ANNEX IV
on Eco-design implementing measures for dedicated water heaters.

Draft v2

European Commission

Brussels, 29.6.2008

NOTICE

Note that Annex IV may contain parts that are not in harmonised standards approved by the European Commission. As soon as these standards are available, the European Commission will undertake to incorporate references to these standards into revisions of the Annex V text, in as much as is legally feasible.

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inconspicuous yet possibly significant changes in this document with respect of previous version(s) or material cited are indicated in red

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ANNEX A: DEFINITIONS

A1. Product

- A *Product* in this document is a *dedicated Water Heater*.
- A *Water Heater* is a product that is connected to a given external supply of sanitary water and is equipped to generate heat and transfer this sanitary water to desired temperature levels and at desired quantities, flow rates and intervals.
- The *primary function* of a *Water Heater* is the capability to reach and maintain the desired temperature levels at desired quantities, flow rates and intervals as mentioned in the product definition. A *dedicated* Water Heater means that the product has no other primary function.
- The *Product* shall include one or more of the following heat generation processes:
  - combustion of gaseous and/or liquid fossil fuels
  - use of the Joule effect in electric resistance heating elements
  - capturing solar thermal energy
  - capturing ambient heat, including but not limited to transformation processes to bring the heat to a higher exergy level.

  A *heat generator* is the part of the *Product* that accomodates a heat generation process as mentioned above. Multiple heat generators, including cascades of the same type of *heat generators*, are explicitly within the defintion of a *Product*.
- The *minimum output performance* of a *Product* shall meet the requirements of the smallest *load profile* ('XXS') as defined in Annex C for the *primary function*.
- The *energy efficiency performance* of a *Product* is defined in
  - Paragraph E6 according to the *Direct Method* and
  - Paragraph E11 according to the *Indirect Method*
- If the *Product* contains the whole or part of the means required for *space cooling, ventilation, air purification, humidification, de-humidification or any other functionality related to indoor air quality*, this extra functionality will not be part of the compliance assessment.
- The following *Products* are explicitly not included in the scope:
  - Water heating devices that are within the scope of Directive 2001/80/EC on Large Combustion Plants (LCPD).
  - Water heating devices that produce a surplus of electricity, i.e. beyond what is needed for driving the electrical components within the system (a.k.a. *CHP*, Combined Heat and Power).
  - Water heating devices using solid fuels, including biomass and bio-oil, as an energy source.
  - Water heating devices driven by District Heating ("DH"). These are systems fuelled by waste heat from power plants, waste incineration plants, larger industrial installations, etc..
  - Product components, i.e. devices that are not capable of performing the *primary function*. This includes but is not limited to burners, heat exchangers, storage tanks as well as controls or other provisions for heat generation technologies that are not part of the product offered for CE-marking.

A2. Product features

- ***Conventional*** *Products*: All *Products* that do not (also) use renewable energy sources in the form of solar and/or –through heat pump technology- ambient heat. In the context of this document this comprises electric (Joule effect), gas- and oil-fired water heaters.
- *Products* ***with renewables***: All *Products* that (also) use renewable energy sources in the form of solar and/or –through heat pump technology- ambient heat.
- *Products* ***with combustion technology***: *Products* where whole or part of the imposed heat load is fulfilled by capturing and transferring the heat energy from combustion (exothermic reaction with oxygen) of gaseous or liquid fossil fuels to CH-water and/or sanitary hot water.
- ***Electric resistance*** *Products*: *Products* where whole or part of the imposed heat load is fulfilled by capturing and transferring the heat energy from the Joule-effect of inducing an electric current in a heating element to sanitary hot water.
- *Products* ***with solar technology***: Products where whole or part of the imposed heat load is fulfilled by capturing and transferring solar heat energy to sanitary hot water.
- *Products* ***with heat pump technology***: *Products* where whole or part of the imposed heat load is fulfilled by capturing ambient heat, transforming it to a higher exergy level and transferring this heat to sanitary hot water.
- *Product* ***cascade***: configuration of more than one heat generator, whereby the heat generators are operating consecutively or in parallel to supply heat to the sanitary hot water.
- ***Back-up*** heating: Any conventional heat generation and heat transfer technology that is used to fulfill the remaining heat demand after the application of the renewable heat (solar and/or heat pumps).
- *Water heating load profile* (***waterload***): For water heating nine load profiles (0=none, 1 to 9) are defined, denominated XXS, XS, S, M, L, XL, XXL, 3XL, 4XL. Each load profile has a predefined 24h water tapping patterns, with per tapping a
    - start-time,
    - minimum flow rate,
    - useful hot water energy to be drawn-off and –for some tappings—
    - minimum peak temperature.

  The water heating load is declared by the manufacturer for a *Water Heater* and it is used to

    - Establish the primary energy efficiency of the product and
    - Comply with the minimum performance requirements posed by the selected pattern.

  A product can be offered for CE-marking under more than one water heating load profile, but each load profile can and usually will result in a different evaluation.

  Details of the load patterns can be found in Annex C (Reference Conditions).
- ***Outdoors***: Any water heater that is designated by the manufacturer to operate only outdoors. ***Indoors*** is defined as the complementary concept of *outdoors*, i.e. *indoors* is not *outdoors*.
- ***Smart control*** water heater: Any water heater that complies with the definitions in Annex H of this document.
- ***Default****:* Any feature or parameter value of the *Product* that is used as a basic reference. It does not require verification, i.e. it does not require the feature to be implemented and/or the parameter value to be valid.

A3. Combustion parameters

- ***airintake***: method of combustion air intake of the burners. Affects waste heat recovery. Possible values:
    1. ***room sealed***: Type C appliance, according to `NPR-CEN/TR 1749; 2006

2. ***open***: Type A or B appliance, according to `NPR-CEN/TR 1749; 2006. For appliances that are classified as both type B and type C airintake shall be given as "open".
3. ***none*** (electric): no air intake. Appliance uses electric power only.

- Combustion efficiency (***ηcomb*)**, as defined in Annex C: Affects waste heat recovery of gas- or oil-fired water heaters in the model.

- Flue gas temperature (***Tflue***) as defined in Annex C: Affects waste heat recovery of gas- or oil-fired water heaters in the model.

A4. Geometry

Product volume (***volumeb***, in m^3): The envelope of the product (in m^3) represented by the smallest cuboid or the smallest cylindrical shape that can contain the product. If the product consists of more than one envelope, then the measurement applies to the largest envelope that is designated for use indoors.

The definitions in this annex apply to concepts not or only partially defined in harmonized standards. For other parameters and concepts the definitions in the harmonized standards apply.

A5. Mathematical operators and expressions

+. -, *, /	addition, subtraction, multiplication, division
[X1; X2]	array (one-dimensional, with 2 elements X1 and X2)
MIN (X;Y)	if $Y \leq X$ then Y else X
MAX (X;Y)	if $Y \geq X$ then Y else X
SUM(X;Y)	X+Y
SUM(X)	if X is an array: sum of all elements in the array. If X is a value SUM(X)=X
MIN(X;MAX(Y;Z))	$X \leq Y \leq Z$
POWER (X;Y)	X to the power Y (X^Y)
LN (X)	natural logarithm of X
SIN (X)	sinus of X
COS (X)	co sinus of X
ATAN (X)	arc tangent of X
SQRT(SUMX2PY2(X;Y))	square root of the sum of the square of X and the square of Y; $\sqrt{(X^2 + Y^2)}$
IF(A;X;Y)	IF expression A is True THEN X else Y (X and Y can be values or expressions)
IF(A;X;IF(C;Y;Z))	Nested IF..THEN statement: If expression A is True then X else if expression C is True then Y else Z. Represented by a table:

<table>
<tr><td colspan="3">Parameter=</td></tr>
<tr><td colspan="3">condition IF A</td></tr>
<tr><td>YES</td><td colspan="2">NO</td></tr>
<tr><td rowspan="2">X</td><td colspan="2">condition IF B</td></tr>
<tr><td>Y</td><td>Z</td></tr>
</table>

CHOOSE — Stacked IF..THEN statement. Example: If X=1 then Y=a else if X=2 then Y=b else if X=3 then Y=c. Represented by a table:

CHOOSE	
X	**Y**
If value	**then equation or value**
1	**=a**
2	**=b**
3	**=c**

MATCH(X; A1:A3)	Result: Closest lower value matching X in array A1:A3 (cells A1, A2, A3)
INDEX([X1;X2]; X;Y)	**Returns a value from a position in an array (X position only) or a table (X and Y positions)**

A6. Naming conventions

Q	Energy [kWh]
P	Power [kW]
T	Temperature [ºC or K]
V	Volume [m³]
A or F	Surface [m²]
η or eta	Efficiency
t	Time-period [h] (exception *hd* = length of *d*ayperiod for space *h*eating)
v	Speed [for cooling down or heating up, in K/h]

pre-/postfix (most used only)

b	Gas/oil fired
el or elec	Electric
hp	Heat pump
sol	Solar
h	space heating
w	water heating
a	annual
m	monthly
d	increment

ANNEX B: DATA REPORT

B1. General

Each application for CE-marking shall be accompanied by a *DATA REPORT* on specific performance characteristics of the product, as defined in the table on the following page.

This table is also the general format of the Technical Fiche that manufacturers are to supply with the product (user's manual, installation instruction).

Section 1 (manufacturer, model, date and ID number) is compulsory.

Depending on the features of the water heater only a limited part of the other sections has to be filled out:

For conventional water heaters:

- Electric resistance dedicated water heaters: Param. nr. 7.1, 7.2, 7.3, 12.2, 13.1
- Gas- or oil-fired dedicated water heaters: Sections 6, 7, 12, 13 and 14. [parameter 6.2 komt wel voor in formule E 4.1, p.31 waste heat recovery, parameter 6.1 "airfuelmix" zie ik niet in rest document en denk ik niet van belang voor WH]

For water heaters combined with renewable energy:

- Solar assisted dedicated water heaters (indirect method): Sections 15 and 18
- Heat pump (assisted) dedicated water heaters (indirect method): Sections 16 and 18
- Solar assisted and heat pump (assisted) dedicated water heaters with electric resistance back-up heater (direct method): Param. nr. 7.1, 7.2, 7.3, 12.2, 13.1
- Solar assisted and heat pump (assisted) dedicated water heaters with gas- or oil-fired back-up heater (direct method): Sections 6, 7 (except 7.4), 12, 13 and 14.

In case of a Water Heater with renewables measured according to the indirect method ascertain that the values for param. nr. 12.1 and 12.2 are 0 (zero).

In case of a Water Heater with renewables measured according to the direct method ascertain that the values for param. nr. 15.1 and 16.1 are 0 (zero).

Values in the DATA REPORT on the next page are fictitious and used to indicate the precision (number of decimals) required.

DATA REPORT DEDICATED WATER HEATERS

1.1	Manufacturer		1.3 Date	
1.2	Model		1.4 ID	

11.1	**WATER HEATING LOAD**	**4 -M**	(a.k.a. 'waterload'. Choice of manufacturer)

DIRECT METHOD

-

12.1	Fuel consumption (in GCV) **Qfuel**	kWh/d	**9999,99**
12.2	Electricity consumption **Qelec**	kWhe/d	**9999,99**
13.1	smart control factor **dhwsmart**	**0 -no**	
13.2	noise (**noisew**)	dB-A	**99**
14.1	combustion efficiency **ηcomb**	%	**99%**
14.2	avg. flue gas temp. at tapping **Tflue**	oC	**999**
7.1	Combustion **airintake**	1 -room sealed	
7.2	Designated in-/outdoors **boilpos**?	1 -indoors	
7.3	Env. Volume **volumeb**	m3	**99,99**
6.2	Fueldewpoint **dpt**	1 - gas	

The DIRECT METHOD measures energy consumption during a 24h tapping cycle pertaining to the water heating load chosen (see Annex C). Param. 12.1 and 12.2 are the direct outcome of that test

The INDIRECT METHOD measures relevant parameters of the product and then derives the energy consumption with the chosen 24 h tapping cycle through calculation.

Both methods also include distribution losses and waste heat recovery, on the basis of noise (13.2), envelope losses (derived from 14.1 and 14.2), air intake (7.1), designated position (7.2) and product volume (7.3)

When using the indirect method paramters 12.1 and 12.2 must be zero.

For conventional products only the direct method is allowed. For products with renewables the manufacturer can choose between the direct or the indirect method.

INDIRECT METHOD

-

SOLAR ASSIST

15.1	Collector aperture area **Asol**	m2	**999,9**
15.2	Zero-loss collector efficiency **η0**	-	**0,99**
15.3	First-order loss coefficient **a_1**	W/(m²K)	**9,99**
15.4	Second-order loss coefficient **a_2**	W/(m²K²)	**9,999**
15.5	Incidence angle modifier **IAM**	-	**9,99**
15.6	**Solar part of** tank volume **vsol**	ltr	**9999**
15.7	UA-value of heatexchanger **UAsol**	W/K	**999**
15.8	Collector loop pipe lenght, **Lpipesol**	m	**999,9**
15.9	Coll. loop loss per m pipe **Upipesol_m**	W/(m.K)	**9,99**
15.10	Tank heat loss coeff **UA**	W/K	**99,9**
15.11	Solar pump power **solaux**	W	**9.999**
15.12	Tank position **solpos**	1 -indoors	

HEAT PUMP

16.1	Nominal Power **Phpnom**	kW	**999,99**
16.2	turndownhp	%	**99,90%**
16.3	HPtype (Tsrc/Tsnk)	3 -El. air/ water 7/45	
16.4	Nominal COP **COPnom**		**9,9**
16.5	50%. load COP correct **COP50**	%	**999,90%**
16.6	Maximum sink temperature **Tsnkmax**	oC	**99**
16.7	Auxiliary el. consumption **hpaux**	W	**9999**
16.8	Tank volume nominal **Vhp**	ltr	**9999**
16.9	Tank ref. heat loss **Pstbyhp**	W	**9999**
16.10	Tank hot water capacity **V40hp**	frac. Vhp	**9,99**
16.11	Use (also) vent. exhaust air **ventmix** ?	0 -no	

16.13 Heat pump testpoints *

	hp	**Pcor**			**COPcor**		
16.13T	oC	99	99	99	99	99	99
16.13a	99	9,99	9,99	9,99	9,99	9,99	9,99
16.13b	99	9,99	9,99	9,99	9,99	9,99	9,99
16.13c	99	9,99	9,99	9,99	9,99	9,99	9,99
16.13d	99	9,99	9,99	9,99	9,99	9,99	9,99
16.13e	99	9,99	9,99	9,99	9,99	9,99	9,99

*= In the indirect method heat pumps must be tested at a minimum of 4 different test points, with at least 2 different sink temperatures and 2 different source temperatures. At least one of the sink temperatures must be 45 ºC or higher

BACK-UP HEATER

18.1	Waterloadmin	**1 -XXS**	
18.2	**Qfuelmin**	kWh	**999,99**
18.3	**Qelecmin**	kWhel	**999,99**
18.4	Waterloadmax	**4 -M**	
18.5	**Qfuelmax**	kWh	**999,99**
18.6	**Qelecmax**	kWhel	**999,99**

The back-up heater is tested with two water heating loads. Waterloadmax is waterload or waterload+1. Waterloadmin is at least one lower than waterloadmax.

OUTPUT: WATER HEATING ENERGY

- - -

B.1	Water heat net load	kWh/a	**999.999**
B.2	Water heat primary energy use.	kWh/a	**999.999**
B.3	Water heat energy eff.	99,90%	
B.4	Energy label Water Heating		

B2. Input parameters based on measurements

The table below gives input parameters for which definitions and test methods are given in harmonised standards.

Table B1. Input parameters for which definitions and test methods are given in harmonised standards.

Nr.	Parameter	unit	Standards
12.1	Fuel consumption (in GCV) **Qfuel**	kWh/d	**Annex E, with reference to EN 13203-2** **prEN 50440** **see annex F (EIWH, SWH)** **see Annex G, examples of direct test methods**
12.2	Electricity consumption **Qelec**	kWhe/d	
18.2	**Qfuelmin**	kWh	
18.3	**Qelecmin**	kWhel	
18.5	**Qfuelmax**	kWh	
18.6	**Qelecmax**	kWhel	
13.1	smart control factor **dhwsmart**	yes/no	**Annex H**
13.2	noise (**noisew**)	dB-A	**standard to be established (choice)**
14.1	combustion efficiency **ηcomb**	%	**EN standards**
14.2	avg. flue gas temp. at tapping **Tflue**	oC	

The manufacturer shall indicate the selected load profile by specifying the ***waterload*** parameter [param. nr. 11.1, values 1 to 9 corresponding to XXS to 4XL] and shall confirm that the product meets the requirements of the selected load profile. The test standard used shall be reported separately (not in the fiche).

For the selected load profile and/or from the tapping pattern test(s) shall be reported as follows:

In case no solar and/or heat pump technology is incorporated in the product or if the product incorporates the assistance from renewables and is measured according to the direct method:

- the measured fossil-fuel consumption ***Qfuel*** for the *waterload* [param. nr. 12.1, in kWh/d, in Gross Calorific Value GCV]
- the measured electricity consumption ***Qelec*** for the *waterload* [param. nr. 12.2, in kWh/d]

In case solar and/or heat pump technology is incorporated in the product and the indirect measurement method is used:

- *Qfuel* =0 [param. nr. 12.1] and *Qelec*=0 [param. nr. 12.2]
- for the electric or gas/oil-fired back-up heater a load profile ***waterloadmax*** [param. nr. 18.4] is selected that is equal or one higher than the *waterload*. For the tapping pattern test of *waterloadmax* the following data shall be reported:
    - the measured fossil-fuel consumption ***Qfuelmax*** [param. nr. 18.5, in kWh/d, GCV]
    - the measured electricity consumption ***Qelecmax*** [param. nr. 18.6, in kWh/d]
- for the electric or gas/oil-fired back-up heater a load profile ***waterloadmin*** [param. nr. 18.1] is selected that is at least one lower than the *waterloadmax*. For the tapping pattern test of waterloadmin the following data shall be reported:
    - the measured fossil-fuel consumption ***Qfuelmin*** [param. nr. 18.2, in kWh/d, GCV]
    - the measured electricity consumption ***Qelecmin*** [param. nr. 18.3, in kWh/d]

- For solar assisted products: The collector surface ***Asol*** [param. nr. 15.1, in m²] shall be larger than zero. Other input variables of the solar technology shall be reported as described hereafter.

- For products with (also) heat pump technology: The heat pump nominal power output ***Phpnom*** shall be larger than zero. Other input variables of the solar technology shall be reported as described hereafter.

The requirements above are based on an approach whereby the single characteristics of solar, heat pump and back-up heater technologies are fed into a mathematical model that evaluates performance and energy efficiency.

Future harmonised standards whereby solar and/or heat pump and back-up heater technologies are tested as a whole, e.g. with an emulation of solar- or heat pump inputs, can be deemed admissible by the notified bodies if:

- the referenced tapping patterns are used, including the requirements for ambient temperature and cold water temperature.
- solar and/or heat pump heat input data are used as given in Annex C. (Reference Conditions)
- If for the other aspects of the test procedure the same or similar accuracy and repeatability is used as in EN 13203-2 and/or prEN 50440.

In case such a new harmonised test standard is used, this shall be explicitly reported and the data that need to be reported are limited to *Qfuel* and *Qelec* [param. nr. 12.1 and 12.2].

B3. Input parameters based on self-declaration

Table B2 gives multiple choice input parameters based on self declaration, taking into account the definitions in Annex A and the reference conditions in Annex C.

