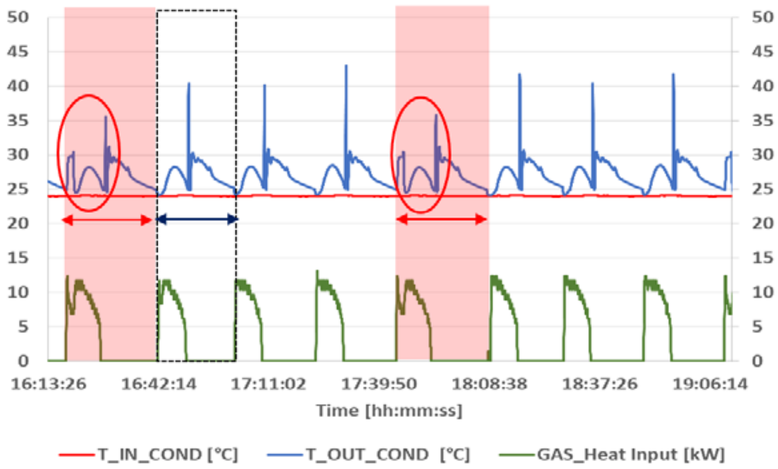


Figure 5. Operational cycles: definition of test duration (T_IN_COND – inlet water temperature to the condenser; T_OUT_COND – outlet water temperature from the condenser; GAS_Heat Input – energy input from the gas calculated with the lower heating value)

A final remark concerning the reduced capacity tests: according to the standard, when the minimum heating capacity provided by the machine is higher than the required part load ("target"), on-off tests shall be performed, i.e. tests where periods when the machine is "on" and works at the minimum allowed capacity alternate with periods when the machine is "off". The duration of these periods are calculated using a given formula. From the round robin test it emerged that these tests are not only being far away from the real operation conditions, but they are also quite time consuming.

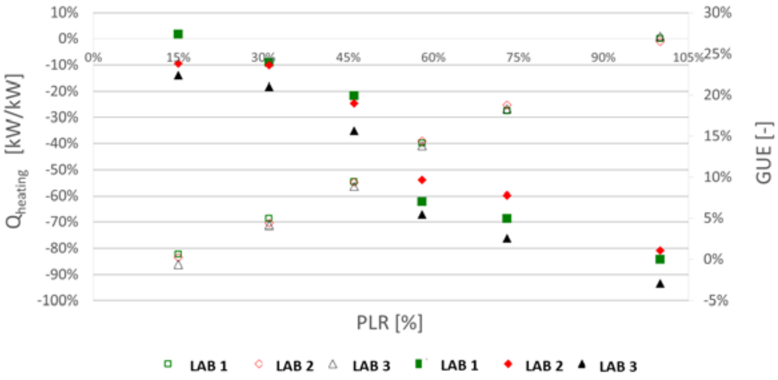


Figure 6. Dimensionless test results: measured heating capacities (left axis, filled marks) and GUE for each laboratory (right axis, hollow marks)

The round robin test involved three laboratories, two of them being also in the consortium of the EcoTest Project for performing round robin tests on fuel absorption heat pumps, as described in the next chapter.

Figure 6 shows the (dimensionless) results obtained during the round robin test. As it is possible to observe, even if there is the necessity to revise some parts of the test procedure, the achieved results showed a high grade of consistency among them especially in terms of Gas Utilisation Efficiency (GUE).

While concerning the heating capacity, due to a wrong flow rate at source side used by the laboratory 3, the difference between the highest and the lowest value on the average vary from 3 % to 7 %.

5. Round Robin Test on a water-to-water absorption heat pump (EcoTest)

Within the EcoTest project, a water-to-water absorption heat pump was tested according to EN 12309 and EN 13203-6. The aim of the project was to assess the inter-laboratory reproducibility, intra-laboratory repeatability and variability required to be used for the application of the regulations by evaluating the standards implementing those regulations. The work also aimed at commenting on the applicability and understandability of the relevant standards and their applicability in the light of market surveillance, minimise the room for different interpretations and to suggest improvements to the CEN/TCs.

5.1. Space heating efficiency according to EN 12309

The measurements according to EN 12309 were conducted by four participating laboratories. The appliance was tested for high temperature application (supply temperature of 55 °C), constant water volume flow rates at both the heat source and the heat sink. The appliance was a continuously operated water-to-water absorption unit with a nominal capacity of 40 kW.

The laboratories showed an overall high level of common understanding regarding the testing and test data evaluation methodology. Only a small number of questions in this regard were raised during the test cycle.

