Methodology for the Assessment of the Hot Water Comfort of Factory Made Systems and Custom Built Systems

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Description

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1 Introduction

The knowledge of the level of comfort for hot water is an important piece of information for planners and customers related to aspects of the reliability of hot water supply. It is also used for the assessment and comparison of solar thermal systems. Since the term “hot water comfort” is already used, but not defined, in EN 12977, it is the goal of the Subtasks 3.1.4 and 3.2.3 of the QAiST project to define an appropriate clarification on terms and methods for the assessment of the hot water comfort.

The testing method must fulfil the following requirements:

- cost effective tests
- compatible to already existing and established methods
- applicable to stores where the domestic hot water is prepared in a direct as well as in an indirect way

Furthermore the test methods are providing information about the hot water comfort in a way, enabling planers and customers to compare the solar thermal product with products using other technologies for heating of domestic hot water.

2 Overview of existing methods considering the determination of hot water comfort

In principle the following methods are available for the determination and assessment of hot water comfort aspects for stores / systems for domestic hot water preparation.

- General guideline VDI 6003 (see chapter 3)
- Method acc. to EN 13203-1 (see Annex A.1)
- EU energy labelling according to the EU ecodesign directive (see chapter 4 and Annex A.2)
- DFS hot water performance test (German method) (see Annex A.3)
- Method acc. to EN 15332 (TC 57 / WG 8) (see Annex A.4)
- Method acc. to EN 12897 (see Annex A.5)
- NL-Number according to DIN 4708-3 (see Annex A.6)
- SPF hot water performance test (Swiss method) (see Annex A.7)
- SPF test procedure for external domestic hot water modules (see chapter 5)

A short description of each method can be found in the Annex A.

A technology independent guideline for comfort criteria and performance levels for planning, evaluation and implementation of water heating systems is defined in VDI 6003. For the assessment of the hot water comfort of gas-fired domestic appliances producing hot water the aspects of the VDI 6003 are implemented in the European standard EN 13203. The same approach is pursued by the Swiss institute SPF for the assessment of the hot water comfort of domestic hot water modules (chapter 5).

3 Terms and definitions

A general definition of the term "hot water comfort" is given in the VDI 6003:

"A high comfort level for hot water is given if the required volume of hot water and mass flow is available at each draw-off point, at any time and at the desired temperature."

This definition emphasises two different aspects: the first aspect is the **ability to cover the load** by means that the thermal solar system is able to provide the required volume of hot water and the required thermal power according to the needs of the user. This aspect is a minimum requirement regarding the comfort level for hot water. The second aspect is the **temperature stability** of the withdrawn water during the draw-off.

The first aspect will be covered in Chapter 4 on the basis of a method described in Section 5.9 of EN 12976-2 [1] with a combination with the EU energy labelling scheme .

The second aspect will be discussed in Chapter 5 according to the method elaborated by the Swiss institute SPF.

4 Determination of the ability to cover the load

The definition provided in chapter 3 declares the term "high comfort level for hot water" to be a pass/fail decision with regard to the required needs. If the system is able to provide the required load at any time, it fulfils the terms of the given definition. In order to verify the ability to cover the load, the test must be performed under the most disadvantageous conditions. For thermal solar systems this means under conditions without solar irradiation.

As the "high comfort level for hot water" depends on the needs of the system user, it is required to define a set of "standard profiles" representing the needs of typical areas of application. The implementation of the EU energy labelling scheme according to the EU ecodesign directive [2] defines such standard profiles by daily load patterns for water heaters.

The profiles are divided into classes (XXS-4XL) depending on the energy content of water withdrawn during the whole day (Q_{ref} [kWh]). Each tapping cycle is defined as a set of the following parameters: heat demand per tapping (Q_{tap} [kWh]), minimum volume flow rate (f [l/min]), minimum temperature (T_m [°C]) and peak temperature (T_p [°C]). For solar water heaters the profiles M to 4XL shall be used. These are listed in the Tab. 2 and Tab. 3 of Annex B.