Apart from multiple-choice parameters, there are also a limited number of numerical values and defaults for *conventional* water heaters that do not require any measurements, i.e. are based on self-declaration:

- In case of conventional electric water heaters: default 35 dBA (lowest possible value) for ***noisew*** *(does not apply to water heaters with heat pump technology, where actual measurement values shall be used)*
- 7.3 -Envelope volume ***volumeb*** [in m³]

Table B2. Multiple choice input parameters based on self declaration

Nr.	Parameter	Options	Nr.	Parameter	Options
11.1	**WATER HEATING LOAD**	0 -none	15.12	Tank position **solpos**	0 -outdoors
18.1	Waterloadmin	1 -XXS			1 -indoors
18.4	Waterloadmax	2 -XS	16.3	**HPtype** (Tsrc/Tsnk)	1 -El. brine/ water (0/45)
		3 -S			2 -El. water/ water (10/45)
		4 -M			3 -El. air/ water 7/45
		5 -L			4 –Gas/oil eng.air/water (7/45)
		6 -XL			5- Gas/oil abs. NH3/H2O water/water (10/45)
		7 -XXL			6 –Gas/oil abs. H2O/LiBr water/water (10/45)
		8 -3XL			7 –Gas/oil brine/water NO DEFAULTS
		9 -4XL			
7.1*	Combustion **airintake**	1 -room sealed			
		2 -open	16.11	Use (also) vent. exhaust air	0 -no
		3 -none (electric)			1 -yes
			6.2	Fueldewpoint dpt	1- gas
7.2*	Designated in-/outdoors **boilpos**?	0 -outdoors			2 -oil
		1 -indoors			3 -LPG

B4. Solar input parameters

Applicable standards and defaults are given in the tables below. For solar assisted dedicated water heaters measured according to the direct method the parameters do not apply, but the standards may be relevant for the assessment of emulator power output.

Table B3. Input parameters and measurement standards solar water heaters

Nr.	Parameter	Name	Unit	Test standard	Parameter	Symbol
15.1	Collector aperture area	Asol	m²	EN 12975-2	aperture area of collector	A_a
15.2	Zero-loss collector efficiency	η0	-	EN 12975-2	zero loss collector efficiency (η at T^*_m = 0), reference to T^*_m	η_0
15.3	First-order loss coefficient.	a_1	-	EN12975-2	heat loss coefficient at (T_m-T_a)=0	a_1
15.4	Second-order loss coefficient	a_2	-	EN12975-2	temperature dependence of the heat loss coefficient	a_2
15.5	Incidence angle modifier.	IAM	-	EN12975-2	collector incidence angle modifier	K_θ
15.6	Solar part of tank volume	vsol	litres	Self-declaration Total tank volume minus supplementary volume; supplementary volume = volume heated by boiler and or electrical heating element; if no supplementary heating	Symbol in EN 15316-4-3:2007	V_{sol}
15.7	UA-value of heat exchanger	UAsol	W/K	ENV 12977-2	Heat transfer rate of heat exchanger Symbol in EN 15316-4-3:2007	$(UA)_{hx}$ $(U_{st})_{hx}$
15.8	Collector loop pipe lenght, total	Lpipesol	m	Self-declaration		
15.9	Collector loop pipe heat loss per m pipe	Upipesol_m	W/mK	Self-declaration		
15.10	Tank heat loss coefficient	UA	W/K	ENV 12977-3	Store heat loss rate Symbol in EN 15316-4-3:2007	$(UA)_s$ U_{st}
15.11	Solar pump power	solaux	W	Self-declaration (ref. EN 15316-4-3)	Total nominal input power of pumps.	$P_{aux,nom}$

Table B4. Solar: Normative values that may be used as Defaults (instead of measurements)

Nr.	Parameter	Name	Unit	Informative value	Normative value
15.2	Zero-loss collector efficiency	η0	-	0.80	0.60
15.3	First-order loss coefficient.	a_1	-	1.8 / 3.5 / 15 (evac / glazed / unglazed)	3 / 6 / 20 (evac / glazed / unglazed)
15.4	Second-order loss coefficient	a_2	-		a2 = 0
15.5	Incidence angle modifier.	IAM	-		0.97 / 1.00 / 0.94 / 1.00 (evac-flat / evac-circ / glazed / unglazed)
15.7	UA-value of heat exchanger	UAsol	W/K	`-	40 * Asol [W/K] *
15.8	Collector loop pipe lenght, total	Lpipesol	m		6
15.9	Collector loop pipe heat loss per m pipe	Upipesol_m	W/mK		0,3 [W/mK] *
15.10	Tank heat loss coefficient		W/K		$0.16\ vsol^{0.5}$
15.11	Solar pump power	solaux	W	25+2Asol	50+5Asol

Informative and normative values for Parameters nr. 15.2, 15.3, 15.4, 15.5, 15.10 and 15.11 from EN 15316-4-3;2007 and are given as "default" or "penalty" data. Values for 15.7 and 15.9 supplied by ESTIF. Note that for parameters nr. 15.1 and 15.6 and 15.8 measurement values are compulsory.

B5. Heat pump input parameters

Applicable standards and defaults are given in the tables below. For heat pump (assisted) dedicated water heaters measured according to the direct method these parameters do not apply.

Table B4. Reported data and applicable standards for heat pump contribution

	parameter	name	unit	Test standard	Parameter name	symbol
16.1	Nominal heating power heat pump	Phpnom		electric: EN14511-3	heating capacity	P_H
				gas: EN12309-2	heating capacity	Q_H
16.2	Turndown ratio heat pump	turndownhp		stated by manufacturer	% of rated heating capacity at minimum power	%
16.3	Heat pump type	HPtype		stated by manufacturer		-
16.3a	Nominal source temperature	Tsrc		test conditions in: electric: EN14511-2	in heating mode: standard rating conditions for inlet (dry bulb) temperature	-
				gas: EN12309-2	in heating mode: inlet temperature T1	-
16.3b	Nominal sink temperature	Tsnk		test conditions in: electric: EN14511-2	in heating mode: standard rating conditions for outlet temperature	-
				gas: EN12309-2	in heating mode: outlet temperature T1	-
16.4	Nominal COP	COPnom		electric: EN 14511	COP at standard rating conditions	COP
				gas: EN 12309-2	gas utilization efficiency	η_h
16.5	Correction to COP at 50% load	COP50	%	electric: CEN/TS 14825	COP of unit at 50% of rated capacity	$COP_{50\%}$
				gas: equivalent procedure	gas utilization efficiency at 50% of rated capacity	-
16.6	Maximum sink temperature	Tsnkmax	ºC	Self-declaration	measured at outlet [1]	
16.7	Auxiliary electric power consumption (not already included in COP)	hpaux	W	Self-declaration specify the nominal electric power of pumps, controls, etc. not included in determination of COPnom. Examples: - sourcepump (from source to outdoor heat exchanger), - de-freeze control, - sinkpump aka central heating circulator		
16.8	Nominal storage tank volume of heat pump	Vhp	ltr	EN 60379 / prEN50440	actual capacity	C_{act}
				or prEN153322:2005	actual storage capacity	C_A
16.9	Tank reference heat loss	Pstbyhp	W	prEN15332:2005 (at medium storage temp. of 55ºC or higher)	Standby-loss per 24 h (convert kWh/24h to W)	Q_B
				or EN 60379:2004 / prEN50440 (at medium storage temp. of 55ºC or higher)	Standing loss per 24h (convert kWh/24h to W)	Q_{pr}
16.10	Storage tank hot water capacity V40	V40hp	-	prEN50440	Mixed water quantity delivered at 40ºC	V_{40}
				or EN 60379	Mixing factor, mixed water output at 40ºC	C_m
16.11	Use (also) ventilation exhaust air (no=0, yes=1)	ventmix		stated by manufacturer		
16.12	Usage of heat pump	usehp		stated by manufacturer		
16.13	- requirement to fill in test results or default data			see COPnom, Phpnom		

[1] Some heat pump technologies use –for water heating—not a fixed maximum sink temperature Tsnkmax, but a dynamic parameter Tsnkmax depending on outdoor temperature. In such a case, the declared value for Tsnkmax is the weighted average (weighted by Tout in Table C5).

B6. Auxiliary energy consumption heat pump and solar

The self-declaration of auxiliary energy consumption for solar and heat pump technology requires the manufacturer to make an additional technical report specifically on this issue. This report shall cover at least

For solar: operating time and power level(s) of:
- Solar pump (if any)
- Solar controls (if any)
- Defrost installation (if any)
- Circulator pump(s) (if any)

For heat pump technology: operating time and power level(s) of:
- Feeder pump or fan (if any or if not included in COP)
- Heat pump controls (if any)
- Defrost installation (if any)
- Sink pumps, a.k.a. circulator pump(s) (if any)
- Standby heat losses

Note that the indicated operating times shall be consistent with the mathematical model. Furthermore, note that with respect of the circulator pump for the central heating (and also water heating) the model only takes into account pump power for the operating time of the back-up heater. If that same pump is used also for the heat pump or solar technology, the extra running hours of that pump have to be taken into account in ***hpaux*** and ***solaux.***

ANNEX C: REFERENCE CONDITIONS

C1. Water heater load profile: Tapping patterns

The tapping patterns in Table C4 shall be used for energy efficiency assessment. Two general testing methods are distinguished:

- The DIRECT METHOD measures the water heating energy consumption during a 24h tapping cycle pertaining to the water heating load chosen. Param. 12.1 (Qfuel) and/or 12.2 (Qelec) of the DATA REPORT are a direct outcome of the test. The direct method is compulsory for conventional water heaters and optional for water heaters with renewables. The method is described in paragraphs E4 to E6.
- The INDIRECT METHOD is optional for water heaters with renewables. It requires measurement of relevant parameters of the renewables section (solar, heat pump) plus test results with the direct method for the (conventional) back-up water heater at two different water loads. The test results are the input for sections 18 and 15 and/or 16 of the DATA REPORT. Parameter nr.'s 12.1 and 12.2 shall be set to 0 (zero). The energy consumption of the product is then calculated for the chosen 24 h tapping cycle. The method is described in paragraphs E7 to E9.

Tests according to the DIRECT METHOD will measure the energy consumption of the water heater during the 24 h cycle as specified in Table C4, no more and no less. Typically corrections and/or special measures may be required for differences between energy content of the water heater before and after the 24h test cycle, differences between the actual and required delivery of energy equivalent of hot water, deviations in energy inputs and test conditions, etc..

Irrespective of specifications in harmonised standards, the measurements with the DIRECT METHOD shall be performed with

- an ambient temperature of 20 ± 2 ºC and
- a cold water temperature of 10 ± 2 ºC
- using the original appliance thermostat, in the position specified by manufacturer, and at the factory settings.

For other aspects of the DIRECT METHOD the manufacturer can choose one of the following standards:

- EN 13203-2
- prEN 50440
- For electric instantaneous water heaters only: method as described in Annex F.1.
- For dedicated solar water heaters with an electric back-up: method as described in Annex F.2.
- For dedicated solar water heaters with a gas-fired back-up heater only: prEN 13203-3, but with the **solar cycle** as in Annex F.2.
- For dedicated heat pump water heaters with an electric back-up: EN 255-3, but with the source temperatures: outdoor air 10,5 °C, brine 2,5 °C, water 11,5 °C. For exhaust air heat pumps the source temperature is 20 °C to a maximum flowrate indicated by the ventex parameter for the waterload (see Table C6). If the exhaust air heat pump requires a higher flowrate, the remainder is assumed to be filled in by outdoor air at 10,5 °C and the test will be executed with an air-source temperature corrected accordingly.

As example of test methodologies based on these standards, the informative Annex G describes a possible test of electric storage water heaters (G1), gas-fired water heaters (G2), solar-assisted gas-fired water heaters (G3) and electric heat pump water heaters (G4).

Other tests or measurements described in the used harmonized standards but not useful for the determination of the Qelec and Qfuel values are not to be performed.

A derived parameter from table C4 is the largest tapping in each tapping pattern. This is used with heat pump water heaters. To accommodate the calculation, this parameter tapmax is expressed not in kWh but in the equivalent litres of 45°C hot water.

tapmax =IF(waterload>0;CHOOSE(waterload; 2; 6; 10; 26,6; 69; 84; 119; 239; 477);0) **C6**

For the partitioning of solar and heat pump capacity between space- and water heating the water heating energy requirement per day-period is useful:

qtap(morn) = sum(Qtap_07.00:Qtap_08.59)
qtap (mid) = sum(Qtap_09.00:Qtap_15.59)
qtap (eve) = sum(Qtap_16.00:Qtap_20.59)
qtap (late) = sum(Qtap_21.00:Qtap_22.59)
qtap (night) = sum(Qtap_23.00:Qtap_6.59) = 0

Note that the parameters above are specific for each water heating load profile, leading to parameter names composed of the load profile (XXS, XS, etc) and the name of the day-period (morn, mid, etc.). Example: ***qtapxxsmorn*** is the total energy equivalent of the hot water tappings [in kWh] for the morn-period and for the water heating load profile XXS. For a selected load profile, the model uses he array ***qtap,*** containing the 5 relevant values per day-period.

Legend for table C4 (parameters apply only for table next page)

Qref = useful energy content of water withdrawal per 24h
f = flow rate l/min
Tm = temperature from which counting of useful energy content starts
Tp = minimum temperature to be achieved during tapping
Qref = daily water heater load (useful energy)

Table C4: Water heater load patterns (reference test tapping patterns)

	XXS				XS				S			
	Qtap	f	Tm	Tp	**Qtap**	f	Tm	Tp	**Qtap**	f	Tm	Tp
	kWh	l/ min	oC	oC	**kWh**	l/min	oC	oC	**kWh**	l/min	oC	oC
07.00	**0,105**	2	25						**0,105**	**3**	**25**	
07.05												
07.15												
07.26												
07.30	**0,105**	2	25		**0,525**	**4**	**35**	**-**	**0,105**	**3**	**25**	
07.45												
08.01												
08.05												
08.15												
08.25												
08.30	**0,105**	2	25						**0,105**	3	25	
08.45												
09.00												
09.30	**0,105**	2	25						**0,105**	3	25	
10.00												
10.30												
11.00												
11.30	**0,105**	2	25						**0,105**	3	25	
11.45	**0,105**	2	25						**0,105**	3	25	
12.00	**0,105**	2	25									
12.30	**0,105**	2	25									
12.45	**0,105**	2	25		**0,525**	4	35	-	**0,315**	4	10	55
14.30												
15.00												
15.30												
16.00												
16.30												
17.00												
18.00	**0,105**	2	25						**0,105**	3	25	
18.15	**0,105**	2	25						**0,105**	3	40	
18.30	**0,105**	2	25									
19.00	**0,105**	2	25									
19.30	**0,105**	2	25									
20.00	**0,105**	2	25									
20.30					**1,050**	4	35	-	**0,420**	4	10	55
20.45	**0,105**	2	25									
20.46												
21.00	**0,105**	2	25									
21.15	**0,105**	2	25									
21.30									**0,525**	6	45	
21.30	**0,105**	2	25									
21.45	**0,105**	2	25									
Qref	**2,100**				**2,100**				**2,100**			

	M				L				XL			
	Qtap	f	Tm	Tp	**Qtap**	f	Tm	Tp	**Qtap**	f	Tm	Tp
	kWh	l/min	oC	oC	**kWh**	l/min	oC	oC	**kWh**	l/min	oC	oC
07.00	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
07.05	**1,400**	6	40		**1,400**	6	40					
07.15									**1,820**	6	40	
07.26									**0,105**	3	25	
07.30	**0,105**	3	25		**0,105**	3	25					
07.45					**0,105**	3	25		**4,420**	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**	3,6	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**	3,6	10	55	**0,735**	4	10	55	**0,735**	4	10	55
20.45												
20.46									**4,420**	10	10	40
21.00					**3,605**	10	10	40				
21.15	**0,105**	3	25						**0,105**	3	25	
21.30	**1,400**	6	40		**0,105**	3	25		**4,420**	10	10	40
21.30												
21.45												
Qrer	**5,845**				**11,655**				**19,070**			

	XXL				3XL				4XL			
	Qtap	f	Tm	Tp	**Qtap**	f	Tm	Tp	**Qtap**	f	Tm	Tp
	kWh	l/min	oC	oC	**kWh**	l/min	oC	oC	**kWh**	l/min	oC	oC
07.00	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
07.05					**11,20**	48	40		**22,40**	96	40	
07.15	**1,820**	6	40									
07.26	**0,105**	3	25									
07.30					**0,840**	24	25		**1,680**	48	25	
07.45	**6,240**	16	10	40								
08.01	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
08.05												
08.15	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
08.25												
08.30	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
08.45	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
09.00	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
09.30	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
10.00	**0,105**	3	25									
10.30	**0,105**	3	10	40	**0,840**	24	10	40	**1,680**	48	10	40
11.00	**0,105**	3	25									
11.30	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
11.45	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
12.00												
12.30												
12.45	**0,735**	4	10	55	**2,520**	32	10	55	**5,040**	64	10	55
14.30	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
15.00	**0,105**	3	25									
15.30	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
16.00	**0,105**	3	25									
16.30	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
17.00	**0,105**	3	25									
18.00	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
18.15	**0,105**	3	40		**0,840**	24	40		**1,680**	48	40	
18.30	**0,105**	3	40		**0,840**	24	40		**1,680**	48	40	
19.00	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
19.30												
20.00												
20.30	**0,735**	4	10	55	**5,880**	32	10	55	**11,76**	64	10	55
20.45												
20.46	**6,240**	16	10	40								
21.00												
21.15	**0,105**	3	25		**0,840**	24	25		**1,680**	48	25	
21.30	**6,240**	16	10	40	**11,20**	48	40		**22,40**	96	40	
21.30												
21.45												
Qref	**24,530**				**46,760**				**93,520**			

C3. Heat pump and solar technology source parameters

The table below gives the outdoor temperature, solar irradiance, soil temperature (“brine” heat pumps) and groundwater temperature (for “water” heat pump boilers) that are used as default inputs for heat pump technology. (source: JRC Ispra)

Table C5. Heat pump and solar technology source temperatures

		Tout	Toutm	qsol	qsolm	Tsrc brine	Tsrc water	Q_solm
		oC	oC	W/m²	W/m²	oC	oC	kWh/m²
JAN	morn	2,2		62		2,28	10,44	
	mid	4,4		218		2,55	10,88	
	eve	4,5	3,44	4	70	2,57	10,90	51
	late	3,4		0		2,43	10,69	
	night	2,2		0		2,28	10,44	
FEB	morn	3,1		126		2,38	10,61	
	mid	6,4		309		2,80	11,28	
	eve	6,4	4,82	15	104	2,80	11,28	76
	late	4,8		0		2,60	10,97	
	night	2,9		0		2,36	10,58	
MAR	morn	5,2		217		2,65	11,04	
	mid	9,2		411		3,15	11,84	
	eve	8,8	6,88	41	149	3,10	11,76	109
	late	6,6		0		2,82	11,31	
	night	4,1		6		2,51	10,82	
APR	morn	8,7		301		3,09	11,75	
	mid	12,9		495		3,62	12,59	
	eve	12,3	10,09	78	192	3,53	12,45	140
	late	9,3		0		3,17	11,87	
	night	6,8		18		2,84	11,35	
MAY	morn	13,8		353		3,73	12,76	
	mid	17,8		541		4,23	13,57	
	eve	17,2	14,75	111	221	4,15	13,43	162
	late	14,3		0		3,78	12,85	
	night	10,9		32		3,36	12,18	
JUN	morn	17,3		354		4,16	13,46	
	mid	21,2		529		4,65	14,24	
	eve	20,7	18,17	123	222	4,59	14,14	163
	late	17,8		0		4,22	13,56	
	night	14,3		39		3,79	12,86	

		Tout	Toutm	qsol	qsolm	Tsrc brine	Tsrc water	Q_solm
		oC	oC	W/m²	W/m²	oC	oC	kWh/m²
JUL	morn	19,0		366		4,37	13,80	
	mid	23,2		566		4,90	14,63	
	eve	22,8	20,06	119	232	4,85	14,57	170
	late	19,8		0		4,48	13,96	
	night	15,9		35		3,99	13,19	
AUG	morn	18,9		335		4,37	13,79	
	mid	23,8		555		4,98	14,77	
	eve	23,1	20,21	93	217	4,89	14,62	159
	late	19,5		0		4,44	13,90	
	night	15,7		23		3,97	13,15	
SEP	morn	14,4		259		3,80	12,88	
	mid	18,9		479		4,36	13,78	
	eve	17,9	15,67	54	176	4,23	13,57	129
	late	14,5		0		3,82	12,91	
	night	12,1		9		3,51	12,42	
OCT	morn	10,5		166		3,31	12,10	
	mid	14,2		375		3,78	12,85	
	eve	13,4	12,07	24	129	3,68	12,69	94
	late	11,6		0		3,46	12,33	
	night	9,8		1		3,23	11,97	
NOV	morn	6,2		76		2,77	11,23	
	mid	8,6		247		3,07	11,71	
	eve	8,4	7,42	6	80	3,05	11,68	58
	late	7,4		0		2,93	11,49	
	night	6,1		0		2,77	11,23	
DEC	morn	2,8		44		2,35	10,56	
	mid	4,6		177		2,57	10,92	
	eve	4,6	3,77	2	56	2,57	10,91	41
	late	3,6		0		2,45	10,73	
	night	2,8		0		2,35	10,57	

For air-source heat pump technology that uses (also) ventilation exhaust air (***ventmix***=yes) then the model assumes the following default values for the volume of exhaust air ***ventex*** [in m³/h] that is available.