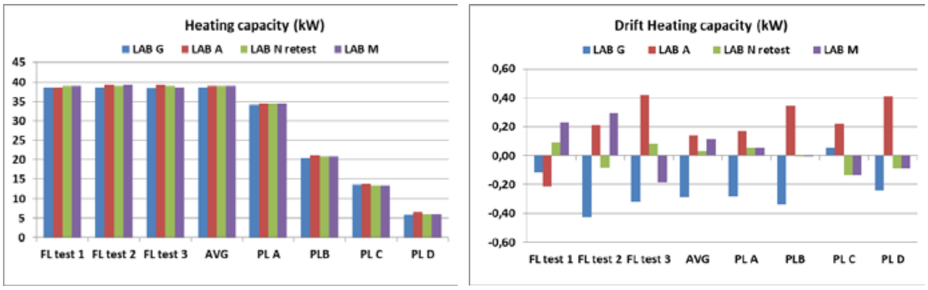


Figure 7. Measured heating capacities (left) and absolute deviation from the average value for each laboratory (right)

As shown in Figure 7, the measured heating capacities by each of the laboratory were very close to each other with a highest absolute deviation from the arithmetic mean value of 400 W or about 1 % of the nominal heating load for full load test (FL) or around 7 % for part load (PL) D (6 kW).

The test at full load was performed three times at each lab to assess the intra-laboratory repeatability of the measurement. The arithmetic average values from all three tests are shown in column “AVG”. It can be seen from Figure 7 that the intra-laboratory repeatability of the measurements did not differ in its magnitude from the inter-laboratory reproducibility, which is a positive indication for the robustness of the methodology as well as for the high level of the measurement quality by the participating laboratories.

In Figure 8, the calculated seasonal space heating efficiency η_s (left) and the deviations of the results for each laboratory from the arithmetic mean value of the round robin test (right) are shown. The difference between the highest and the lowest reported value is 3,5 %, as can be seen also in Table 2. The maximum deviation from any single reported value from the overall average is less than 2 %. Taking into account the complexity of the method and the characteristics of the appliance under test, these results can be considered to be very good and show that the provisions of the methodology described in EN 12309 are in line with the requirements of the Ecodesign and Eco Labelling Regulations in this respect. However, as only four laboratories took part in the testing, a final conclusion based on a full statistical evaluation cannot be drawn.

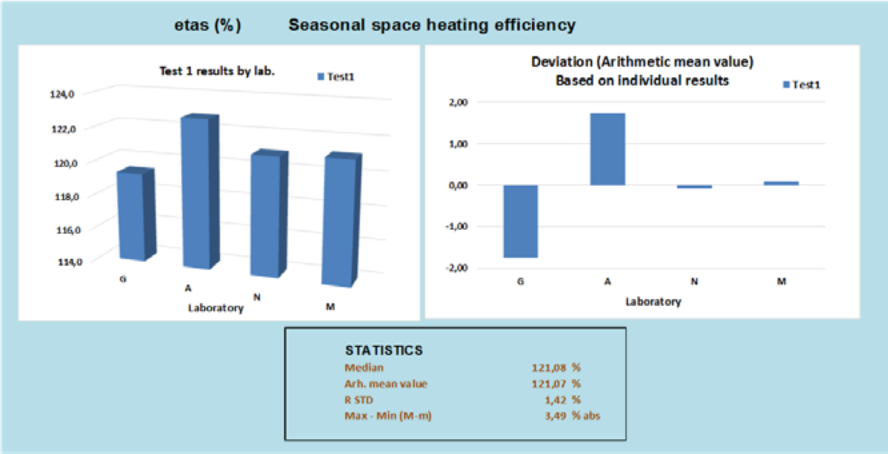


Figure 8. Calculated η_s (left) and absolute deviation from the average value for each laboratory(right)

Other reported significant efficiency parameters such as Seasonal Auxiliary Energy Factor (SAEF) and Seasonal Gas Utilisation Efficiency (SGUE) also showed very good agreement among the laboratories. In Table 2, the median, arithmetic mean, standard deviation, difference between the maximum and the minimum reported values (max-min) and its relative difference ((max-min/avg) are shown for SAEF, SGUE and seasonal space heating efficiency η_s.

Table 2. Statistical values obtained for the seasonal performance parameters for space heating

Parameter	Median	Arithmetic average	Standard deviation (σ_R)	max-min	(max-min) / avg [%]
SAEF	20,73	20,62	0,83	1,87	**9,0**
SGUE	1,48	1,48	0,02	0,04	**2,7**
η_s	121,08	121,07	1,42	3,49	**2,9**

5.2. Energy consumption for the domestic hot water production according to EN 13203-6

At the time of the testing, the EN 13203-6 was still not officially published. While scrutinising the final draft, some inconsistencies of the method compared to the methodology described in the EU Regulations and in a methodologically similar standard for electrically driven heat pumps (EN 16147:2017) were detected. Therefore, it was decided to adapt the methodology and to perform two tapping cycles for comparison: one according to EN 13203-6 and one according to EN 16147. The resulting overall test protocol is shown in Figure 9.