The standard profiles are used within the EU energy labelling scheme as basis for energy efficiency figures. The profile and its typical usage are displayed on each product energy label (see Tab. 4 in Annex B). In this context it is only natural to use the same standard profiles to verify the ability to cover the load, hence to verify that the system is capable to provide the declared level of comfort for hot water not only under standard conditions, but also under conditions without solar irradiation.

A certain level of comfort for hot water in the meaning of the ability to cover the load of the specified profile at any time can be realized using a large hot water volume or a high switch-off temperature. Both parameters have great influence on the thermal behaviour of a thermal solar system (heat losses of the store and solar energy gain). Therefore, the yearly system simulation to determine the energy efficiency figures has to be performed with the same parameters (same position of the auxiliary heat exchanger and the switch-off temperature sensor as well as the same switch-off temperature) as used to determine the ability to cover the load.

4.1 Ability to cover the load of factory made systems

The ability to cover the load of factory made systems should be determined as stated in EN 12976-2 section 5.9 except for the definition of the daily load profile in subsection 5.9.3.

The daily load profile should be chosen from the profiles M to 4XL according to the EU energy labelling scheme (see Tab. 2 and Tab. 3 of Annex B) by the manufacturer or determined iteratively: The maximum level of comfort for hot water is characterised by the highest load pattern, which can be covered under operating conditions without solar irradiation.

Additionally the start of the daily cycle (end of the conditioning: $t=t_0$) should correspond to the time of the end of the last tapping of the chosen profile. In this case the first heat up period will be during the “night time” and allow to heat up the store without tapping. For example when using the profile M the last tapping is scheduled for 21:30 with an estimated duration of 6 min. For this profile the start time t_0 will correspond to 21:36 and the next tapping should be performed at t=9,4 h later (at 7:00 profile time).

The test is considered valid if the temperature during all draw-offs of one tapping cycle satisfies the requirements of the chosen profile.

4.2 Ability to cover the load of custom built systems

The determination of the ability to cover the load by custom built systems under operation conditions without solar irradiation is not specified in EN 12977 standard series. The methodology described in EN 12976-2 section 5.9 is nevertheless directly applicable to system simulation performed according to FprEN 12977-2 [3]. The standard EN 12976-2 provides in subsection 5.9.5 a methodology for "Determination of the ability to cover the maximum daily load by means of numerical simulations". For custom built systems the same numerical model must be used as for the yearly system simulation.

Alternatively physical testing of the combination of the store and the components for hot water preparation is possible according to EN 12976-2 subsection 5.9.4. If a mixing valve or a hot water module is foreseen for the system, it should be installed according to manufacturer's instructions. The same equipment may be used as auxiliary heater that have been used for the test sequences NiA (Sequence for determination of the heat transfer capacity rate and the position of the auxiliary heat exchanger(s)) and/or NiE (Sequence for determination of the position(s) and length(s) of the electrical heating source(s)) according to sections 6.3.2.5 and 6.3.2.6 of EN 12977-3 [4].

The used tapping profile should be adopted in the same way as for factory made systems described in chapter 4.1.

4.3 Solar only and solar preheat systems

Solar only and solar preheat systems without integrated backup heaters are per definition not able to provide a high level of comfort for hot water under conditions without solar irradiation. Therefore an additional sequentially installed heater is necessary if a high level of comfort for hot water is needed. The backup heater is the only part of the system that is relevant for the level of comfort for hot water but is not scope of EN 12976 or EN 12977 series and thus not scope of this procedure.