Table C6. Default values *ventex* per water load profile (if *ventmix*=yes)

parameter	unit	1 -XXS	2 -XS	3 -S	4 -M	5 -L	6 -XL	7 -XXL	8 -3XL	9 -4XL
ventex	m³/h	109	136	128	159	190	870	1021	2943	8830

For the partitioning between the volume of exhaust air *ventex* and the outside air, the model assumes that an air-based heat pump technology uses 300 m³/h per kW of nominal heating capacity as in table B4 (*Phpnom*). Internal parameter ***hpaf*** = 300 m³/h.kW.
Also in the DIRECT METHOD the inlet air temperature shall be determined according to this principle.

C4. Fueldewpoints

For each type of fuel [param nr. 6.2, fueldewpoint] the model gives a reference fueldewpoint:

Table C12. Look-up table fueldewpoint (param. nr. 6.2)

fueldewpoint (param. nr. 6.2)		**dpt**
value	description	dew point
1	1-gas	58
2	2-oil	47
3	3 –LPG	54

ANNEX D: SHARED PARAMETERS

D1. Introduction

The methodology for water heaters shares some parameters with the Ecodesign modeling of space heating. For reasons of consistency these parameters are presented here with the exact denomination used in the more extended model for space heating.

D2. Intermediate parameters

The input parameters in Annex B represent the minimum number of inputs required to make the calculations. For the mathematical model this section gives a number of derived parameters that facilitate further calculation and data processing.

D2.1 Waste heat recovery parameters

Table D1 gives heat recovery parameters.

Table D1. Determination of heat recovery parameters

boilpos	air_intake	volumeb	noiseh (noisew)	qrecovb_winter Oct.-Apr.	qrecovb_summer June-Aug.	(qrecov) All year
[-]	[-]	[m³]	[dB(A)]	[%]	[%]	[%]
indoor (= 1)	3 (electric)	≤ 0.5	< 35	85%	-71%	32%
			≥ 35, ≤ 44	55%	-46%	21%
			> 44	25%	-21%	9%
		> 0.5	any value	25%	-21%	9%
	1 or 2 (fossil fuel)	≤ 0.15	≤ 44	85%	-71%	32%
			> 44	25%	-21%	9%
		≤ 0.5, > 0.15	≤ 44	55%	-46%	21%
			> 44	25%	-21%	9%
		> 0.5	any value	25%	-21%	9%
outdoor (= 0)	any value	any value	any value	0%	0%	0%

Note 1: qrecovb_transit (May + Sept.)=0

Note 2: qrecov= (7/12)*qrecovb_winter + (3/13)*qrecovb_summer but with noisew instead of noiseh

Note that *qrecovb_winter*, *qrecovb_transit* (=0) and *qrecovb_summer* are used for the CH-Boiler mathematical model with the noise parameter *noiseh*. The annual recovery factor *qrecov* with the noise parameter *noisew*, is used for the Water Heater mathematical model in Annex E.

The equations indicated by Table D2 are

***qrecovb_winter* = *boilpos**IF(AND(*airintake*=3;*noiseh*<35; *volumeb*<=0,5); 85%; IF(*airintake*=2; 25%; IF(*volumeb*<=0,15; IF(*noiseh*<=44; 85%;25%);IF(*volumeb*<=0,5;IF(*noiseh*<=44;55%;25%);25%))))** **D7**

***qrecovb_transit* = 0** **D8**

***qrecovb_summer* = *boilpos**IF(AND(*airintake*=3;*noiseh*<35; *volumeb*<=0,5);-71%; IF(*airintake*=2;-21%;IF(*volumeb*<=0,15; IF(*noiseh*<=44;-71%;-21%);IF(*volumeb*<=0,5;IF(*noiseh*<=44;-46%;-21%);-21%))))** **D9**

***qrecov* = *boilpos**IF(AND(*airintake*=3;*noiseh*<35; *volumeb*<=0,5);32%; IF(*airintake*=2; 9%;IF(*volumeb*<=0,15; IF(*noisew*<=44; 32%; 9%);IF(*volumeb*<=0,5; IF(*noisew* <=44; 21%;9%);9%))))** **D10**

D2.2 Intermediate parameters CH-Boiler with solar technology

Table D2. Intermediate parameters CH-Boiler with solar technology

name	*description*	*unit*	*equation*	
a_c	Resulting collector heat loss coefficient	W/(m²K)	**a_c** = a_1+a_2*40	D11
ηloop	Collector loop efficiency	-	**ηloop** =1 - (η_0*Asol*a_c)/UAsol	D12
UL	Collector loop pipe loss **per m² collector**	W/(m².K)	**UL** = Lpipesol*Upipesol_m/Asol	D13

D2.3 Exhaust air heat-pump technology

For a ventilation exhaust air heat pump (*ventmix*=yes), the source temperature ***Tsrc_ventmix*** of the mix of outside air (at *Tout*) and the exhaust air (default 20 °C, unless *Tout*>20) can be calculated per day-period using the reference values for hpaf and ventex given in Annex C.

***Tsrc_ventmix* = ((*Phpnom**hpaf* - *ventmix**ventex*)**Tout* + *ventmix**ventex** MAX(20;*Tout*)) /(*Phpnom**hpaf*)** D14

D2.4 Extrapolation of test-points for heat pumps

Input parameter 16.3 of the Data Report is, apart from the non-numerical headers, a 6x7 table. The first row (16.13T) contains two identical sets of a maximum of 3 declared sink temperatures (minimum 2). The first column gives a set of maximum 5 declared source temperatures (minimum 2). What remains are two 5x3 matrices.with each a maximum of 15 declared values for the declared source and sink temperatures. In the lefthand matrix (with header “Pcor”) the manufacturer gives correction factors for the heat pump output power Phpnom [param. nr. 16.1]. The correction factor for Phpnom, with its sink and source temperature, must be one point of the matrix and its value is by definition 1. The other points of the matrix follow from the output power values measured at different sink and/or source temperatures.
These test-results are then divided by Phpnom to find the correction factors that should be filled in.
The same procedure applies to the righthand matrix (with header “COPcor”) where the correction factors relate to the declared nominal Coefficient of Performance [***COPnom***, param. nr. 16.4].

The purpose of parameter 16.3 is to provide input data for the “seasonal” correction of the output power and the COP, i.e. on the basis of the given values the mathematical model recalculates the output power and COP for each of the relevant day-periods (9 x 5= 45 day-periods for space heating and 12 x 5 = 60 day-periods for water heating).

A two-step approach is followed to facilitate this seasonal correction per day-period. The first step is to expand the matrix of declared values with extrapolated values for source and sink temperatures at the extremes. For the source temperatures the extremes are +30°C and –20°C. For the sink temperatures the extremes are +70 and +20°C. Thus the smallest declared matrix is 2x2 is transformed into an “internal” 4x4 matrix. In general terms, a declared matrix of r x c is transformed into a matrix (r+2) x (c+2).

For the output power, where prEN 15316-4-2 allows only 2 test values, this transformation includes not only extrapolation at the extremes, but also the assessment of the “missing values” in the 2x2 matrix.

After the transformation a matrix of correction factors (at least 4x4) is found for the output power, called _HPPmatrix, and for the COP, called _COPmatrix. The source temperatures at which these values are assessed (declared+ 2 extremes) are listed in an array _Tsrcs, containing 2 or 3 declared values and the the two extremes. Likewise, the relevant sink temperatures are in an array called _Tsnks.

In a second step, the two matrices _HPPmatrix, _COPmatrix and their arrays _Tsrcs, Tsnks are used to find intermediate values. This second step is discussed in paragraph D12 for space heating and in paragraph E9 for water heating.

This section concentrates on the first step, i.e. the extra/interpolation. This extra-/interpolation is less self-evident than it may seem:

In the worst case the matrix may contain as little as 2 diagonally placed test-points, from which 14 unknown values should be derived to arrive at a 4x4 matrix. There is more than one way to do that and therefore the model should specify the extrapolation formula's to be used.

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Table D3. Principle of extrapolation of test-points : from given value11 and value 22

f = Tsnk3-Tsnk1

d =Tsnk3 -Tsnk2

b =Tsnk2 -Tsnk1

e =Tsrc3-Tsrc1

c =Tsrc3-Tsrc2

a =Tsrc2-Tsrc1

	Tsnk1	**Tsnk2**	**Tsnk3**
Tsrc1	value11 = given	**value12 = value11 + SIN(ATAN(a/b)) * (value22-value11)**	**value13 = value12 + (d/b) * (value12 - value11)**
Tsrc2	**value21 = value11 + COS(ATAN(a/b)) * (value22-value11)**	value22 = given	**value23 = value13 + (a/f) * (value33 - value13)**
Tsrc3	**value 31 = value 21 + (c/a) * (value21 - value11)**	**value 32 = value31 + (b/f) * (value33 - value31)**	**value33 = value22 + (value22-value11) * SQRT(SUMX2PY2(d;c)) / SQRT(SUMX2PY2(b;a))**

The table shows four types of extra/interpolation employed to find the "missing" test points:

1. **value12** and **value21** follow from the projection of the angle [atan(a/b)]
2. **value 33** follows from a diagonal linear extrapolation of value11 and value22
3. **value31** and **value13** follow from a straight linear extrapolation of the two preceding values (value11 and value21→ value 31; value11 and value12→value13)
4. **value32** and **value23** follow from a linear interpolation from values at the left and right (for value32) and at the top and bottom (for value23) respectively.

With these four methods a matrix of at least 4 x 4 can be extrapolated from 2 given test-points plus conditions at the extremes (-20<Tsrc<30, 20<Tsnk<70 in°C[2]). Or a 5x5 matrix can be created from 3 test points.

Table D4. Matrix 4x4 created with 4 methods (1 to 4) from 2 test-points

_Tsnks (columns), _Tsrcs (rows)

	20	a	c	70
-20	**2**	**3**	**3**	**3**
b	**3**		**1**	**3**
d	**3**	**1**		**4**
30	**3**	**3**	**4**	**2**

Table D5. Matrix 5x5 created with 4 methods (1 to 4) from 3 test-points

_Tsnks (columns), _Tsrcs (rows)

	20	a	c	e	70
-20	**2**	**3**	**3**	**3**	**3**
b	**3**		**1**	**3**	**3**
d	**3**	**1**		**4**	**3**
f	**3**	**3**	**4**		**4**
30	**3**	**3**	**3**	**4**	**2**

[2] Under consideration: Current version of the mathematical model uses 70°C as the maximum sink temperature. With the introduction of new CO2-based types, higher sink temperatures (e.g. 85°C) are possible. But for the COP there is also a strong dependence on system return temperature, which is to be taken into account. The modality of considering these new types in the model is under consideration (e.g. simple correction factor now, more complete modelling after a few years of practical experience).

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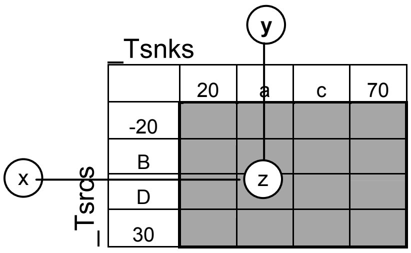
D3. Heat pump

D3.1 Asssesment of 'Seasonal' and part-load correction factors

Starting point are two matrices of (at least) 4 x 4 points resulting from section D2.5: one _HPPmatrix for the correction factors of the power output Phpnom and another one –with identical sink and source temperatures-- for the correction of the COP, called _COPmatrix. The array of sink temperatures, indicated as [20;a;c;70] in the picture below, will be called _Tsnks. The array of source temperatures [-20;b,d;-30] will be referred to as _Tsrcs.



Goal is the assessment of an unknown value z=correction factor for a given source temperature x=Tsrc and and a given sink temperature y=Tsnkin each day-period. The source temperature Tsrc depend on the source-type (air, water, brine) and the "season", i.e. the month and day-period. The source temperature per day-period is identical for space heating and water heating (see also paragraph E9). An overview of source temperatures per day-period is given in table C5. The type of source is chosen through the parameter HPtype (param. nr. 16.3)

Tsrc = CHOOSE(HPtype;Tsrc_brine;Tsrc_water;Tsrc_airmix;Tsrc_airmix; Tsrc_water; Tsrc_water) D107

where Tsrc_airmix indicates an air-source heat pump, but with a correction for the possible use of (also) ventilation exhaust air:

Tsrc_airmix = IF(Phpnom*hpaf>0;MIN(MAX(20;Tout);((Phpnom*hpaf-ventmix*ventex)*Tout + ventmix *ventex *MAX(20;Tout)) /(Phpnom*hpaf));0) D108

The sink temperature is specific for space and water heating. For space heating it depends on the system feed temperature for a specific day-period, established for the heating system in previous paragraphs, with a declared maximum Tsnkmax [declared by manufacturer as param. nr. 16.6]

Tsnk = IF(Tsysfeed<Tsnkmax;Tsysfeed;Tsnkmax) D109

With the Tsrc and Tsnk for a specific day-period, the correction factor can be found first by finding the 4 given neighbouring values within the matrices _HPPmatrix and _COPmatrix and then making an interpolation on the basis of how far the sink- and source temperatures of these neighbouring values are from the actual Tsnk and Tsrc.

For this the function MATCH is used, which first finds –for a given reference-- the closest lower value in the _Tsnks and the _Tsrcs arrays. I This results in the values ***col*** and ***row***. Col and Row identify the 4 neighbouring source temperature, sink temperature and correction values inside _Tsrcs, _Tsnks and _HPPmatrix or _COPmatrix. As a final step the weighted interpolation between the neighbouring values val1 to val4 and val1cop to val4cop is done. Note that src1 to src4 and snk1 to snk4 are identical for _HPPmatrix and _COPmatrix, so they have to be assessed only once.

ANNEX E: WATER HEATING MODEL

E1. Inputs

On the basis of the inputs from Annex B and C this annex gives the mathematical model used to evaluate the energy efficiency of dedicated water heaters. The diagram below gives an overview of the steps in the mathematical model

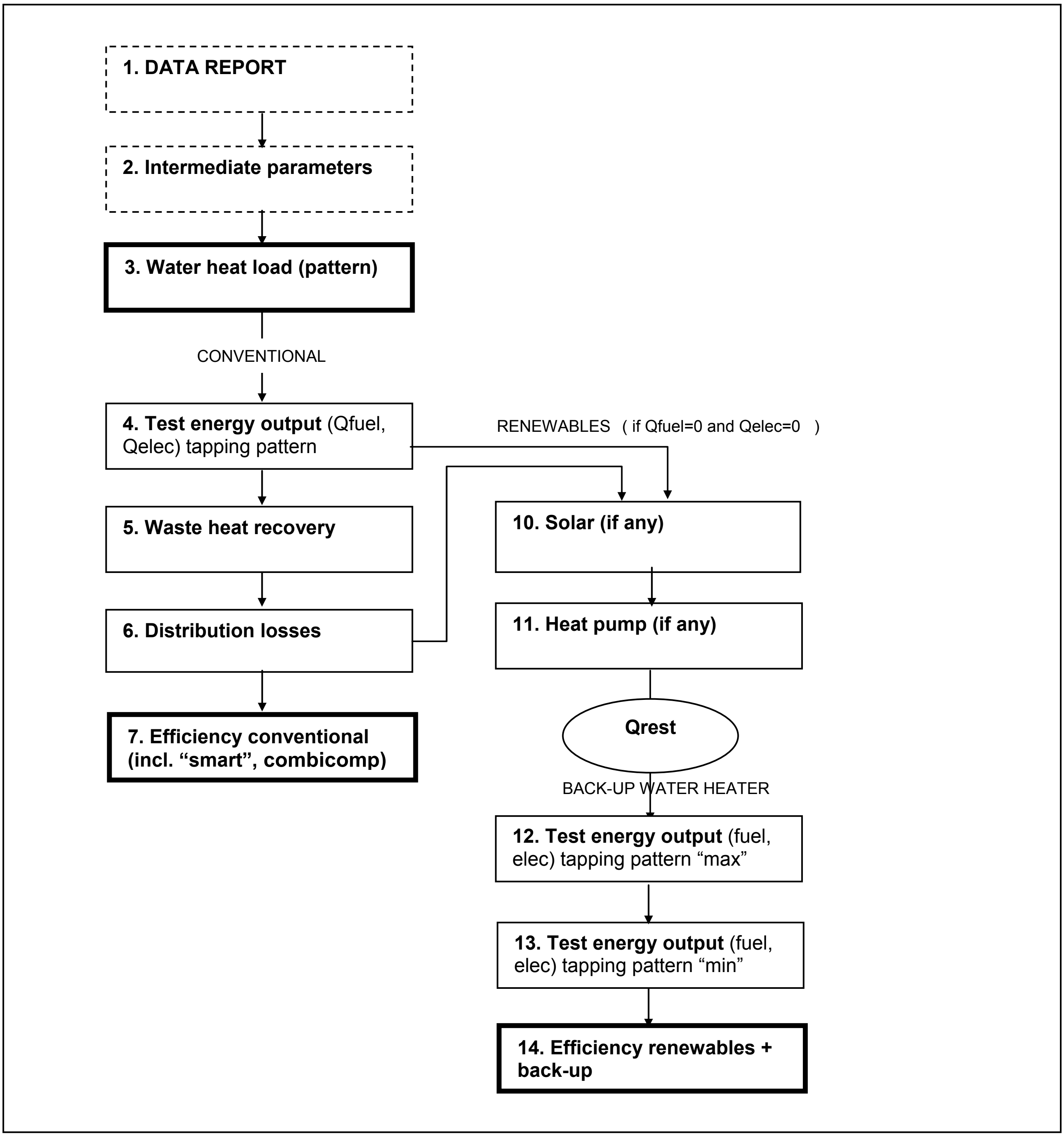


Fig. 7. Water heating (WH sheet) structure, Summary.