After the common heating-up and standby measurements, the EN 16147 tapping cycle was initiated right after the end of the standby period with the first draw-off at 07:00. After the 24 hours' cycle and after the heat pump was switched off by the controls when the set hot water tank temperature was reached, the two tapping cycles of EN 13203-6 starting with the first draw off at 21:30 were performed.

The system used consisted of the appliance described in Chapter 5.1 with an additional 1000 l tank. As the unit is not declared by the manufacturer for the DHW production, hydraulic connections and controls had to be adapted to enable the laboratories to perform the tests. Thus, the results were used only to discuss the applicability of the standard itself and not to conclude on the reproducibility or repeatability of the methodology. Already while preparing the measurement and discussing the methodology, a number of remarks on EN 13203-6 was made. Obvious mistakes and inconsistencies were fixed for the test protocol and were reported to the relevant CEN Technical Committee.

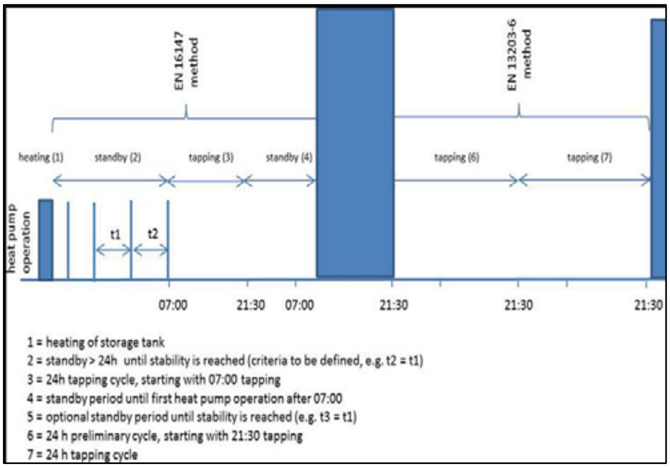


Figure 9. Test protocol for the evaluation of EN 13203-6

Table 3 shows the results for gas (Q_{gas}) and electricity (Q_{elec}) consumptions, as well as for the seasonal water heating efficiency (η_{wh}). Compared to the results for space heating, the variability of the reported results is much higher for all parameters. This lies partly in the lack of the experience with the newly developed standard, partly in the methodology description itself, but partly also in the tested system itself, since it was only adapted to the water heating function. Therefore, as stated before, the results below cannot be taken for any final conclusion regarding the measurement quality or the methodology itself.

Table 3. Statistical values obtained for the seasonal performance parameters for domestic hot water

Parameter	Arithmetic average	Standard deviation (σ_R)	max-min	(max-min) / avg [%]
Q_{gas}	24,80	2,71	5,42	**21,85**
Q_{elec}	1,32	0,12	0,12	**9,09**
η_{wh}	68,70	8,11	15,87	**23,10**

6. Conclusions

Even though there are only a few products on the market for residential heating and sanitary hot water application, a considerable amount of R&D activity is reported from many countries. The current EU legislative, including the Ecodesign and the Energy Labelling Regulations include the technology, which is a very important market drive. Further, gas heat pumps are explicitly eligible to obtain the Heat Pump Keymark, the main voluntary quality scheme in Europe – also a very important signal for the end consumers, as well as governmental subsidies, which are available for gas heat pumps in most of the principal European markets. There are testing and performance standards available – both on the CEN and national levels. The CEN standards are currently in the process of harmonisation with the Energy Labelling directive. Within two recent projects, the CEN standards EN 12309 and EN 13203 were evaluated in round robin tests. The results showed that the methodology is yielding very good results regarding applicability, repeatability and reproducibility. For the continuously operated absorption heat pump the reported seasonal efficiency values lie within 3,5 percent points for the heating application. For the water heating application, the reported values were not homogenous, mainly due to the novelty and some shortcomings of the described methodology in the standard, as well as due to the system used for the test. Further, a more in-depth analysis by the expert community pointed out some weak points of both standards and proposed improvements which will be considered by the relevant technical committees.

It has to be pointed out that the results shown above were obtained on only two products (one of which has been removed from the market) and by a rather small number of participating laboratories. As the market develops and more products enter the market, similar trials will have to be performed in order to ensure that the testing and evaluation methodology is transparent and fair for all stakeholders.

With current primary energy efficiencies, gas heat pumps can deliver heat with 30 % higher efficiency than condensing gas boilers. If applied on a large scale as a replacement product for the gas boiler, they can considerably reduce the CO_2 emissions in short time period without the need of further investments in supply grids or building envelopes.

A large scale monitoring campaign to investigate the full potential of the technology and supply reliable information for the policy and customers would be needed. It would also send a message to hesitant manufacturers, that the investment in the technology can pay off in the future.

Acknowledgements

The project EcoTest was financed by the EU, agreement number A/CEN/GROW/EFTA/534/535/2015-14

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