5 Temperature stability during a draw-off

Besides the amount of delivered hot water the comfort level is influenced as well by the time dependent behaviour of the hot water preparation system. The following phenomena might occur during a tapping and influence the quality of the prepared hot water in negative way:

- Temperature oscillations
- Time until constant tapping temperature at tapping start
- Variations of tapping temperature depending on mass flow rate

The degree of the occurrence of these effects depends on the configuration of the thermal solar system. While the impact of these phenomena can be neglected in system configurations where the hot water is tapped directly from the store, the influence is more distinct when the hot water preparation is carried out in an indirect way.

But since the all systems must provide a kind of equipment for scald protection according to the requirements in section 4.1.4.2 of EN 12976-1 [5] and 6.2.4.1 of FprEN 12977-1 [6], this equipment has more impact on the temperature stability than the system itself. The most common way to satisfy the requirements for scald protection is the use of a mixing valve. But since the mixing device is not always part of the system but a requirement stated by the manufacturer in the installer's manual, the same system may be installed with different mixing devices. This will lead to different behaviour regarding the temperature stability during the draw-off. Since mixing devices are not covered by the EN 12976 or EN 12977 standard series, no recommendation for the analysis of the temperature stability will be made in this document.

The number of thermal solar systems packaged with domestic hot water modules (DHWM) available on the market has increased in the last years and there are no standards covering this application. Since the DHWM technology prepares the hot water in an indirect way, great impact on the temperature stability has been noticed for these systems. These aspects have been investigated by the Swizz institute SPF. As shown in [7] for thermal solar systems with DHWM the effects can occur noticeably. In a further (German) publication by the SPF [8] attenuation of temperature oscillations in water pipes was investigated and showed that temperature oscillation induced by the DHWM are dampened but still present after a typical pipe length. The magnitude of temperature oscillations while using a mixing device at the draw-off point have not been investigated yet.

The approach presented in [7] is very promising and should be followed up if a test procedure investigating the temperature stability during the draw-off is desirable. Nevertheless this procedure needs further work to define characteristic values and pass/fail criteria to provide information suitable as end user information. This work should be done in context of harmonisation with standards for different dedicated water heaters (e.g. EN 13203)

6 Conclusions and Recommendations

This document provides a definition for the term “high level of comfort for hot water”. Furthermore a suggestion for a test procedure covering a basic investigation of the question if a high level of comfort for hot water is provided by the thermal solar system has been made. It was formulated as a pass/fail criterion. This procedure is in line with the current procedure used in EN 12976-2. Since its boundary conditions are the same as used within the EU energy labelling scheme a harmonisation with other dedicated water heaters is easy to achieve.

In order to harmonise both standard series EN 12976 and EN 12977 the proposed procedure for determination of the ability to cover the load should be introduced into the EN 12977 series.

A more detailed method for the investigation of the level of comfort for hot water has been shown for thermal solar systems incorporating domestic hot water modules. But since this method is only relevant to a small amount of market available thermal solar systems, efforts for introducing the methodology into the standard have not been made yet.

7 Bibliography

[1] EN 12976-2:2006 Thermal solar systems and components – Factory made systems – Part 2: Test methods

[2] EU Eco-design Directive - Annex IV Working Document Water Heaters | Draft v2 | 15.9.2008

[3] FprEN 12977-2:2011 Thermal solar systems and components - Custom built systems - Part 2: Test methods for solar water heaters and combisystems

[4] EN 12977-3:2008 Thermal solar systems and components – Custom built systems – Part 3: Performance test methods for solar water heater stores

[5] EN 12976-1:2006 Thermal solar systems and components – Factory made systems – Part 1: General requirements

[6] FprEN 12977-1:2011 Thermal solar systems and components - Custom built systems - Part 1: General requirements for solar water heaters and combisystems

[7] F. Ruesch, E. Frank: Development of a test procedure for external domestic hot water modules. Eurosun Conference 28.09-01.10.2010, Graz, Austria

[8] F. Ruesch, E. Frank: Einfluss von Rohrleitungen auf die Veränderung propagierender Temperaturprofile" in 21. OTTI Symposium Thermische Solarenergie, 11. - 13. Mai 2011