E2. Intermediate parameters

Equation D10 for waste heat recovery parameter ***qrecov*** applies.

Equations D11, D12 and D13 for solar technology apply to calculate ***a_c, ηloop*** and ***UL***.

Equation D14 applies to calculate ***Tsrc_ventmix*** for heat pump technology that (also) uses ventilation exhaust air.

The extrapolation of test-points for heat pump technology to arrive at least at a 4x4 matrix follows the methodology and equations as in section D2. 5. The resulting matrices _HPPmatrix, _COPmatrix and the arrays of sink and source temperatures _Tsnks and _Tsrcs are identical to the ones calculated there.

Accounting parameters for the water heating function are less numerous and integrated in the following sections.

Sections E4 to E6 deal with the DIRECT METHOD. Sections E7 to E11 deal with the INDIRECT METHOD (see paragraph C1).

If Qfuel [param. nr. 12.1]>0 and/or Qelec [param. nr. 12.2] > 0 in the DATA REPORT, it is assumed that the Direct Method applies and any values in sections 15, 16 and 18 will be ignored.

E3. Load

For the most part the load for the water heating efficiency assessment is based on the tapping pattern pertaining to the selected water heating load (param. nr. 11.1 in the DATA REPORT). A relatively smaller part of the load, i.e. relating to waste heat recovery and distribution losses, is added through through calculation, based on certain features --size, noise, air intake-- of the Product.

The 24-hour hot water energy output of a test-tapping pattern ***Qref*** [in kWh/d] is given in the last row of table C4 in Annex C. For a realistic representation (e.g. on a label) it is assumed that the full testing pattern represents a peak situation, i.e. in the weekends, and that on average only 60% of the indicated hot water energy of the tapping pattern will be used.

For the conversion from the test load energy to the average annual heat load ***Qaload*** a factor 0.6 (60%) is applied during 366 days (actually 365,2 but rounded upwards to be consistent with a month period of 30,5 days which is easier to factor in into formulas).

***Qaload* [selected load]= 0.6 * 366 * *Qref* [selected load]** E1

The actual annual energy consumption ***Qanet*** is derived from the fossil-fuel consumption *Qfuel* [in kWh] and the electricity consumption *Qelec* [in kWhe] for the test-tapping pattern, also with a multiplier of 0,6 during 366 days. For the electricity consumption *Qelec* the primary energy conversion factor *primenergy* (=2.5) is applied. The expression also takes into account the presence of the smart control ***dhwsmart*** [yes/ no= 1/ 0], which results in a 10% efficiency improvement (see Annex H).

***Qanet* [generic] = (1-*dhwsmart**0,1) * 0.6 * 366 * (*Qfuel+primenergy*Qelec*)** E2a

Note that for electric water heaters (*Qfuel*=0; *Qelec*>0) the efficiency improvement of the smart control can never lead to a primary energy efficiency of more than 40%, hence the function below gives a boundary condition in case Qfuel=0:

***Qanet* [electric water heater] = MAX (*primenergy* * *Qaload*; *Qanet* [generic])** E2b

Note that the ratio (*Qaload/Qanet*) gives the net efficiency for the water heating (excl. distribution losses and without credits for waste heat recovery.

E4. Waste heat recovery

E4.1 Recoverable losses

The calculation of recoverable losses only applies to conventional water heaters. For water heaters with solar and/or heat pump technology the recoverable and recovered losses are treated in section E6.

Basis for the calculation is the assessment of the total losses ***Qwaste*** from the fossil energy consumption *Qfuel* [in kWh] and the electricity consumption *Qelec* [in kWhe] for the tapping pattern compared to the useful energy in the hot water ***Qref*** [in kWh, Qref defined in Annex C].

Qwaste* = *Qfuel* + *Qelec* − *Qref E3

For electric water heaters all waste heat is recoverable : ***Qrwaste*** = *Qwaste*

For conventional dedicated fossil-fuel fired water heaters the recoverable fraction follows from

1. the corrected dew point ***dptc***= ***dpt*** – 6 (assuming an air factor of 1,3)
2. the combustion efficiency ηcomb [param. nr. 13.1, in %]
3. the flue gas temperature Tflue [param. nr. 13.2, in °C]
4. the latent heat loss LHL, depending on the fuel [param. nr. 6.2, if gas then 10% else 6%]

The expression for recoverable waste heat loss is in this case

***Qrwaste* [dedicated gas/oil water heater] = *Qwaste* − (1−*ηcomb)*Qfuel* − IF(*Tflue*<*dptc*+20; ((*Tflue*−20)/(*dptc*+20))**LHL*Qfuel; LHL*Qfuel*))** E4

E4.2 Recovered loss

The percentage of waste heat recovered for the water heater is determined by the parameters boilpos, air_intake, volumeb and noisew and result in the reference value qrecov explained in Annex D2 and equation D10.

The annual credit for heat recovery ***Qarecover*** [in kWh/a] again takes into account only 60% of the test load for a total of 366 days/a

Qarecover* = 0,6 * 366 * − *qrecov* * *Qrwaste E5

E5. Distribution losses

The distribution losses depend on the *airintake* [param. nr. 7.1, values 1/2/3 corresponding to "none (electric)", "room sealed" / "open"] and *volumeb* [param. nr. 7.3, in m^3], as is shown in the table. Values take into account only distribution losses inside dwellings. For collective/centralized systems as well as circulation systems extra distribution losses and –in case of an extra store—storage losses are to be taken into account in application-oriented measures (see also Annex J).[3]

[3] Under consideration: Add forfaitary extra distribution losses for load profiles XXL, 3XL, 4 XL because at least in part they will be used in centralised systems.

Table E1. Determination of parameter Qwdistr										
parameter = Qwdistr [kWh/a]										
air_intake	**volumeb**	**Load profile**								
[−]	**[m3]**	**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**	**3XL**	**4XL**
none (electric)	<=0,5	15	15	15	15	15	15	15	15	15
	>0,5	80	80	120	240	240	240	240	480	960
room sealed	<=0,1	15	15	80	120	240	240	240	480	960
	>0,1, <0,15	80	80	120	160	240	240	240	480	960
	>=0,15	80	80	120	240	240	240	240	480	960
open	any value	80	120	240	240	240	240	240	480	960

The primary energy for distribution ***Qadistr*** is found by applying the previously found net efficiency (*Qaload/Qanet*) to the established ***Qwdistr*** [in kWh/a]:

Qadistr = (Qanet/Qaload)*Qwdistr **E7**

E6. Direct Method: Efficiency

The preliminary annual energy consumption of the water heater ***Qawh*** results from the summation of the energy consumption for water heating *Qanet* and the distribution losses *Qadistr*

Qawh=Qanet+Qadistr **E8**

For the final annual energy consumption of the conventional water heater ***Qatot*** also the credits (negative value!) from the waste heat recovery *Qarecover* are taken into account

Qatot = Qawh + Qarecover **E9**

The total efficiency of the conventional water heater ***ηwh*** is given by

ηwh = Qaload/ Qatot **E10**

In the Data Report, Output B.1 “Water heat net load” corresponds to ***Qaload***. Output B.2. “Water heat primary energy use” is ***Qatot*** and Output A.3 “Water heat energy efficiency” is given by ***ηwh.***

E7. Water heater with renewables: load and partitioning

The annual reference load *Qaload* [in kWh/a] and the distribution losses *Qadistr* [in kWh/a] are used as an input for the monthly solar load ***Qsolloadw***:

***Qsolloadw = (Qaload + Qadistr)*/12** **E11**

E8. Solar contribution

The table below gives the consecutive expressions to be solved to calculate the solar contribution to water heating ***Qsolnetsavew*** and the remaining water heating load after the solar contribution ***Qsolrestw***. The expressions are taken from EN 15316-4-3 with a second iteration to include the tank and piping losses (***Qsoltankw*** and ***Qsolpipew***) in the load. The calculation is done per month.

Table E2. Solar contribution to water heating Qsolnetsavew and remaining water heating load Qsolrestw per month		
Eq. Nr.	**Expression**	Boundary condition
E16	Trefw =11,6+1,18*40+3,86*Tcold−2,32*Toutm	
E17	Asolw= partsolw * Asol	
E18	Vsolw= partsolw * Vsol	
E19	Ccapw = POWER(75 *Asolw/ Vsolw;0,25)	IF(Vsolw>0; Ccapw;0)
E20	Xw1= Asolw*(a_c+ UL) *ηloop*(Trefw − Toutm) * Ccapw * 732 / (Qsolloadw*1000)	IF(AND(Qsolloadw>0;Asolw>0);X1;0)
E21	Yw1= Asolw*IAM*η0*ηloop*qsolm*732 / (Qsolloadw*1000);0)	IF(Qsolloadw>0;Y1;0)
E22	Qsolw1= Qsolloadw * (1,029*Yw1 − 0,065*Xw1 − 0,245*Yw1*Yw1 + 0,0018 * Xw1*Xw1+ 0,0215*Yw1*Yw1*Yw1)	MAX(0; MIN(1;Qsolw1/Qsolloadw))
E23	Qsoltankw= partsolw *0,001*UA*(60− (Toutm+solpos*(20−Toutm))) *(Qsolw1/Qsolloadw)*732	IF(Qsolloadw>0;Qsoltankw;0)
E24	Qsolpipew= partsolw*0,02*Qsolloadw*(Qsolw1/Qsolloadw)	IF(Qsolloadw>0;Qsolpipew;0)
E25	Qsolloadw2= Qsolloadw+Qsoltankw+Qsolpipew	
E26	Xw2= Asolw*(a_c+ UL)*ηloop*(Trefw − Toutm) * Ccapw * 732 / (Qsolloadw2*1000)	IF(AND(Qsolloadw2>0;Asolw>0);X2;0)
E27	Yw2= Asolw*IAM*η0*ηloop*qsolm*732 / (Qsolloadw2*1000);0)	IF(Qsolloadw2>0;Y1;0)
E28	Qsolw2= Qsolloadw2 * (1,029*Yw2 − 0,065*Xw2 − 0,245*Yw2*Yw2 + 0,0018 * Xw2*Xw2+ 0,0215*Yw2*Yw2*Yw2)	MAX(0; MIN(1;Qsolw2/Qsolloadw2))
E29	Qsolloadrestw = Qsolloadw2 – Qsolw2	
E30	Qsolauxlossw = partsolw * 0,001 * (2000*qsolm/Q_solm)*solaux*(2,5−0,85*solpos)	IF(Asol>0; Qsolauxlossw; 0)
E31	Qsoltankrecovw = (solpos*0,55)*0,001*UA*(60 − (Toutm+solpos*(20−Toutm))) * (Qsolw2/Qsolloadw2) * 732	IF(Qsolloadw2>0; Qsoltankrecovw;0)
E32	Qsolnetsavew= Qsolloadw−Qsolloadrestw−Qsolauxlossw+Qsoltankrecovw	MIN(Qsolloadw; MAX(0; Qsolnetsavew))
E33a	**Qsolrestw** = Qsolloadw – Qsolnetsavew	
E33b	**Qsolnetconsw** =Qsoltankw+Qsolpipew+Qsolauxlossw-Qsoltankrecovw	

The net energy consumption of the solar installation ***Qsolnetconsw*** is used in the calculation of the output.

The remaining water heating load *Qsolrestw* is used as an input for the calculation of the heat pump technology contribution. Note that if there is no solar contribution (*Qsolnetsavew*=0) the remaining load equals the original water heating load *Qsolloadw* = *Qaload* + *Qadistr*.

E9. Heat pump contribution

The methodology for the heat pump water heater is the same as the one for the heat pump space heater, except for a different sink temperature and the inclusion of a hot water tank. The first leads to an adjustment of the seasonal correction. The second leads to an adjustment of the load parameters.

<u>*E9.1. Seasonal correction*</u>

The heat pump water heater uses the same methodology for 'seasonal correction' of output power and COP as the space heater, described in par. D 2.5. Also, not only the equations are the same, but most of the results are identical: the arrays of source- and sink temperatures ***_Tsrcs*** and _Tsnks, the matrices with correction factors _HPPmatrix and _COPmatrix.

And even the source temperature Tsrc, and therewith the value for row, src1, src2, src3 and src4, are identical as the ones in par. D11.

For the seasonal correction, the only change is in the sink temperature Tsnk. The water heating sink temperature *Tsnkw* is given by the minimum feed temperature required to realize the tapping pattern ***Tsinkhw*** [in °C] or the input parameter for the maximum sink temperature ***Tsnkmax*** [param. nr. 16.6, in °C], whichever is lowest.

Tsnkw* = MIN*(Tsinkhw;Tsnkmax) **E34**

The value of *Tsinkhw* is set at 65 °C, corresponding to a feed temperature of the heat exchanger to the tank, needed to realize a draw-offs of 55-60 °C (temperature difference between feed- and tank temperature of 5-10 K).

The different sink temperature Tsinkw results in different 'neighbouring' sink values snk1 to snk 4. As a consequence the final correction factors are different. In order to make the distinction with Annex D, the equations numbers and parameters below use the postfix "w" but are otherwise the same as in Annex D, except for Tsnk.

Table E3. Assessment per day-period of water heating correction factor for output power *hppcorrw* and Coefficient of Performance *COPcorrw*

Eq.nr.	**Equation**
D110w	**colw** = MATCH(Tsnkw;_Tsnks)
D114w (a)	**snk1w** =INDEX(_Tsnks;colw)
D115w (a)	**snk2w** =INDEX(_Tsnks;colw+1)
D115w (b)	**snk3w**= INDEX (_Tsnks;colw+1)
D114 w(b)	**snk4w** =INDEX(_Tsnks;colw)
D116w	**Val1w** =INDEX(_HPPmatrix; row;colw)
D117w	**Val2w** = INDEX(_HPPmatrix;row;colw+1)
D118w	**Val3w** =INDEX(_HPPmatrix;row+1;colw+1)
D119w	**Val4w**= INDEX(_HPPmatrix;row+1;colw)
D120wa	**hppcorrw** ==val3w*ABS(((src1-Tsrc)*(snk1w-Tsnkw))/((src1-src4)*(snk1w-snk2w)))+ val4w*ABS(((src2-Tsrc)*(snk2w-Tsnkw))/((src1-src4)*(snk1w-snk2w)))+ val1w*ABS(((src3-Tsrc)*(snk3w-Tsnkw))/((src1-src4)*(snk1w-snk2w)))+ val2w*ABS(((src4-Tsrc)*(snk4w-Tsnkw))/((src1-src4)*(snk1w-snk2w)))
D121w	**Val1copw** =INDEX(_COPmatrix;row;colw)
D122w	**Val2copw** =INDEX(_COPmatrix;row, colw+1)
D123w	**Val3copw** =INDEX(_COPmatrix;row+1;colw+1)
D124w	**Val4copw** = INDEX(_COPmatrix;row+1;colw+1)
D125wa	**COPcorrw** = val3copw*ABS(((src1-Tsrc)*(snk1w-Tsnkw))/((src1-src4)*(snk1w-snk2w)))+ val4copw*ABS(((src2-Tsrc)*(snk2w-Tsnkw))/((src1-src4)*(snk1w-snk2w)))+ val1copw*ABS(((src3-Tsrc)*(snk3w-Tsnkw))/((src1-src4)*(snk1w-snk2w)))+ val2copw*ABS(((src4-Tsrc)*(snk4w-Tsnkw))/((src1-src4)*(snk1w-snk2w)))
Recalculation per month	
D120wb	**hppcorrwm**=(2*hppcorrw[morn]+7*hppcorrw[mid]+5*hppcorrw[eve]+2*hppcorrw[late]+ 8*hppcorrw[night])/24
D125wb	**COPcorrwm**=(2*COPcorrw[morn]+7*COPcorrw[mid]+5*COPcorrw[eve]+2*COPcorrw[late]+8*COPcorrw[night])/24

E9.2 Hot water tank

In prEN 15316-4-2the sanitary hot water tank is only partially taken into account. In the method an adjustment had to made because in a water heater using heat pump technology, this tank plays a role in two ways:

- It results in standby heat losses and
- It places restrictions on the hot water capacity of the heat pump technology. E,g. if the tank is too small it is less capable of meeting the requirements of the tapping pattern and therefore a larger part of the tapping pattern has to be filled in by the back-up heater. Compare: in solar technology this restriction is expressed by the parameter Ccapw.

The standby heat losses ***Qhptankw*** depend on the measured power loss Pstbyhp [param. nr. 16.9, in W]. The monthly value of *Qhptankw* is given by the equation

***Qhptankw = parthpw* * 0,001*Pstbyhp*732** E35

Boundary condition IF(*Phpnom*>0; *Qhptankw*; 0)

The hot water capacity of a hot water tank depends on its effective volume *Vhp* [param. nr. 16.8, in ltr.] and its stratification. For a full coverage of the tapping pattern the nominal volume *Vhp* should be 1,66 times the largest tapping in the waterload. This parameter follows from the tapping patterns and is called ***tapmax*** (in ltr., see reference conditions Annex C).

Stratification is measured in standards EN 12897, EN 60379, prEN 50440 as the variable that is named here ***V40hp*** [param. nr. 16.10].

V40hp is the total energy equivalent of litres of 40 °C hot water at inlet temperature of 15 °C and a storage tank initial temperature of 65 °C that can be drawn off at an outlet water temperature above or equal to 40 °C, expressed as the fraction of the nominal tank volume Vhp. Theoretically, the maximum value of V40hp with this definition is 2. Tests may also be performed at different inlet, outlet and initial storage temperatures, e.g. as defined in prEN 15332, but shall always be recalculated to the definitions above. In such a case the manufacturer is required to state the actual temperatures and the calculation method used.

the correction for the tank volume for the heat pump water heating function is now

***Vhp* / (2 /V40hp * 1,66 * *tapmax*)** E36

This expression is part of the water heater load *Qhploadw* .

E9.3 Heat pump parameters

The table below gives the consecutive expressions to be solved to calculate the heat pump contribution to water heating Qhpnetconsw and the remaining water heating load after the heat pump contribution Qresthpw. The calculation is done per month.

Table E4. Heat pump contribution to water heating Qhpnetconsw and remaining water heating load Qresthpw per month

Eq. Nr.	Expression	Boundary condition
E37	Qloadhpw =Qsolrestw	
E38	Qhptankw = parthpw*0,001*Pstbyhp*732 (identical to E35)	=IF(AND(Phpnom>0;Qhploadiniw>0); Qhptankw;0)

E39	Qhploadw=(Tsnkmax−10)/(Tsinkhw−10)* ((Vhp / (2/V40hp * 1,66 * tapmax)) * Qloadhpw+Qhptankw)	IF((Tsnkmax−10)/(Tsinkhw−10)>1; (Tsnkmax−10)/(Tsinkhw−10)=1)
		
		IF(Vhp /(2,2/V40hp*1,66*tapmax) >1; Vhp /(2,2/V40hp*1,66*tapmax) =1)

E40	Qhpmaxw= parthpw*Phpnom*732*hppcorrwm	
E41	Fcw= Qhploadw/ Qhpmaxw	IF(Qhpmaxw>0; Fcw;0) Fcw=MAX(0;MIN(1;Fcw))
E42	COPpartcorrw= COP50+2*(1−COP50)* (FCw−0,5))	
E43	COPcorr2w=COPcorrwm*COPpartcorrw*COPnom	
E44	Qhpw= MIN(Qhploadw;Qhpmaxw)	
E45	Qhpwcons= IF(HPtype<4; primenergy; 1)* (Qhpw/COPcorr2w)	IF(AND(Phpnom>0;COPcorrw>0); Qhpwcons;0)
E46	Qhpaux=parthpw*primenergy*0,001*732*hpaux* FCw	IF(Phpnom>0;Qhpaux;0), IF(Fcw>1; Fcw=1)
E47	Qhprecovw=0,55*(Qhptankw+Qhpauxw/ primenergy)	
E48	Qhpnetconsw= Qhpwcons+Qhpauxw~~+Qhptankw~~−Qhprecovw	
E49a	Qhprestw =Qloadhpw+Qhptankw – Qhpw +Qloadmissw	MAX(0;Qhprestw)
E49b	Qloadmissw = Qhploadiniw + Qhptankw - Qhploadw	

The heat pump energy consumption ***Qhpnetconsw*** is a direct input for the final energy consumption. The remaining water heating load after the contribution of the heat pump and/or solar ***Qhprest-w*** is an inputfor the calculation of the back-up water heater.

E10. Back-up water heater

The annual load input for the back-up water heater is the summation of the remaining monthly load after the heat pump:

Qloadrest=SUM(Qhprestw) **E50**

The energy consumption of the back-up water heater is determined by extra-/interpolation of the primary energy consumption data found in the tests at two different load patterns *waterloadmin* and *waterloadmax* [param. nr. 18.1 and 18.4]. The hot water energy equivalent per 24h [in kWh/d] Qaloadmin and Qaloadmax of these two patterns can be looked up in table C4. The difference between those two, multiplied with the number of days and the factor 0,6 explained earlier, is called ***dQaload*** [in kWh/a]

dQaload= Qaloadmax − Qaloadmin **E51**

Then the actual primary energy consumption per 24h for each tapping pattern is assessed. This amounts to *Qfuelmin+primenergy*Qelecmin* for the smaller pattern and *Qfuelmax+primenergy*Qfuelmax* for the larger tapping pattern. The difference between the the two tests outcomes, projected over a year, is called ***dQanet*** [in kWh/a]

dQanet= 366*0,6*((Qfuelmax-Qfuelmin)+primenergy*(Qelecmax-Qelecmin)) **E52**

With the above the increment ***Inc*** [in kWh/kWh] can be defined

Inc= dQanet/ dQaload **E53**

Inc is used to make the extrapolation to find the primary energy use for the back-up heater ***Qgrossrest*** [in kWh/a] for the situation that Qloadrest>0:

Qgrossrest =MAX(Qloadrest;IF(Qloadrest>0;366*0,6*(Qfuelmin+primenergy*Qelecmin)+Inc*(Qloadrest-Qaloadmin);0)) **E54**

E11. INDIRECT METHOD: Efficiency

The total energy consumption for the water heater ***Qatot2*** follows from the annual consumption data of back-up heater, the solar installation and the heat pump.

Qatot2 = Qgrossrest + SUM(Qsolnetconsw)+ SUM(Qhpnetconsw) **E55**

The total efficiency of the water heater with solar and/or heat pump technology *ηwh2* is given by

ηwh2 = Qaload/ Qatot2 **E56**

E12. Final rating

In the DATA REPORT, Output B.1 “Water heat net load” corresponds to ***Qaload***.
Output B.2. “Water heat primary energy use” is ***Qatot*** for conventional water heaters (Qfuel+Qelec>0) and ***Qatot2*** for water heaters with renewables. Output A.3 “Water heat energy efficiency” is given by ***ηwh*** for conventional water heaters and ηwh2 for water heaters with renewables .

B.1= Qaload **E57**

B.2= IF(Qfuel+Qelec>0; Qatot; Qatot2) **E58**

B.3= IF(Qfuel+Qelec>0; ηwh; ηwh 2) **E59**

Annex F: Direct Testing Methods

F1. Electric instantaneous water heater (EIWH)

Scope

This Annex describes a test method for electric instantaneous water heaters (EIWH) that can be used to generate the value Q_{elec} for the selected tapping pattern. The measuring equipment should respond fast enough to enable correct measurement of power, including reactive power. Electric showers are a special case for which the test conditions below do not apply. Electric showers are to be tested according to the XS testing pattern as defined in Annex C.

General conditions for measurements

- Ambient temperature: 20ºC ± 2 K
- Cold water inlet temperature T_{in}: 10ºC ± 2K
- Flow rate: ± 1%
- Power supply :230/400 V ± 1 %, 50 Hz ± 1%
- Water pressure (dynamic) at the water inlet: within the range indicated by the manufacturer
- Mounting / positioning of appliance: according to manufacturers instructions

List of measurements to be carried out:

- Water flow rate (l/min);
- Power consumption (effective power per time interval) (kWh) ;
- Cold water inlet temperature (ºC);
- Hot water outlet temperature (ºC);
- Elapsed time (s).

Test procedure

Step 1 Measurement of static losses

- Measurements shall commence after min. 30 min at max. load.
- Measure at nominal load the difference in effective power between the mains terminals and the heating elements. The difference in power is called P_{loss} [in kW].
  NOTE 1 The measurements are carried out by measuring the voltage across the terminals and the connectors of the heating elements and measuring the current of each phase. P_{loss} is the sum of the products of the measured voltage and current of each phase.
  NOTE 2 For electronic instantaneous water heaters the voltage between the power terminals of the triacs is subtracted from the measured voltage.
- In order to increase exactness of results the measurement can be done with measuring devices operating in their optimal measurement range and using a measurement time interval as long as necessary to attain reliable results
- Uncertainty of voltage measurement: ± 0,2%;
- Uncertainty of current measurement: ± 0,5%;
- The energy loss for part load operation can be derived through linear interpolation. Determine the static power P_{static} [in kW] for each type of draw-off defined in the tapping pattern.
- $\eta_{static} = (P_{static} - P_{loss}) / P_{static}$

Step 2 Measurement of start-up losses Q_{start}

- The test shall measure the time it takes for the appliance to reach the required minimum outlet temperature per tapping: t_{start} [in s] starting from the point of energizing the heating elements. This is done using the prescribed flow rate. The flow rate should not be lower than the minimum flow rate of the appliance.
- The test method assumes that the power consumption during the start-up period is equal to the power consumed in static mode for that specific draw-off.
- The accuracy of the flow rate measurement is ± 0.1 l/min

- The accuracy of measurement of temperature is ± 1 K; the temperature sensor being a thermocouple having a diameter of max. 0,5 mm located in the middle of the water stream directly at the outlet of the appliance.
- The accuracy of measurement of time is at least ± 0,1 seconds for electronic measuring devices;
- At least three measurements shall be done. The result is the mean value from these measurements.
- T_{out} $T_{out} = T_{in} + 14{,}3 * (\boldsymbol{P_{static}} - \boldsymbol{P_{loss}}) / f$ (theoretical continuous flow water outlet temperature)

Step 3 Calculation of energy losses
Calculate per tapping:

- the energy loss for the tapping: $\boldsymbol{Q_{taploss} = Q_{start} + (1 - \eta_{static}) Q}$ [kWh].
  <u>Key ((to be added to list of parameters))</u>

$\boldsymbol{Q_{taploss}}$	energy loss for the tapping
Q	the useful energy content per draw-off [in kWh], defined in the table C4
$\boldsymbol{P_{static}}$	electrical power input (see Step 1) [in kW],
$\boldsymbol{P_{loss}}$	power loss (see Step 2) [in kW].

- the start-up energy loss: $Q_{start}[kWh] = t_{start} \frac{1}{3600} * (\frac{(T_{out} - T_{in}) * f}{14{,}3} + P_{loss})$.

Calculate the energy input per tapping. Add these to calculate the daily cycle energy input Q_{elec} [in kWh/d].

$$Q_{taplossi} = Q_{starti} + (1 - \eta_{static}) * Q_i$$

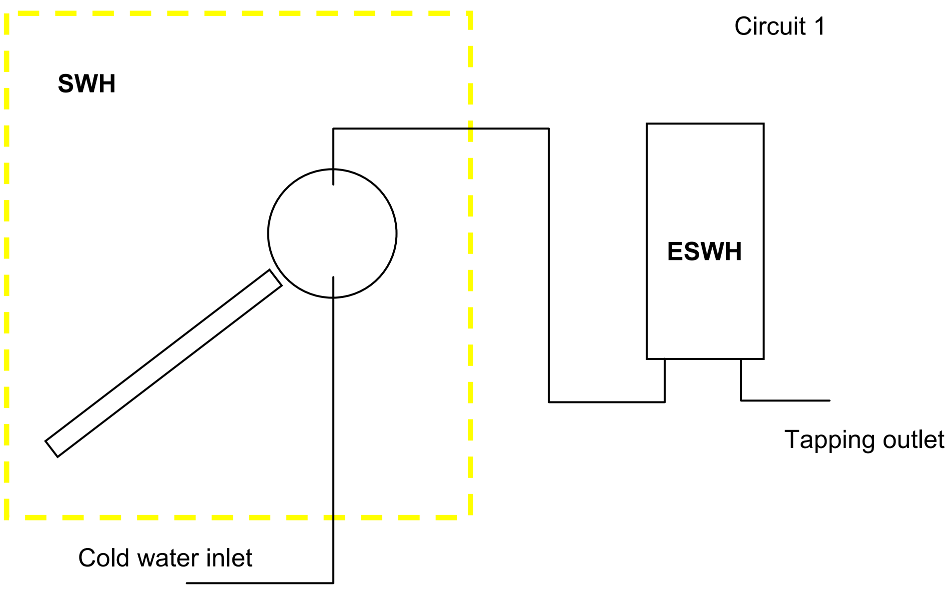
$$Q_{elec} = \sum_{i=1}^{n} (Q_{taplossi} + Q_i)$$

F2. Solar water heater (SWH) with electric storage water heater (ESWH) integration

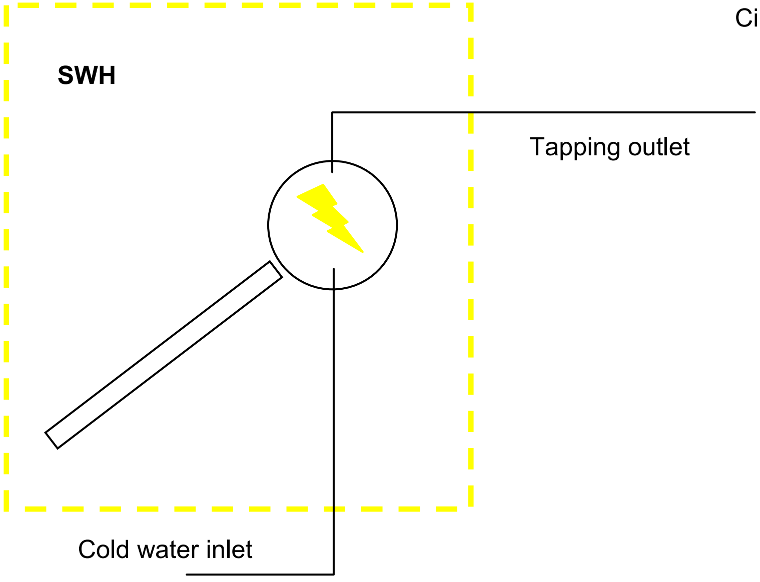
Scope
This Annex describes a test method for solar water heater (SWH) with electric storage water heaters (ESWH) integration that can be used to generate the value *Qelec* for the selected tapping pattern. It can be used to verify if a specific waterload is respected as well.
This test methodology is used for appliances that can work in "night tariff conditions" as well.

Preface

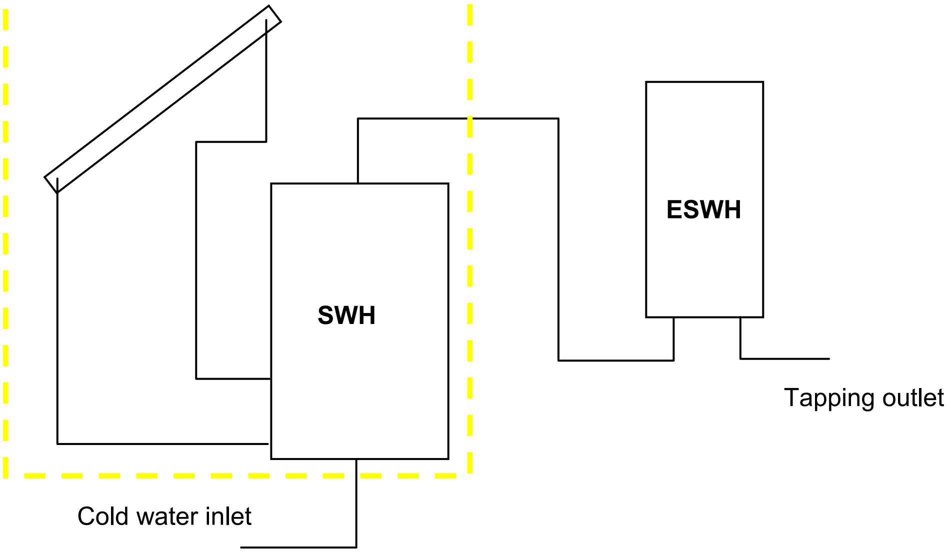
The following SHW configurations are considered:
1. Thermosiphon solar water heaters with external electric backup
2. Thermosiphon solar water heaters with internal electric backup
3. Forced circulation solar water heaters with external electric backup
4. Forced circulation solar water heaters with internal electric backup



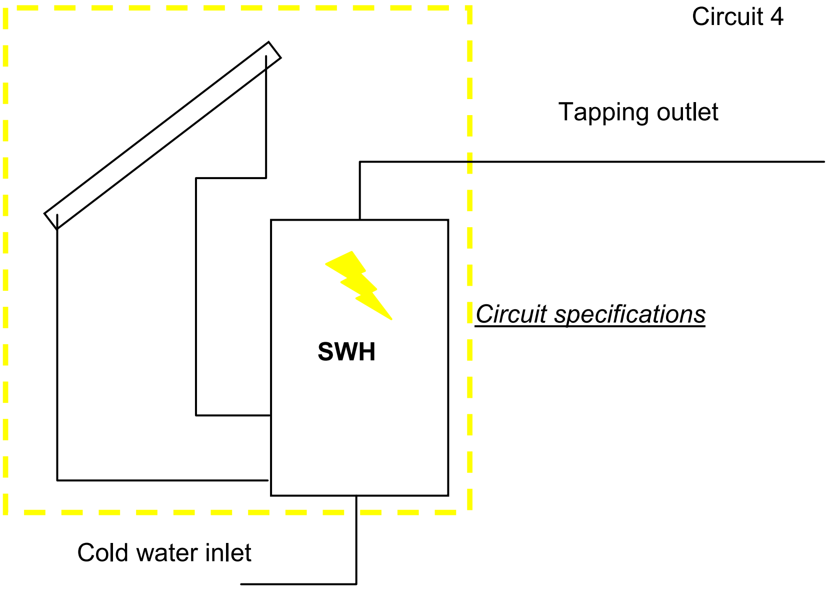
Circuit 2



Circuit 3



Circuit 4



Circuit specifications

The water is supplied to the solar water heater at a temperature θ_C = (10 ± 2) °C and provided from a source having a substantially steady pressure.

The water supplied to the ESWH (if present) is the outlet of solar cylinder.
If a closed water heater is tested, a pressure-relief device (comply with EN 1487) shall be installed on its inlet tube.

All other installation requirements are made according to the manufacturer's instructions.
These test conditions shall be maintained for all the test duration.

General conditions for measurements: solar cycle

For other ESWH installation and measurement consider Annex G.1.
Solar water heater shall be installed according manufacturer specifications and solar good practice.

Testing conditions are to be in line with Annex V indirect method and are inspired by EN 12975-2 5.4
More specifically tests shall be performed at an ambient temperature of 9 ºC throughout the whole tapping cycle and the global solar irradiance in W/m2 shall be according to the following 24h cycle:

24 h Solar Test Cycle in line with Annex V results, at a fixed outdoor temperature Tout= 9 ºC

h	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**total**
W/m2	0	0	0	0	0	0	100	180	250	320	370	415	460	500	540	480	230	50	0	0	0	0	0	0	**3895**

The test can be performed with a solar irradiance simulator or with a solar collector simulator as defined in prEN 13203-3 or Annex G3.

Preparation of the storage water heater
See Annex G.1.

Preparation of the solar water heater
Solar water heater shall be installed according the manufacturing instruction. If some electrical devices are used it's necessary to measure the electrical consumption.

Properties of thermostat
See Annex G.1.

Measurement uncertainties
See Annex G.1 and EN 12975-2 chapter 6.1.2

Definitions

Electricity consumption, Qelec: the electricity consumption (in kWh electric) at test pattern defined in Annex C, Table C4; it is measured during any 24 h period with withdrawals (step 4: tapping profile).

Thermostat of the appliance: the thermostat of the water-heater, whose settings have been fixed by the manufacturer before to leave the production plant.

Test procedure

The test to perform any ESWH in series to a SWH shall be made following the sequence of steps below.

Step 0: Filling up. The solar water heater and the electric storage water heater are filled up with water having a temperature of (1**0** ± 2) °C. The filling up shall be finished when the pressure is 3 bar. This step starts at t_0 and ends at t_1.

Step 1: SWH and ESWH heating up. At t_1 the solar water heater is heated by sun (according general conditions in the table F3.1) till t_2. At time t_2–X (X is the calculated heating up time of the ESWH) the heating up of the ESWH according to the Annex G-Step 2 starts.

Step 2: First draining and ESWH stabilization. At t_2 a volume corresponding to the capacity of the connection pipe between the SWH and the ESWH (if present) is drawn off to heat it up. The stabilization according **to Annex G.1**-Step 3 starts.

Step 3: TAPPING PROFILE (water withdrawal and 24h cycle): according **to Annex G.1**-Step 4 except should be considered the electrical consumption of the solar electrical devices $E_{solar\ devices}$.
The Q_{elec} becomes:

$$Q_{elec} = E_{withdrawal-HW} + E_{loss-24h} + E_{solardevices}$$

ANNEX G: Examples of Direct Test Methods (informative)

G.1: Direct test method for ESWHs

This Annex describes a test method for (closed and open-outlet water heater) electric storage water heaters (ESWH) that can be used to generate the value $Qelec$ for the selected tapping pattern. It can be used to verify if a specific WHL (Water Heater Load, described by a selected tapping pattern) is respected as well. This test methodology is used also for appliances that can work in "night tariff conditions".

G1.1 General conditions for measurements

Unless otherwise specified measurements are carried out on the water heater operating

- in a substantially draught-free room
- at an ambient temperature θ_{amb} = (20 ± 2) °C.

The ambient temperature is calculated from measurements at a number of locations half-way between the water heater and the walls of the room or 1 m distant from the water-heater, whichever is less, and at half the height of the water-heater.

Three different probes are used to measure the water temperature:

- at the dome. The position of the temperature probe is indicated in EN 60379;
- on outlet tube. The position of the temperature probe is immerged in the water flow near the outlet tube of water heater. This probe shall have a response time very fast to measure any temperature changing due to hot water flow; a thermocouple type T should be used;
- on inlet tube. The position of the temperature probe is immerged in the water flow near the inlet tube of water heater.