[9] Working Document on a Draft COMMISSION DELEGATED REGULATION (EU) No […]/[...] of [...] supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of water heaters, hot water storage tanks and packages of water heater and solar-only system. Given date: February 2nd 2012

Annex A: Description of the Existing Methods

A.1: Method acc. to EN 13203-1:2006

The standard EN13203-1 targets gas fired hot water preparation units with a maximum volume of 300 l and a maximum power of 70 kW. It introduces a method for the assessment of the energy consumption of the hot water preparation unit as well as a method for the assessment of hot water comfort. This standard is only applicable to thermo siphon systems, if the thermo siphon system is used as cold water preheating system. There is no information about application of this method to stores with greater volume (e.g. combi stores).

Hot water comfort is assessed by a „Comfort factor F“. This factor is determined on the basis of tests that gain information about the aspects listed below. The reference hot water flow rate for all the tests corresponds to the nominal flow rate of 7 l/min or lower if specified by the manufacturer.

- Waiting time:

  The time needed from opening the tap, to reach 90 % of 45 K temperature increase between draw-off temperature and cold water temperature is measured.

- Temperature variation according to water rate:

  The water rate of the appliance is adjusted to 70 % of the reference hot water flow rate. After a delay of between 0 and 2 min (chosen by the manufacturer) the mean temperature T_{1m} obtained, during the following two min is recorded. The hot water flow rate is then increased to a delivery rate equal to 95 % of the reference hot water flow rate. After a stabilisation period of one minute the temperature T_2 is recorded during the following two minutes and the mean temperature T_{2m} after this period is calculated. The difference (T_{2m}-T_{1m}) of the mean temperatures is the desired indicator.

- Temperature fluctuation at constant hot water flow rate:

  1st test:

  The appliance is adjusted to deliver hot water corresponding to 95 % of the reference hot water flow rate. After a delay of between 0 and 2 min the hot water temperature is recorded over the time necessary to obtain the energy corresponding to a shower (1.82 kWh)

  2nd test:

The appliance is adjusted to deliver hot water at a rate of 5 l/min. After a delay of between 0 and 2 min. the hot water temperature is recorded over the time necessary to obtain the energy corresponding to a shower (1.82 kWh).

The maximum temperature fluctuation observed between the two tests is recorded.

- Temperature stabilisation time on variation of the water rate:

1st stage: the test begins at a hot water rate corresponding to 95 % of the reference hot water flow rate, it is checked during the third and fourth min for a four min delivery that the temperature fluctuation is not greater than 5 K.

2nd stage: the hot water rate is reduced to 70 % of the reference hot water flow rate; the time required to obtain a temperature fluctuation equal to or less than 5 K is measured.

3rd stage: the value of the hot water rate of the 1st stage is established and the time required to obtain a temperature fluctuation equal to or less than 5 K is measured.

The stabilisation time is the greater of the two lengths of time measured, on the one hand, with the rate lowering and, on the other, with the rate increasing.

- Minimum declared water rate:

The test begins at a minimum rate (chosen by the manufacturer). After a time period between 0 and 2 min (chosen by the manufacturer) it is checked that during the following 7 min the hot water temperature does not vary from the manufacturer’s specified temperature by more than 5 K.

- Temperature fluctuation between successive deliveries:

With the appliance adjusted at the reference hot water flow rate, in steady state condition, the hot water delivery tap is closed quickly. After a time of 10 s the tap is opened quickly and the maximum temperature at the centre of the flow is measured. The appliance is put back in its steady state condition. The same measurement is carried out at intervals, increased each time by 10 s, until the increase in the flow temperature variation is less than 1 K.

A.2: Method acc. to EU Ecodesign Directive

This method introduces classes of energy demand the tested systems must cover. Each class is characterised by a load profile (XXS, XS, S, M, L, XL, XXL, 3XL, 4XL), which stands for the behaviour of residents of a living unit. If a tested system is able to cover the energy demand of the specified profile, it satisfies the requirements on hot water comfort for the given class.