Measurements shall be carried out with a supply voltage of 230/400 V ± 2%

The water is supplied at a temperature θ_C = (10 ± 2) °C and provided from a source having a substantially steady pressure.
If a closed water heater is tested, a pressure-relief device shall be installed on its inlet tube[4].
All other installation requirements are made according to the manufacturer's instructions.
These test conditions shall be maintained for all the test duration.

G1.2 Preparation of the storage water heater

Wall-mounted water heaters are mounted on a panel situated at least 150 mm from any structural wall.

There shall be a clear space of at least 250 mm above and below the heater and at least 700 mm at the sides and front.

Floor-mounted water heaters are placed on the floor or on any stand supplied with them. A false floor may be used to facilitate measurements.

Water heaters for building-in are built in according to the manufacturer's instructions.

The water heater is connected to the water system by means of a pressure hose; the delivery pressure is 3 bar.

Any tube and fitting, used for the test, shall be thermal-insulated if they are not mentioned in the manufacturer's instructions.

[4] as in EN 1487

G1.3 Properties of thermostat
It is the thermostat of the water-heater, whose settings have been fixed by the manufacturer before to leave the production plant. This thermostat is used to ensure the switching on- and off-level of the heater.

G1.4 Measurement uncertainties
Except where otherwise stated in the clauses describing the tests, tThe uncertainties of measurements carried out shall be not greater than the maximum uncertainties indicated below.
These uncertainties correspond to two standard deviations.
The laboratory evaluates these standard deviations taking account of the various sources of uncertainty: contribution from the instrument, repeatability, calibration, ambient conditions, etc.

- Temperatures:
  - ambient: ±1 °C
  - water: ±0,5 °C
- Pressure: ±5 %
- Water flow rate: ±1 %
- Electrical energy: ±1 %
- Thermal energy withdrawn: single withdrawal (±10 Wh or max. ±2%), total (max. ±2%)
- Time: ±0,2 s
- Water volume: ±0,5 %

The stated measurement uncertainties relate to individual measurements. For measurements that combine a number of individual measurements, smaller uncertainties on the individual measurements may be necessary to ensure a total uncertainty within ±2 %.

G1.5 Definitions

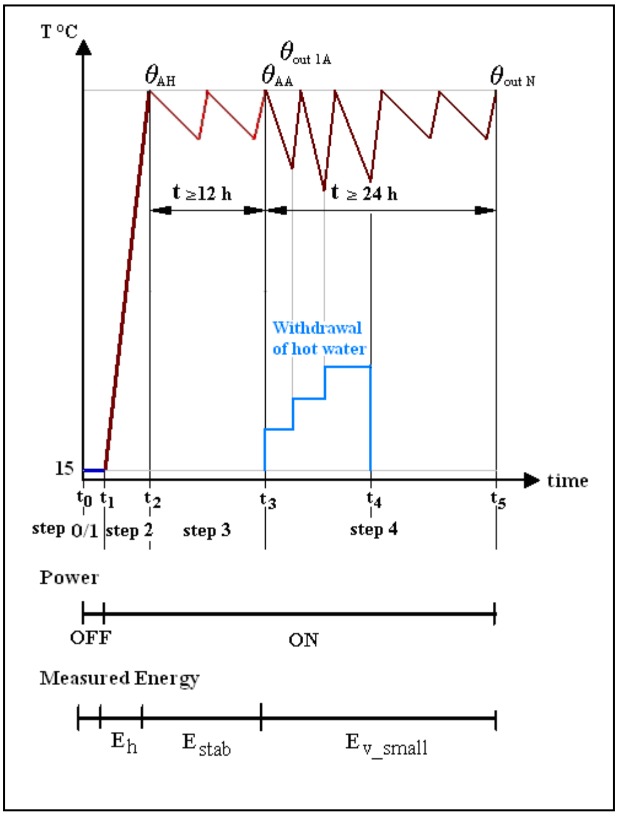
Electricity consumption, Qelec: it is the electricity consumption (in kWh electric) at test pattern selected in the mathematical model (i.e. Water Heating Load) for EuP directive; it is measured during any 24 h period with withdrawals (step 4: tapping profile).

Thermostat of the appliance: it is the thermostat of the water-heater, whose settings have been fixed by the manufacturer before to leave the production plant.

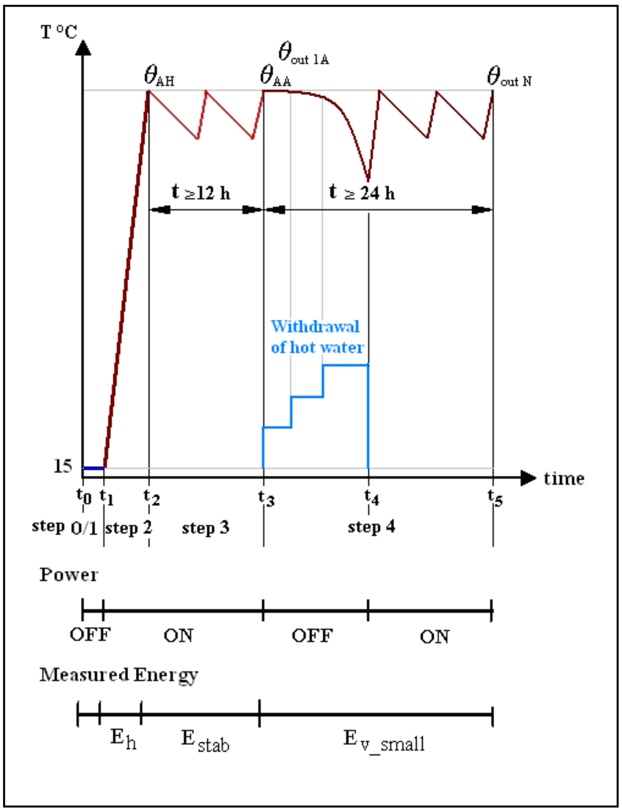
G1.6 Test procedure

The test to perform any ESWH shall be made following the sequence of steps shown in the figures below.

POWERED APPLIANCES



"NIGHT TARIFF" APPLIANCES



Step 0: Water heater stabilization. Before starting the test, the water heater must be pre-conditioned at temperature of (20 ± 5) °C for at least 24 h.

Step 1: Filling up. The water heater is filled up with water having a temperature of (10 ± 2) °C. The filling up shall be finished when the pressure is 3 bar. This step starts at t_0 and ends at t_1.

Step 2: Heating up. At t_1 the water heater is powered ON. The heating up starts until t_2, defined as the first cut out of the appliance thermostat. This temperature is defined by the manufacturer to be in compliance with the constraint conditions fixed by the chosen tapping profile (WHL) and the temperature sensor is located at the dome in contact with water.
The software will record the following data:

$$E_h = E_{h-\exp} \cdot \frac{(\theta_{AH} - 10)}{(\theta_{AH} - \theta_C)} \text{ [kWh]} \qquad (1)$$

$$t_{h\_\exp} = t_2 - t_1 \qquad \text{[hh:mm:ss]} \qquad (2)$$

$$t_h = t_{h\_\exp} \cdot \frac{\theta_{AH} - 10}{\theta_{AH} - \theta_C} \qquad \text{[hh:mm:ss]} \qquad (3)$$

P_{mis} [W] (4)

with:

- $E_{h\text{-}exp}$ [kWh]: it is the measured heating up energy;
- E_h [kWh]: it is the normalized heating up energy;

- $t_{h\_\exp}$ [hh:mm:ss]: it is the actual heating up time;
- t_h [hh:mm:ss]: it is the normalized heating up time;
- θ_{AH} [°C]: it is the actual water temperature at the dome when there is the first cut out of the thermostat;
- θ_C [°C]: it is the initial water temperature in the tank (in particular, it is the average between the dome temperature and the inlet temperature, measured at the end of the filling up);
- P_{mis} [W]: is the actual power of the appliance measured at t_1.

Step 3. System stabilization: the water heater remains energised with water and without withdrawals for at least 12 hours (starting from t_2). This procedure aims at stabilizing thermally the system. This step is checked by the appliance thermostat and ends when there is the first cut out of the thermostat, after 12 hours.

The data acquisition system will record:

- when there is the first cut out of the appliance thermostat after 12 hours, t_3 [hh.mm.ss.]
- the water temperature at t_3, θAA [°C]
- the actual energy E_{stab} consumed between t_2 and t_3 [kWh].

After this stabilization step, the withdrawal step will start according to the tapping profile defined by the manufacturer/laboratory (see table C4).

Step 4. TAPPING PROFILE (water withdrawal and 24h cycle): the test shall be made choosing a "tapping pattern" profile, in compliance with Table C4 for the waterload selected by the manufacturer.

During step 4, the water heater is energised and the cut-in and cut-out temperatures are checked by the appliance thermostat.

This step can be viewed as the sum of two energetic contributes:

- TAPPING PROFILE CYCLE. The electrical consumption that is due to WHL chosen (Water Heater load; i.e. withdrawal of hot water);
- STAND-BY CONDITION. The electrical consumption that is due to standing losses condition.

These two contributes are named $E_{withdrawal\text{-}HW}$ and $E_{loss\text{-}24h}$ and then Qelec, total electrical consumption (after the normalization, in terms of nominal quantity of hot water and time [24h]), is:

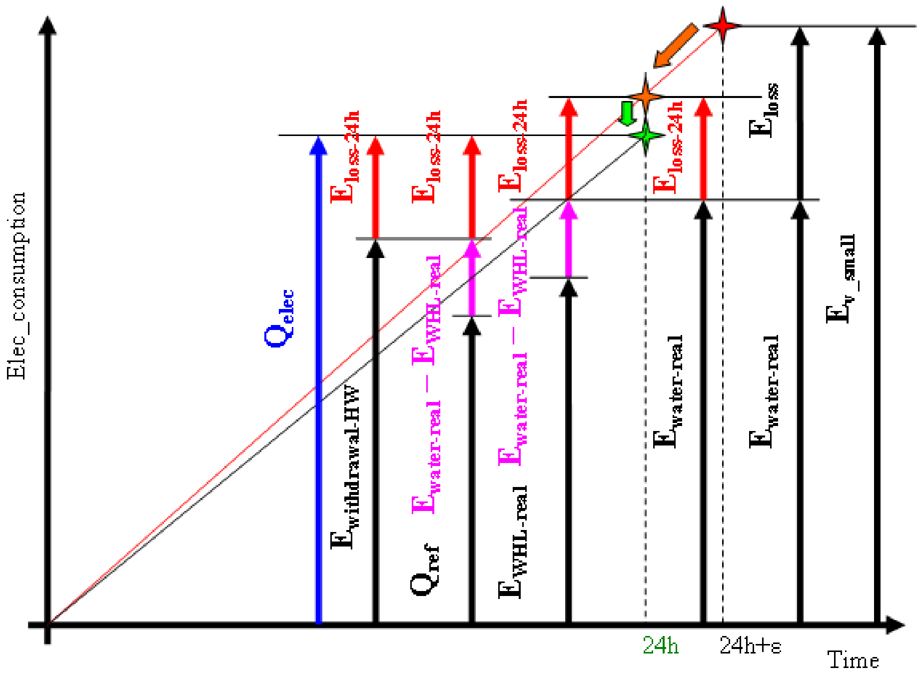
$$Q_{elec} = E_{withdrawal-HW} + E_{loss-24h} \qquad (5)$$

This value is expressed in kWh per 24 h with a declared precision of three decimals. Below, the method to calculate these contributes is explained.

Tapping profile cycle: the appliance remains energized during step 4. If an ESWH shall be tested in "night tariff conditions", it shall be powered only when the last tapping will be finished. It means this appliance will not be powered between 7.00 and 21.30 (see Table C4, if it will be tested with a WHL bigger than XXS).

- It starts at t_3;
- Qref [kWh] is a daily water heater load (useful energy, see table C4).
- The tapping cycle ends at t_4 when the last withdrawal finishes.

The figure shown in this page is used to explain any energy contribution? that shall be calculated in this step. The vector-method was used to emphasise this analysis.



During step 4, the real energy consumption of the water heater (E_{v_small} [kWh]) is recorded; the overall withdrawn real thermal energy, $E_{WATERreal}$, is calculated by using the following equation:

$$E_{WATERreal} = \sum_{i=1}^{n} 1{,}9184 \cdot 10^{-5} \cdot \dot{v}_i \left(\theta_{Si} - \theta_{Ci}\right) \cdot \left(t_i - t_{(i-1)}\right) \qquad \text{[kWh]} \qquad (6)$$

with:

- $\dot{v}_i$ is the withdrawal flow rate at i-mo [litres/min],
- θ_{Si} is the water temperature measured on the outlet tube of the water heater during the tapping time [°C],
- θ_{Ci} is the cold water temperature measured at the inlet tube of the water heater during the tapping time [°C],
- ti – t(i-1) is the withdrawal time [sec.].

and E_{WHL_real} is the measured value of the overall withdrawn useful thermal energy that shall be normalized in terms of WHL; this measuring is based on WHL patterns showed in Table C4. Its value is calculated using the same formula (6) but adding the temperature constraints concept (i.e. T_p [°C] and T_m[°C]).

After that, the first contribute in the formula (5) is calculated using:

$$E_{withdrawal-HW} = Q_{ref} + \left(E_{WATER\_real} - E_{WHL\_real}\right) \qquad \text{[kWh]} \qquad (7)$$

Stand-by condition: at t_4 the second part of the cycle is started and ESWH works in stand-by conditions without hot water withdrawals. The appliance thermostat controls the cut-in and cut-out of the heating element, according to the temperature defined by the manufacturer.
This test period will last until the step is equal or higher than 24 hours and shall have not less than 5 switch off/on of the thermostat: $t_5 - t_3 \geq 24$ hours, with t_5 when there is the first cut out of thermostat after 24 hours.

$$E_{loss-24h} = \left(E_{v\_small} - E_{WATERreal}\right) \cdot \left(\frac{24}{t_5 - t_3}\right) \quad \text{[kWh]} \qquad (8)$$

Annex G.2 Direct method for gas-fired water heaters

This is an example of the direct method for gas-fired water heaters. The aim is the assessment of the required parameters Qfuel and Qelec, i.e. parameters 12.1 and 12.2 of the Data Report in Annex B.

Note: This assessment is based on the relevant parts of EN 13203-2, EN 13203-1, EN 6

G2.1 Definitions

control cycle
time cycle for keeping components and/or the tank (if any) of the domestic hot water circuit at predetermined temperature level, consists of an «ON» duration time during which the heating of the domestic hot water (by gas energy and/or auxiliary energy) is operating, and an «OFF» duration time during which no heating occurs

domestic water mean temperature
average temperature of the water delivered during the time Δt

$T_m = (1/\Delta t)*\int T\,dt$

SYMBOL T_m

nominal domestic hot water heat input
value of the heat input stated by the manufacturer for the production of domestic hot water[1].
SYMBOL Q_{nw}
NOTE Q_{nw} is expressed in kilowatt (kW)

off mode
state of an appliance, selected by the user, in which hot sanitary water can not be provided

stand-by mode
operating state in which the appliance can provide hot sanitary water at any time. In the case of an appliance with a control cycle for keeping components and/or the tank (if any) of the domestic hot water circuit at predetermined temperature level no tapping is made.

tank
reservoir for domestic hot water

useful water
quantity of water delivered for which the temperature increase is in accordance with the requirement fixed for each individual delivery of the tapping cycles

G2.2 Test conditions

General test conditions are as follows:

- cold water temperature: (10 ± 2), in °C;
- cold water pressure: (2 ± 0,1), in bar;
- ambient air temperature: (20 ± 3), in °C;
- electrical supply voltage: (230 ± 2), in V.

Test fuel(s) have to comply with Essential Requirements of Gas Appliances Directives 90/396/EEC (‘GAD’).

The uncertainties of measurements carried out shall be not greater than the maximum uncertainties indicated below.

- water rate: ±1 %;
- gas rate: ±1 %;
- time: ±0,2 s;
- temperatures:
- ambient: ±1 °C;
- water: ±0,5 °C;
- gas: ±0,5 °C;

- mass: ±0,5 %;
- gas pressure: ±2 %;
- gas calorific value: ±1 %;
- gas density: ±0,5 %;
- electrical energy: ±2 %.

These uncertainties correspond to two standard deviations. The laboratory evaluates these standard deviations taking account of the various sources: contributions from the instruments, repeatability, calibration, ambient conditions, etc.

The stated measurement uncertainties relate to individual measurements. For measurements that combine a number of individual measurements, smaller uncertainties on the individual measurements may be necessary to ensure a total uncertainty within ± 2 %.

The appliance is tested under conditions during which the appliance supplies energy only for the production of domestic hot water

G2.3 Test room and measurements

The appliance is installed in a well-ventilated, draught-free room (air speed less than 0,5 m/s).
The appliance is protected from direct solar radiation

For the tests:

- the domestic water pressure is the static inlet pressure under dynamic conditions measured as close as possible to the appliance;
- the inlet and outlet temperatures of the domestic water are measured in the centre of the flow and as close as possible to the appliance.

The inlet temperatures are measured immediately upstream of the water inlet connection.
The outlet temperatures are measured immediately downstream of the outlet connection or, in the case of an appliance with spout delivery, by means of an immersed temperature measuring device, e.g. a u-tube fitted at the outlet of a tube of the same length as the minimum length of the spout normally supplied by the manufacturer.

The hot water temperature is measured with a rapid response thermometer.
"Rapid response thermometer" means a measuring instrument with a response time such that 90 % of the final temperature rise, from 15 °C to 100 °C, is obtained within about 1 s, when the sensor is plunged into still water.

G2.4 Initial state adjustments

The appliance shall be installed and adjusted in the initial state conditions and in the initial adjustment conditions defined as follows : [5]

The appliance is installed in accordance with the manufacturer's instructions.

The heat input shall be adjusted to within ± 2 % of the nominal domestic hot water heat input determined under the conditions prevailing at the time of the test and a test is carried out to check whether the appliance is fit-for-purpose, defined as follows[6]

The test is carried out with each appropriate reference gas, as indicated in the Essential Requirements of the Gas Appliances Directive[7] , at a water pressure of 2 bar. The gas rate may be adjusted according to the manufacturers instructions. A water draw off takes place to check whether the nominal domestic hot water heat input shall be obtained or may be adjusted ± 5%.

The delivered water temperature at the appliance outlet is defined as follows (see Figures 1 and 2):

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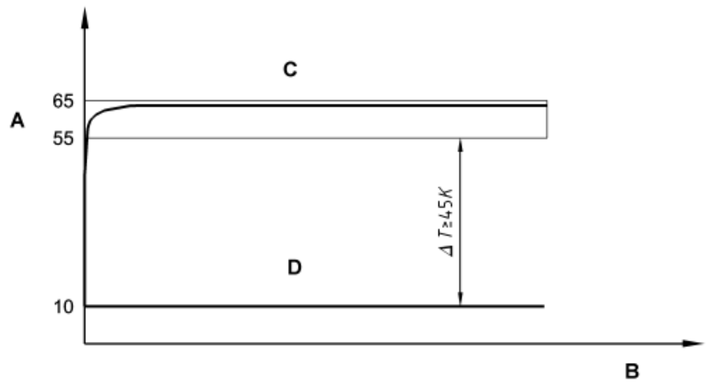
[5] as in 4.3.5 and 4.3.6 according to EN 13203-1;2007.

[6] as in par. 6.4.2.1. and par. 5.4.2.1 of EN 625;1995.