Even this method actually targets the determination of the energy consumption of different systems for hot water preparation it can be used to determine the hot water comfort of the tested system.

Test Procedure:

This method uses the same numerical model of the tested system which is used for the LTP prediction. The characteristic performance parameters describing collector and store efficiency contained in the numerical model are determined according to EN 12976 or CEN/TS 12977. With this model the performance of the system for three climatic variations one generic day is calculated for each specified load profile.

Each tapping of the load profile is defined by the amount of energy withdrawn at the given time of the day, a prescribed flow rate, a minimal hot water temperature and a minimal hot water peak temperature. With these factors it is possible to describe the behaviour of the user of the tested system. Situations like taking a shower, filling the kitchen sink or just using a bit of hot water (e.g. for washing hands) correspond to each specific tapping.

Evaluation:

The product satisfies the level of hot water comfort (=load profile), if it is able to cover the energy demand of this profile. The result is a label for the hot water comfort class (e.g. M class hot water comfort) corresponding to the highest load profile covered.

Since this method is not applicable to the store only but to the combination of store and auxiliary heat source, a standard auxiliary heating power and switch off temperature must be defined for systems, which are not bundled with a specific auxiliary heat source.

The energy consumption needed to cover the specified profile is an additional criterion to determine how cost expensive the gain of the specified level of hot water comfort with the tested product will be.

A.3: DFS hot water performance test

Detailed description in the IEA SHC - Task 26 report titled „Hot water performance of solar combistores, description of a test method and the experience gained with the application of the method on three different types of combistores.

Test procedure:

- Conditioning of the whole store to 30 °C
- Charging of the auxiliary volume for domestic hot water preparation with the parameters specified by the manufacturer
- Charging is stopped, when the switch-off temperature is reached at the appropriate temperature sensor
- Directly after the charring hot water tapping is started (without mixing valve and without further auxiliary heating)

5 min with 300 l/h → 3 min with 900 l/h → 600 l/h

Evaluation:

1. Determination of the heat Q_{HW}, which can be tapped from the store until the temperature difference between hot water outlet and cold water inlet is continuously below 30 K
2. Calculation of the „usable hot water volume“, which is the water volume that can be heated with Q_{HW} from 10 °C to 45 °C

A.4: Method acc. to EN 15332:2008 (TC 57 / WG 8)

The purpose of this method is to group the systems into performance classes. The key figures used for the basis of the labelling are the store heat losses and the usable heat capacity.

Determination of the usable heat capacity

There are 3 methods for the determination of the usable heat capacity:

1. estimation based on the total store volume
2. estimation based on the total store volume and the performance of the heat exchanger
3. measurement of the usable heat capacity

Test procedure:

- charging the store to the temperature of 65 °C
- first pre-tapping until the store temperature sinks to 60 °C
- charging the store to 65 °C
- second pre-tapping until the store temperature sinks to 60 °C
- charging the store to 65 °C
- tapping until the store temperature sinks below 45 °C. The tap water mass flow rate has to be set in a manner, that the tapping will be completed within 10 min. To find the value of the mass flow rate multiple iteration of the test procedure may be necessary.

Evaluation:

The usable heat capacity is calculated as follows:

$$C_u = \sum_{\tau_{m0}}^{\tau_{m1}} V_w \times \Delta\tau_m \times \frac{(\vartheta_w - \vartheta_c)}{(\vartheta_u - 10\ °C)}$$

with $\tau_{m0..1}$ as measurement points, $\Delta\tau_m$=10 min and ϑ_u = 45 °C

A.5: Method acc. to EN 12897:2006

Test procedure:

1. Conditioning of the store to 15 °C
2. Charging of the store to a temperature of 60 °C at sensor T2 (located 25 mm below hot water outlet) with a volume flow rate 900 l/h and an inlet temperature of 80 ± 2 °C → Recording of the charging time t
3. After 1 min.: Tapping with V_dot (see Table A1) until the temperature T2 decreases 40 °C

Evaluation:

- Determination of the hot water volume V [l], that can be tapped with a temperature ≥ 40 °C
- Determination of the power P [kW] that can be transferred via the heat exchanger:

$$P = ((T_{av} - 15\ °C) \cdot V) / (14.3 \cdot t)$$

With: T_{av} [°C] = average tap temperature

V [l] = hot water volume at T ≥ 40 °C

t [min] = charging time

Volume (l)	Volume Flow Rate V_dot (l/h)
up to 100	540
101–250	900
251–500	1800
501–750	2700
751–1 000	3600

Tab. 1: Function of volume flow rate dependent on total store volume

A.6: NL-number according to DIN 4708-3

- Determination of the number of „standard flats“ that can be supplied with hot water by the system under investigation
- Every NL-number is corresponding to a certain tapping profile
- Based on an iterative procedure, the tapping profile (or NL-number respectively) has to be determined which is even able to cover the hot water demand related to the maximum tapping profile or maximum NL-number respectively (the maximum deviation in the reduction of the hot water temperature is 2 K for 1 min) → NL-number
- auxiliary heating is enabled during the whole test
- hot water temperature = cold water temperature + 35 K
- cold water temperature: max. 18 °C

A.7: SPF hot water performance test

Test procedure:

1. Conditioning of the whole store to 30 °C
2. Charging of the auxiliary volume (4 h ± 1 h)
3. Stand-by period max. 1 h (optional)
4. First tapping: 5 kWh with 900 l/h (approx. 8 min.)
5. After 30 min.: Tapping1 kWh with 600 l/h (approx. 2.5 min.)
6. After 45 min.: Tapping 1 kWh with 300 l/h (ca. 5 min.)
7. After 47 min.: Auxiliary heating enabled for 1 h
8. After 95 min.: Tapping with 600 l/h until hot water outlet temperature drops below 30 °C

Details:

- Parameters for auxiliary heating are the same as used for the determination of the system performance
- Cold water temperature: 12 °C
- Mixing valve is used if necessary
- If necessary the requirements are reduced in case of a small auxiliary volume

Evaluation:

- Plot of hot water outlet temperature
- Minimum requirement: The first time, the hot water temperature is allowed to drop below 40 °C should be after tapping of 10 kWh

Annex B: Tapping profiles according to the EU energy labelling scheme

	M				L				XL			
	Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p
h	kWh	l/mn	°C	°C	kWh	l/min	°C	°C	kWh	l/min	°C	°C
07:00	0,105	3	25		0,105	3	25		0,105	3	25	
07:05	1,4	6	40		1,4	6	40					
07:15									1,82	6	40	
07:26									0,105	3	25	
07:30	0,105	3	25		0,105	3	25					
07:45					0,105	3	25		4,42	10	10	40
08:01	0,105	3	25						0,105	3	25	
08:05					3,605	10	10	40				
08:15	0,105	3	25						0,105	3	25	
08:25					0,105	3	25					
08:30	0,105	3	25		0,105	3	25		0,105	3	25	
08:45	0,105	3	25		0,105	3	25		0,105	3	25	
09:00	0,105	3	25		0,105	3	25		0,105	3	25	
09:30	0,105	3	25		0,105	3	25		0,105	3	25	
10:00									0,105	3	25	
10:30	0,105	3	10	40	0,105	3	10	40	0,105	3	10	40
11:00									0,105	3	25	
11:30	0,105	3	25		0,105	3	25		0,105	3	25	
11:45	0,105	3	25		0,105	3	25		0,105	3	25	
12:00												
12:30												
12:45	0,315	4	10	55	0,315	4	10	55	0,735	4	10	55
14:30	0,105	3	25		0,105	3	25		0,105	3	25	
15:00									0,105	3	25	
15:30	0,105	3	25		0,105	3	25		0,105	3	25	
16:00									0,105	3	25	
16:30	0,105	3	25		0,105	3	25		0,105	3	25	
17:00									0,105	3	25	
18:00	0,105	3	25		0,105	3	25		0,105	3	25	
18:15	0,105	3	40		0,105	3	40		0,105	3	40	
18:30	0,105	3	40		0,105	3	40		0,105	3	40	
19:00	0,105	3	25		0,105	3	25		0,105	3	25	
19:30												
20:00												
20:30	0,735	4	10	55	0,735	4	10	55	0,735	4	10	55
20:45												
20:46									4,42	10	10	40
21:00					3,605	10	10	40				
21:15	0,105	3	25						0,105	3	25	
21:30	1,4	6	40		0,105	3	25		4,42	10	10	40
21:30												
21:45												
Q_{ref}	5,845				11,655				19,07			