[7] as in EN 473

a) appliances with an adjustable temperature: the tests are carried out at a temperature not greater than 65°C, with a minimum temperature increase equal to or greater than 45 K above water inlet temperature.

b) appliances with a fixed temperature: the tests are carried out at the temperature specified by the manufacturer, with a minimum temperature increase equal to or greater than 45 K.



Key

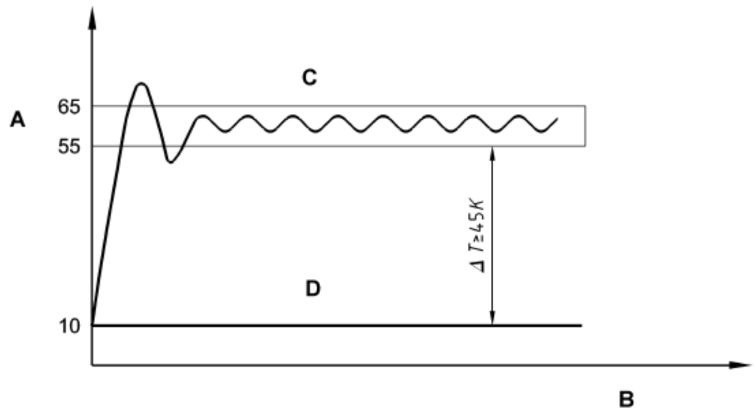
A Temperature (°C)

B Time (min)

C Hot water

D Cold water

Figure 1 – Initial adjustment of the appliance with storage maintained in temperature



Key

A Temperature (°C)

B Time (min)

C Hot water

D Cold water

Figure 2 – Initial adjustment of the appliance without storage maintained in temperature

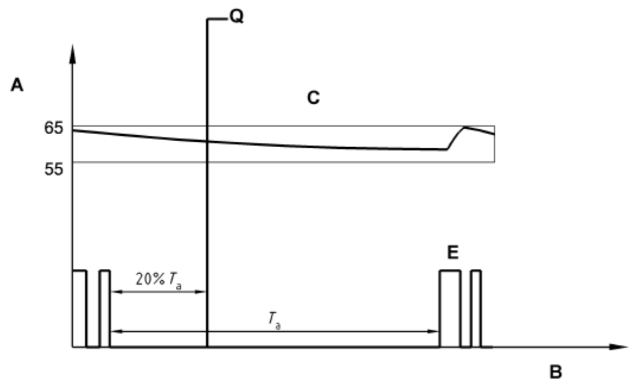
The conditions of initial adjustment are included in the test report.

G2.5 Initial state conditions

The tests according to initial state conditions are conducted as follows (see Figures 3 and 4):

- when there is no control cycle to consider: at least one hour after the previous delivery;
- when there is a control cycle to consider : after a time corresponding to 20 % (but not exceeding 1 h) of the "OFF" time of the burner. The time is taken from the time the burner turns off.

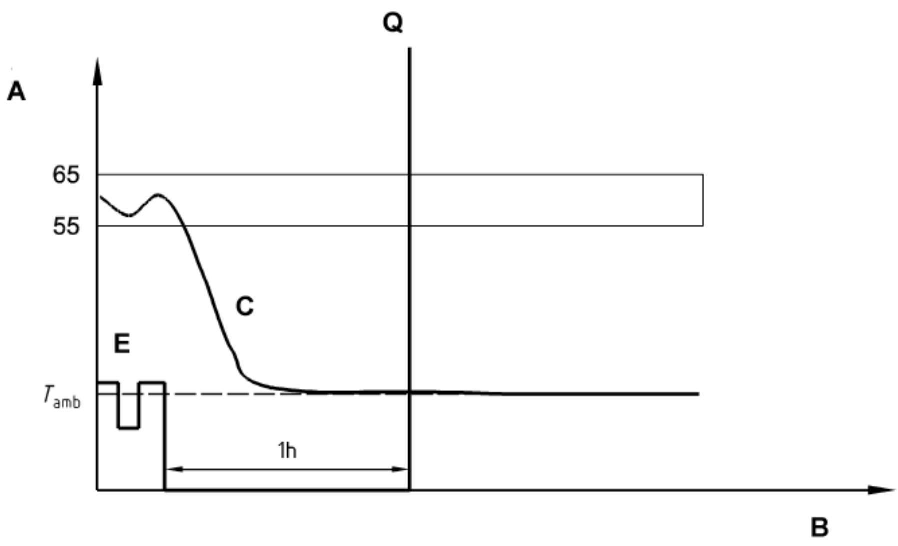
The initial state conditions are included in the test report.



Key

A Temperature (°C)
B Time (min)
C Hot water
E Gas rate
Q Initial state of appliance at the opening of the tap to achieve all the tests of this standard are conducted as follows

Figure 3 Initial state conditions of the appliance with storage maintained in temperature



Key

A Temperature (°C)
B Time (min)
C Hot water
E Gas rate
Q Initial state of appliance at the opening of the tap to achieve all the tests of this standard are conducted as follows

Figure 4 – Initial state conditions of the appliance without storage maintained in temperature

G2.6 Tapping cycles

All patterns define a 24h measurement cycle and within that cycle

- the starting times,
- the total energy content of 'useful water' (in kWh equivalent of hot water tapped),
- the minimum flow rate (in litres per minute),
- the minimum temperature per draw-off from which the counting of 'useful water' starts and
- the minimum (peak) temperature to be reached during the draw-off (if applicable)

The tapping patterns are given in Table C4.

If by design of the appliance the test cannot be carried out with the low flow rates in Table C4, the minimum flow rate for the ignition of the appliance is taken.

If by design the appliance is fitted with an excess flow valve, the tests are carried out with a flow rate no higher than the excess flow rate.

Each individual tapping of the tapping cycles shall be completed, that means the valve shall be closed, and a delay of at least one minute is required, before starting the following delivery.

G2.7 Test for determination of the daily energy consumption

The tapping pattern to be used is determined by the manufacturer, through the declaration of the waterload (parameter nr. 11 in Annex B). The tapping pattern serves to determine whether the appliance can fulfill the specific primary function (tapping temperatures, flow rates, etc.) and to determine the energy consumption for fulfilling the specific primary function.

Beginning of the tapping cycles:

For appliances with no energy consumption between deliveries (gas or electricity), the measured programme starts at 07h00 with the appliance cold and finishes when the burner is extinguished after the 21h30 tapping (see Figure 1).

For appliances with energy consumption between deliveries (gas and/or electricity), the tapping starts with the tapping at 21h30. The measured cycles start from the time the burner is extinguished following the 21h30 delivery. The measured cycles end when the burner is extinguished following the last tapping at 21h30 on the next day.

Note that for appliances with no energy consumption between deliveries, also the energy consumption in standby-mode and off mode must be zero.
Also note that for appliances with energy consumption between deliveries, the above does not guarantee that the energy content of the appliance at the beginning and the end of the test is identical (i.e. within a 2% tolerance). Through measurement and/or calculation –e.g. using measurements of tests in stand-by and/or off-mode defined hereafter—the manufacturer has to demonstrate to fulfill the Essential Requirements.

When these tapping rates result in a tapping period of less than 15 s the flow rate should be decreased such that the tapping period is (15 ± 1) s.

The useful energy recovered by the water Q_{H2O} (kWh) is given by the following equation:

$$Q_{H_2O} = 1{,}163 \times 10^{-3} \sum_{i=1}^{n} \int_0^{t_1} d_i \times \Delta T_i(t)\, dt$$

where
- n is the number of tappings;
- d_i is the water rate delivered in litre per minute;
- $\Delta_i(t)$ is the instantaneous temperature rise during the tapping, in Kelvin;
- t_i is the tapping duration of the useful water, in minute.

The useful energy recovered at each individual tapping is set against the values given in Table C4.

For each individual delivery, the accuracy of the value shall be ± 10 Wh or ± 2 % with a tolerance on the overall energy recovery of ± 2 %.

G2.8 Calculation of gas energy

The daily consumption of gas is calculated according to the following equation:

$$Q_{gas}=V_g \times K \times GCV \times Q_{tot}/ Q_{H2O}$$

where

- Q_{gas} is the daily energy contributed in kWh calculated using NCV;
- V_g is the gas consumption in m^3;
- GCV is the gross calorific value in kWh/m^3 (at 15 °C and 1 013,25 mbar);

and

$$K=(p_a + p_g)/ 1\,013{,}25 \times 288{,}15/(273{,}15+T_g)$$

where

- p_a is the atmospheric pressure, in mbar;
- p_g is the gas pressure, in mbar;
- T_g is the gas temperature, in °C;
- Q_{H2O} is the measured energy recovered by the water, as defined earlier;
- Q_{tot} is the total delivered energy of used tapping cycle, value from Table C4, in kWh.

G2.9 Calculation of electrical energy

The electrical energy of all the electrical auxiliaries necessary to achieve the tapping programme(s) at nominal use selected by the manufacturer will be measured even if these auxiliaries are not integrated in the appliance.

Where an electrical auxiliary (e.g. a pump) necessary for the delivery of hot water is not included as an integral part of the appliance, then the essential characteristics of the component shall be specified in the appliance installation instructions. An appropriate component shall be used for test procedures.

The measurement of the electrical consumption starts at the same time and finishes at the same time as the measurement of the gas consumption.

This measurement is corrected, as the gas consumption, according to the following equation:

$$E_{elecco} = E_{elecmes} \times Q_{tot}/Q_{H2O}$$

where
E_{elecco} is the corrected total electrical energy in kWh;
$E_{elecmes}$ is the measured total electrical energy in kWh;
Q_{H2O} and Q_{tot} as defined previously;

As mentioned before: Q_{tot} (the actually recovered energy) should not differ more than 2% from Q_{H2O} (the theoretical energy in the water drawn off) so in fact the correction should be small.

G2.10 Measurement of energy consumption with stand-by mode

The following sections can be relevant to complement the assessment of Qelec and Qfuel for a correct 24h cycle.

The consumed energy in stand-by mode is measured for a 24 h period without tapping.

- for the appliances without a control cycle the gas and auxiliary energy consumption may be measured for a duration time equal to one hour;
- for the appliances with repeated control cycles for a 24 h period, the gas and auxiliary energy consumption may be measured for a duration time (T_a) equal to one or several control cycles, once the appliance is operating in a regular manner.

The daily consumption of gas is calculated according to the following equation:

$$Q_{gas,\ stb} = V_g \cdot K \cdot GCV \cdot 24/T_a$$

where

- $Q_{gas.stb}$ is the daily energy consumed in kWh calculated using GCV;
- T_a is the duration of the test in hour (T_a = 1h for the appliances without control cycle).
- V_g, K and GCV as defined previously.

The daily consumption of auxiliary energy is calculated according to the following equation:

$$E_{elecco.stb} = E_{elecmes.stb} + 24/T_a$$

where

- $E_{elecco.stb}$ is the daily consumption of auxiliary energy, in kWh;
- $E_{elecmes.stb}$ is the auxiliary energy measured during the test, in kWh;
- T_a is the duration of the test in hour (T_a = 1h for the appliances without control cycle).

G2.11 Measurement of auxiliary energy consumption with the off mode

The auxiliary energy consumption is measured for a duration time equal to one hour.
The daily consumption of auxiliary energy $E_{elecco.off}$ (in kWh/day) is calculated from the auxiliary energy measured during the test $E_{elecmes.off}$ (in kWh/h) according to the following equation:

$$E_{elecco.off} = E_{elecmes.off} \times 24$$

Annex G.3: Solar supported gas-fired domestic appliances producing hot water

This method applies to a system marketed as single unit or a system fully specified by a manufacturer that is equipped with at least one solar collector, and which is, with regard to the solar hydraulic circuit, considered as a forced circulation system[8]. It is based on prEN 13203-2 and EN 12975-2.

This method does not apply to thermo-siphon or integral collector storage systems[9]. However, in principle the energy consumption of thermo-siphon solar preheat systems and integral collector storage preheat systems could also be assessed on the basis of this method.

This method is not intended to assess the performance of:

- the solar collector(s)[10] and
- thermal solar systems and components[11].

Instead, performance-characteristics of these solar components –from other test methods-- are used for simulation.

G3.1 Definitions

Definitions of Annex G.2 apply and are extended by the following:

solar supported system
system marketed as single unit or a system fully specified by a manufacturer, and composed of solar collector, water storage tank, controls, pipework and the gas appliance

solar collector field
either one or a combination of more than one solar collectors

solar collector simulator
device delivering the thermal power to the system (store) instead of a real solar collector based on the solar collector efficiency parameters[12]

controls
all hydraulic, thermal and electronic components necessary for the operation of the system

solar collector simulator circuit
circuit containing the piping, the pump, the controls, the heat- exchanger and the collector solar simulator

aperture area of solar collector
maximum projected area through which solar radiation enters the collector. [13]

measurement period
measurement period stars at 0h00 and is defined as an ongoing 24h period during which the system is continuously operated.

[8] compare definition according to EN ISO 9488
[9] compare definition according to EN ISO 9488
[10] compare compliance with EN 12975-1 and EN 12975-2,
[11] compare compliance with EN 12976-1 and EN 12976-2
[12] compare EN 12975-2
[13] compare definition and explanation according to EN ISO 9488

G3.2 Test conditions and installation

In order to apply the test procedures specified in this standard, it is required that:
- the collectors of are already tested according to EN 12975-2, and
- that factory made thermal solar systems are tested according to EN 12976-2.

Reference conditions, measurement uncertainties, test room and water supply are as defined in Annex G2.

The installation for testing, including thermal insulation of the components, shall be in accordance with the manufacturer specifications.

The maximum length of the piping between the gas appliance and the storage tank(s) shall not exceed 3 m in total (inlet plus outlet).

The minimum length of the piping between the solar collector simulator and the storage tank(s) shall be 6 m in total (inlet plus outlet) and shall not exceed 10 m.

If not specified by the manufacturer of the appliance the piping shall be in accordance with EN 12976-2, annex B, table B.2 (pipe diameter and insulation thickness).

For drain back solar thermal systems the installation height of the collector shall be simulated with an additional adjustable pressure relief valve in the solar hydraulic circuit after the pump. The pressure relief valve shall be adjusted to the maximum installation height of the collector according with the manufacturer specification. The unfilled part in the drain back hydraulic circuit shall be simulated with a corresponding storage tank..

Initial adjustment of the appliance
The system is installed in accordance with the manufacturer's instructions.

The heat input of the gas appliance shall be adjusted to within ± 2 % of the nominal domestic hot water heat input under the conditions prevailing at the time of the test with solar collector simulator off.

The delivered water temperature at the system outlet is defined as follows:

- System with an adjustable temperature: the tests are carried out at a temperature not greater than 65 °C, with a minimum temperature increase equal to or greater than 45 K above water inlet temperature.
- System with a fixed temperature: the tests are carried out at the temperature specified by the manufacturer, with a minimum temperature increase equal to or greater than 45 K.

The same conditions of initial adjustment stated by the manufacturer are used for all the tests. These conditions are included in the test report.

Solar thermal input
The solar thermal input is supplied to the solar heat exchanger of the solar tank as follows. For the tests, the fluid used in the solar collector simulator circuit is water at the pressure specified by the manufacturer.

Instead of installing the solar collector field a solar collector simulator is connected to the hydraulic connections of the storage tank originally foreseen for the connection to the solar collector field. The flow rate in the solar hydraulic circuit shall be according to the specifications of the appliance manufacturer. If not specified by the appliance manufacturer, a flow rate of 72 l/h[14] for each m2 of aperture area of the solar collector field shall be used.

[14] 50 l/h in prEN 13203-3 but 0,02 kgs-1 according to EN 12975-2 (=72 ltr/h).

G2.4 Determination of the energy consumption of the solar supported gas-fired appliance

As in Annex G2.6 and Annex G2.7, but with the following amendments:

Solar cycle

The solar cycle given in table below defines a 24h cycle for the total solar radiation available at the surface of the aperture area of the solar collector field and the outdoor ambient temperature.
The data from Table below is required for the generation of the solar thermal input by the solar collector simulator.

24 h Solar Test Cycle in line with Annex V results, at a fixed outdoor temperature Tout= 9 ºC

h	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	total
W/m2	0	0	0	0	0	0	100	180	250	320	370	415	460	500	540	480	230	50	0	0	0	0	0	0	**3895**

The solar cycle has to be used in combination with all tapping cycles.

Performing the test
For appliances with and without energy consumption between deliveries (gas or electricity), the test is performed in the following way.

The time used for the description of the tapping cycle is synchronous with the time used for the description of the solar cycle.

During the operation of the system on the test facility one specific tapping cycle and the solar cycle are repeated.

The measurement period starts at 0H00. The test is continued by operating the system on the test facility until the following criteria are fulfilled:

- the gas energy consumption of the system during two consecutive measurement periods shall not differ by more than 5 %;
- the gas energy consumption measured during the final measurement period shall be used for the determination of the system performance.

If these criteria are not fulfilled after 6 measurement periods the gas energy consumption for the final measurement period can be determined by using the average value of the gas energy consumption measured during the last 3 measurement periods.

NOTE The measurement period can be shortened by pre-heating the solar part of the storage tank.

NOTE that with the requirements above, i.e. the repetition of the tapping cycle until a steady state between cycles is reached, this method fulfills the essential requirements and the separate assessment of energy use during stand-by and off mode is not necessary.

For the Measurement of the energy recovered by the useful water, the calculation of gas energy, the calculation of electrical energy the same stipulations as in Annex G2 apply.

G2.5 Solar collector simulator

A solar collector simulator is a device –typically an electric resistance immersion heater in the circuit designated for the solar collector—that mimicks the heat output of a solar collector when exposed to the solar cycle mentioned above.

The output power of the simulator for any given time of the solar cycle (synchronous with the tapping cycle) is calculated according to equation[15]:

$$Q_{sim,HE} = A_a \cdot \eta \cdot G^* \qquad [1]$$

[15] This is a rewrite of prEN 13203-3, Annex B.3 but with the notation and equations in the latest EN 12975-2 of May 2006.

where

- $Q_{sim, HE}$ is the necessary heating performance of the heating element to simulate the real solar collector field, in W;
- A_a is the collector aperture area, in m2;
- η is the instantaneous collector efficiency, with reference to T*m
- G^* is the global radiation on collector (solar cycle data), in W/m²;

with

$$\eta = \eta_0 - a_1.T^*_m - a_2.G\ (T^*_m)^2 \qquad [2]$$

where

- η_0 is the zero-loss collector efficiency (η at T^*_m,=0), reference to T^*_m [-] ;
- a_1 is the heat loss coefficient at (Tm-Ta) = 0 (first order coefficient), in $Wm^{-2}K^{-1}$;
- a_2 is the temperature dependence of the heat loss coefficient (second order coefficient) , in $Wm^{-2}K^{-1}$;
- T^*_m is the reduced temperature difference in m^2KW^{-1}

with

$$T^*_m = (\ t_m - t_a\ )/\ G^* \qquad [3]$$

where

- t_a is the ambient or surrounding air temperature
- t_m is the mean temperature of the heat transfer fluid

with

$$t_m = t_{in} + 0{,}5.\Delta T \qquad [4]$$

where

- t_{in} is the collector inlet temperature
- ΔT is temperature difference between fluid outlet and inlet (= $t_e - t_{in}$) [16]

Note that the instantaneous efficiency η shall be calculated by statistical curve fitting, using the least square method to obtain an efficiency curve of the format as in equation [2]. For this, at least 16 test-points, with 4 different collector inlet temperatures t_{in} evenly spaced over the operating range and 4 tests per collector inlet temperature are obtained through measurements. If possible, one inlet temperature shall be selected with $t_m = t_a \pm 3K$ to obtain an accurate assessment of η_0 . With fixed collector (no automatic tracking) and test conditions permitting half of tests should be done before solar noon and 2 after. Maximum temperature heat transfer fluid (if water) should be >80 ºC. Recommended maximum value of T^*_m : >0,09.