Tab. 2: Profiles M-XL of the European reference tapping cycles (source: [9])

	XXL				3XL				4XL			
	Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p	Q_{tap}	f	T_m	T_p
h	kWh	l/min	°C	°C	kWh	l/min	°C	°C	kWh	l/min	°C	°C
07:00	**0,105**	3	25		**11,2**	48	40		**22,4**	96	40	
07:05												
07:15	**1,82**	6	40									
07:26	**0,105**	3	25									
07:30												
07:45	**6,24**	16	10	40								
08:01	**0,105**	3	25		**5,04**	24	25		**10,08**	48	25	
08:05												
08:15	**0,105**	3	25									
08:25												
08:30	**0,105**	3	25									
08:45	**0,105**	3	25									
09:00	**0,105**	3	25		**1,68**	24	25		**3,36**	48	25	
09:30	**0,105**	3	25									
10:00	**0,105**	3	25									
10:30	**0,105**	3	10	40	**0,84**	24	10	40	**1,68**	48	10	40
11:00	**0,105**	3	25									
11:30	**0,105**	3	25									
11:45	**0,105**	3	25		**1,68**	24	25		**3,36**	48	25	
12:00												
12:30												
12:45	**0,735**	4	10	55	**2,52**	32	10	55	**5,04**	64	10	55
14:30	**0,105**	3	25									
15:00	**0,105**	3	25									
15:30	**0,105**	3	25		**2,52**	24	25		**5,04**	48	25	
16:00	**0,105**	3	25									
16:30	**0,105**	3	25									
17:00	**0,105**	3	25									
18:00	**0,105**	3	25									
18:15	**0,105**	3	40									
18:30	**0,105**	3	40		**3,36**	24	25		**6,72**	48	25	
19:00	**0,105**	3	25									
19:30												
20:00												
20:30	**0,735**	4	10	55	**5,88**	32	10	55	**11,76**	64	10	55
20:45												
20:46	**6,24**	16	10	40								
21:00												
21:15	**0,105**	3	25									
21:30	**6,24**	16	10	40	**12,04**	48	40		**24,08**	96	40	
21:30												
21:45												
Q_{ref}	**24,53**				**46,76**				**93,52**			

Tab. 3: Profiles XXL-4XL of the European reference tapping cycles (source: [9])

Declared load profile	Pictogram	Typical usage
3XS	35°C	Single basin at 35 °C
XXS	40°C	Single basin at 40 °C
XS		Electric shower
S	35°C	Shower and single basin at 35 °C
M	2x 55°C	Showers and sink at 55 °C
L	55°C	Bath, shower and sink at 55 °C
XL	3x 55°C	Multiple baths and showers
XXL	3x 55°C	Simultaneous baths and showers
3XL	8x 55°C	Small collective housing
4XL	16x 55°C	Large collective housing

Tab. 4: Presentation of the typical usage of a declared load profile as a pictogram on the product label of a dedicated water heater (source: [9])