Other test conditions for thermal performance testing of collectors are given in the table below

Table . Test conditions for solar collectors (summary EN 12975-2;2006)

Pre-conditioning general	Clean collector surface. Remove moisture by running collector at heat transfer fluid circulating at 80 ºC. Vent collector pipework (remove trapped air). Expose empty collector to irradiation for 5h at > 700 Wm^{-2}.
Mounting	Lower edge >0,5 m above local ground surface. Warm air currents from near walls or roofs of buildings shall not be allowed to pass over collector surface. When mounted on roof: >2 m from the edge.

[16] t_e is the collector outlet (exit) temperature. Note that t_{in} and t_e were previously known as $T_{c,in}$ and $T_{c,out}$ in the 2001 version of EN 12975-2

Steady-state pre-conditioning: Tests for a data point shall be performed at steady-state, including a pre-conditioning period of 15 minutes (or –if known—4 times the time constant of the collector). Steady-state exists when over the measurement period the following parameters stay within the indicated maximum deviation from the average. Sampling period is 30 s.	**steady state maximum deviation** (Global) Test solar irradiance ± 50 Wm^{-2} (short wave, symbol G) Long wave thermal irradiance (unglazed only) ± 20 Wm^{-2} (long wave, symbol EL) Surrounding air temperature (indoor) ± 1 K Surrounding air temperature (outdoor) ± 1,5 K Fluid mass flowrate ± 1 % Fluid temperature at the collector inlet ± 0,1 K
Energy input conditions	
Outdoor irradiation (glazed collectors)	G^* > 700 Wm^{-2}
Diffuse solar irradiance:	<30% (and may then be neglected)
Solar radiation measurement	pyranometer, class I or better (ISO 9060), with shading ring or pyrheliometer and provided with a dessicator. Regular inspection of the desiccator shall be observed.
Pyranometer pre-conditioning	Stay fixed in one test-point before data recording begins
Pyranometer mounting	sensor shall be coplanar to collector ± 1º, at midheight of collector, casting no shadow on collector and receiving the same levels of direct, diffuse and reflected solar radiation as collector. mounting with solar irradiance simulator light source: Minimize effect of infrared radiation at wavelength > 3µm.
Incidence angle modifier (IAM, symbol Kθ)	± 2% of the normal (=perpendicular to collector plane) IAM. For a glazed flat plate collector this means an incidence angle <20º to the normal. If >20º then the IAM shall be assessed (as a minimum requires test at 50º incidence if angle is direction-independent).
Incidence angle measurement	simple device with a pointer casting shadows on a base with concentric circles. Base should be coplanar to collector.
Max. pipe heat loss (through insulation) of loop during test:	<0,2 WK^{-1}
Air trapped in loop during testing	fluid should be air-free (air separator and –vent in loop)
Pipe-length during testing	as short as possible
Flowrate (unless otherwise specified):	0,02 kgs^{-1} (72 l/h, glazed), 0,04 kgs^{-1} (144 l/h, unglazed). Deviations from flow rate: to be included in test report
Fluid capacity determination	weighing empty and filled collector (standard certainty <10%, fluid temperature should be within ± 2K of ambient)
Average air speed parallel to collector	3ms^{-1} ± 1ms^{-1}
Artificial wind generator	At air speed < 2 ms^{-1} to be used; requires anemometer and check of uniformity over the collector area. Temperature of artifical wind shall be t_a ±1 K
Air speed measurement position	10 to 50 mm above collector plane at equally spaced positions over the collector area.
Collector inlet/outlet temperature sensor mounting:	within 200 mm of inlet/ outlet
Mass flow rate measurement	by direct measurement (mass) or with volumetric flow meter ±1%
Max. Uncertainty/ accuracy	
Fluid specific heat capacity and density	±1%
Max. flow rate deviation in one test:	±1%
Max. flow rate deviation between tests	<10%
Air speed measurement	0,5 ms^{-1} (glazed), 0,25 ms^{-1} (unglazed)

Time measurement	±0,2 %
Collector area (absorber, gross or aperture) in m2	±0,3 %
Ambient air temperature (around collector):	±0,5 K (sensor mounting shaded from direct solar radiation)
Collector inlet and outlet temperature, absolute standard uncertainty:	±0,1 K
Fluid temperature difference collector in- and outlet:	±0,05 K (preferably ±0,02 K)
Thermal irradiance variation (indoors)	± 10 Wm^{-2} (glazed) , ± 50 Wm^{-2} (unglazed)

Annex G.4 Heat pump for heating sanitary hot water

Based on EN 255-3

The test procedure follows the stages of Annex G.1, but with some amendments regarding the test conditions as described hereafter.

Test room air source heat pump:
- Air speed when appliance is off < 1,5 m/s
- Air speed when appliance is on: < mean air speed at appliance inlet
- Distance of air inlet and outlet from test room surfaces: >1 m

For heat pumps with duct connection, the maximum external static pressure difference available at the nominal flow rate specified by the manufacturer is preferably set on the air outlet side of the heat pump when the heating system does not operate. The nominal air flow shall then be verified.

For heat pumps with integral liquid pumps The maximum external static pressure difference available at the nominal flow rate specified by the manufacturer is preferably set on the liquid outlet side of the heat pump. This also sets the liquid flow.

In case of heat pumps consisting of several refrigeration parts (split units) the following installation conditions shall be complied with for the tests:

- Each refrigerant line shall be installed in accordance with the manufacturer’s instructions with the maximum stated length or 8 m, whichever is shorter,
- the lines shall be installed so that the difference in elevation does not exceed 1 m;
- thermal insulation shall be applied to the lines in accordance with the manufacturer’s instructions.
- Unless constrained by the design at least half of the interconnecting lines shall be exposed to the outdoor conditions with the rest of the lines exposed to the indoor conditions.

For indirect systems each water line shall be installed in accordance with the manufacturer’s instructions to the maximum stated length or 5 m, whichever is shorter. thermal insulation shall be applied to the lines in accordance with the manufacturer’s instructions.

Unless constrained by the design at least half of the interconnecting lines shall be exposed to the outdoor conditions with the rest of the lines exposed to the indoor conditions.

For indirect systems each water line shall be installed in accordance with the manufacturer’s instructions to the maximum stated length or 5 m, whichever is shorter. thermal insulation shall be applied to the lines in accordance with the manufacturer’s instructions.

Tests are to be performed with the following heat source temperatures:
- Outside air (dry bulb) 10,5 ºC
- Brine 2,5 ºC
- Water 11,5 ºC
- Exhaust air 20 ºC

For an exhaust air heat pump, when the requirement of air exceeds the values mentioned in Annex C for ventex, the air test temperature will be lowered depending on the mix between outside air and exhaust air needed. (see Annex C)

Ambient temperature for the storage tank is 20 ºC.

Ambient temperature range for the heat pump is between 15 and 25 ºC for parts designated for use indoors and between 0 and 7 ºC for heat pump parts designated for installation outdoors.

The table on the next page lists the uncertainties of measurement for indicated values

Test conditions source EN 255-3: uncertainties of measurement

Measured quantity	Unit	Uncertainty of measurement
Sanitary water		
temperature difference	oC	± 0,2 K
temperature difference	oC	± 0,2 K
volume	dm3	± 2 %
(volume) flowrate	dm3/s	± 2 %
thermal energy	kWh	± 2 %
Liquid (heat transfer media)		
temperature difference	oC	± 0,1 K
(volume) flowrate	m3/s	± 5 %
static pressure difference	Pa	± 5 Pa (dP ≤ 100 Pa)
		± 5 % (dP > 100 Pa)
composition of brine	%	± 2 %
Air (heat source)		
dry bulb temperature	oC	± 0,2 K
wet bulb temperature	oC	± 0,2 K
(volume) flowrate	dm3/s	± 5 %
static pressure difference	Pa	± 5 Pa (dP ≤ 100 Pa)
		± 5 % (dP > 100 Pa)
Electricity		
power	W	± 1 %
energy	kWh	± 1 %
voltage	V	± 0,5 %
current	A	± 0,5 %
Ambient temperature	oC	± 1 K
Time	s	± 10 s

The table below lists the permissible deviations from set values.

Test conditions source 255-3: Permissible deviations from set values (effects due to defrosting are not included)

Measured quantity	Permissible deviation of the arithmetic mean values from set values	Permissible deviations of individual measured values from set values
Sanitary water		
inlet temperature	± 1 K	± 1 K
volume flowrate	± 5 %	± 10%
Liquid		
inlet temperature	± 0,2 K	± 0,5 K
volume flow	± 2 %	± 5 %
static pressure difference	--	± 10 %
Air		
inlet temperature (dry bulb/wet bulb) -	± 0,3 K -	± 1 K
ambient temperature	± 1 K	± 2 K
volume flow	± 5 %	± 10 %
static pressure difference		± 10 %
Voltage	± 4 %	± 4 %

ANNEX H: Definition Smart control

H1. Definition of "smart control" for Instantaneous Water Heaters

Comprises sophisticated control to supply the desired/required power to the heating system by means of:

1. Power control capable of switching any required power between at least 50% and maximum rated power with a maximum power resolution of 200W depending on flow rate and water temperature to minimize power consumption;
2. devices to detect at least the flow rate and the inlet or outlet temperature;
3. device which calculates without user intervention the power required to stabilize the temperature of the outlet water at the desired level in-between switch on flow rate and power limit, regardless of:

    - flow rate;
    - water pressure;
    - inlet temperature.

Compliance is checked by measurement at minimum 5 different operating points within the specified operating range whereas the operating points should be selected at equidistant points distributed over the variable power part at a tolerance of ± 10%.

H2. Definition of "smart control" for Storage Water Heaters

H2.1 Definition

Smart control is a concept that allows energy saving in a storage water heater, using e.g. electronic controls for optimizing stored water temperature and / or time for better energy efficiency at same levels of comfort and safety. Different approaches of smart control are possible, for example based on auto-learning of consumer behavior, or based on end-consumer self-programming of his own tapping profile.

H2.2 Measurement procedure

Each manufacturer asking smart control bonus must be able to use an efficient smart control solution, to reach at least 10% consumption reduction, compared to the same appliances not equipped with smart controls. In order to demonstrate this, a manufacturer has to assess smart technology in a real life test, using following procedure.

- Manufacturer has to choose a sample of WH equipped with his smart control solution
- Manufacturer has to test the smart control on the basis of a real life situation, following a simple procedure:

    - The appliance will be submitted to the same test procedure as for a usual efficiency test, but using at least for one week a daily tapping profile as shown in following table, in order to allow consumer behavior learning and/or to measure energy consumption without smart control activation. The manufacturer may choose to perform the test for a longer period than the minimum one week period.
    - In a second step, the test is performed for the same period as for the first step, using the same repetition of tapping profile, but with smart control function activated (following manufacturer instructions for end-user in case of not automatic functioning).. The electricity consumption is measured during the second step and compared to the electricity consumption of the first step. The second step value has to be at least 10% lower than the first step value.
    - The tapping profile by day has to follow the table below, where WHL is the tapping profile chosen by the manufacturer corresponding to the product tested. And WHL-1 is the WHL corresponding to the immediate lower tapping profile.

Learning week	"Smart" week
Day 1 : WHL	Repetition in the same order
Day 2 : WHL-1	
Day 3 : WHL	
Day 4 : WHL -1	
Day 5 : WHL	
Day 6 : No tapping	
Day 7 : No tapping	

The complete above mentioned procedure has to be performed without activation of eventual specific national requirements

H2.3 Rating process

First step : Manufacturer has to test the smart control technology as described under point 2°, in order to demonstrate its 10% efficiency

Second step : Manufacturer has to test all his products with "smart control" feature for measuring base Qelec value according to the different tapping profile chosen, but making the test without smart control activation (only one day test). For each tested product, manufacturer has to deliver "smart control technology measurement" (carried out following the measurement procedure at point 2°, declaring his intention to use this specific technology for this specific product.

Third step : Efficiency is calculated by manufacturer using Qelec result of the test (without smart control activation) and applying smart control bonus to the result obtained.

H2.4 Verification process

Market surveillance authorities, to verify the declaration of water heaters using smart controls should set randomly the sequence of tapping during the first step. This should avoid that simple pre-programmed appliances are sold as smart controls, but are not able to save energy or to satisfy real end-user needs.

Annex I: General method for direct measuring

(example)

Void: Reserved for general method summarizing all previous

Stages:

- Defining energy inputs
- Defining general test conditions, tolerances, etc.
- Defining the test procedure, with the following stages:
  - Stabilisation
  - Initialisation: Measuring energy content of WH before the tapping cycle, within tolerances
  - Tapping cycle: Measuring energy consumption during the cycle, within tolerances
  - Finalisation: Measuring energy content of WH after the tapping cycle, within tolerances.
- Calculation and reporting:
  - correction of difference in energy content of appliance before/after tapping cycle
  - correction of difference between required energy (Qref according to table C4) and actual delivered energy
  - calculation of 24h cycle energy consumption to be declared, Qfuel and/or Qelec
  - reporting: other parameters taken into account with test report when required.

Annex J: Items not covered

I3

The mathematical model is to be used for implementing measures in the context of the Directive on Eco-design of Energy-using Products (32/2005/EC), which is a product-oriented directive in the context of Art. 95 of the European Treaty and which uses CE-marking as an instrument. In other words, implementing measures apply to features of the products as they leave the factory gates. They do not apply to the application/ installation of these products e.g. in buildings and are therefore complementary to and not a substitution of application-oriented measures such as the ones relating to energy performance of buildings, energy certification etc..

Having said that, it has been the aim of the mathematical model to facilitate and simplify the rule-making in the context of application-oriented measures as much as possible e.g. by using a fixed set of standard reference conditions, as shown in Annex C, D and E. But this implies that for off-standard conditions and situations where the local circumstances significantly deviate from the reference conditions the application-oriented measures shall make corrections. Furthermore, it is a major task for application-oriented measures to make sure that the appropriate CH Boiler and Water Heater is chosen for a specific building and user.

The data and model in the underlying document aim to facilitate the necessary assessments and corrections at the level of application-oriented measures. The list below gives a non-exhaustive overview of items that are not covered in the mathematical model for Eco-design and that are to be addressed in application-oriented measures.

A.

Subjects related to CH-Boilers and Water Heaters that are not covered and should be corrected in application-oriented measures?

- Deviations from standard WH distribution losses, e.g. circulation systems (pump + higher distribution losses) and collective/central systems.[17]

B.

Possible assessment-procedure in application-oriented measures, using the rating from Eco-design measures.

1. **Add: Water heating** primary energy from the load (XXS – 4XL) indicated on the water heater label and apply the efficiency from the technical fiche (A-G rating is extra check)

[17] Example of complementary approach in **ITG Institut for für Technische Gebäudeausrüstung**, *Ergänzung des Ecohotwater-Modells für eine gesamt-energetische Bewertung von Trinkwarmwassersystemen*, for Stiebel-Eltron, Dresden, Germany, Jan. 2008.

ANNEX K: List of parameters

Table K1 lists the most important parameters in order of appearance in the Annexes B to I and per Annex alphabetically.

Table K1. List of parameters

name	description	unit
ANNEX B		
a_1	first-order collector loss coefficient	W/m^2*K
a_2	second-order collector loss coefficient	W/m^2*K
airintake	identifier of type of combustion	-
Asol	collector aperture area **Asol**	m2
autotimer	identifier of usage of automatic timer	-
boilpos	designated water heater position in- or outdoors	-
COP50	COP correction factor at 50% load	-
COPnom	nominal COP heat pump	-
Date	date	-
dhwsmart	does WH comply with definition smart control?	-
Energy label Space Heat	Energy label class Space Heating	-
Energy label Water Heating	Energy label class Water Heating	-
hpaux	heat pump auxiliary electric power consumption	W
HPtestpoint_a	heat pump correction factor for COP/Pnom at testoint a	-
HPtestpoint_b	heat pump correction factor for COP/Pnom at testoint b	-
HPtestpoint_c	heat pump correction factor for COP/Pnom at testoint c	-
HPtestpoint_d	heat pump correction factor for COP/Pnom at testoint d	-
HPtestpoint_e	heat pump correction factor for COP/Pnom at testoint e	-
HPtype	heat pump type selection	-
IAM	incidence angle modifier	-
ID	number for type/model identification	-
Lpipesol	total solar collector loop pipe lenght	m
Manufacturer	identifier for manufacturer	-
Model	identifier of model	-
Qelec	electricity consumption of water heating test	kWh/day
Qelecmax	Electricity consumption of back-up water heating test at maximum load	kWh/day
Qelecmin	Electricity consumption of back-up water heating test at minimum load	kWh/day
Qfuel	fuel consumption of water heating test (in GCV)	kWh/day
Qfuelmax	fuel consumption of back-up water heating test at maximum load (in GCV)	kWh/day
Qfuelmin	fuel consumption of back-up water heating test at minimum load (in GCV)	kWh/day
solaux	solar electric pump power	W
solpos	solar tank position (boolean value)	-
Testpoints (table left)	heat pump testpoints of COP and Pnom for various Tsrc/Tsnk (table)	-
Tflue	water heating average flue gas temperature	ºC

name	description	unit
UAsol	heat transfer rate of solar heat exchanger	W/K
Upipesol_m	specific solar collector loop loss	W/m*K
V40hp	water heating tank capacity as energy equivalent of litres of 40ºC	ltr
ventmix	identifier of usage of (also) ventilation exhaust air (boolean value)	-
Vhp	heat pump nominal tank volume	ltr
volumeb	water heater volume of envelope	m3
vsol	solar part of solar tank nominal volume	ltr
Water heat energy eff.	water heating efficiency	-
Water heat net load	water heating calculated load	kWh/a
Water heat primary energy use.	water heating final primary energy consumption	kWh/a
WATER HEATING LOAD	identifier of water heating load pattern	-
turndownhp	turndown ratio heat pump	-
UA	tank heat loss coefficient	W/K
Phpnom	nominal heating power of heat pump	kW
Phpnom	nominal heating power of heat pump	kW
Tsink / Tsource	sink and source temperatures of correction factors COP/ Pnom of heat pump	ºC
Tsnkmax	maximum heat pump sink temperature	ºC
dpt	stochastic dew point	ºC
ANNEX C		
dpm	average number of days per month (fixed 30.5)	days
hd	length of day-period	h
hpaf	air flow needed for ventilation air heat pump (fixed at 300)	$m^3/h*kW$
Waterloadmax	identifier of maximum load pattern for back-up water heating	-
Waterloadmin	identifier of minimum load pattern for back-up water heating	-
η0	zero-loss collector efficiency	-
ηcomb	water heating combustion efficiency	-
Q	useful energy content of water withdrawal (tapping)	kWh
Q_solm	solar irradiation - monthly average	kWh/m^2
Qref	daily water heating load (sum of useful energy per tapping)	kWh
qsol	solar irradiance - per m² floor area and per day period	W/m^2
qsolm	monthly average solar irradiance	W/m^2
Tin	indoor temperature	ºC
Tm	water temperature from which counting of useful energy content begins	ºC
Tout	outdoor temperature	ºC
Toutm	outdoor temperature - monthly average	ºC

Tsrcbrine	brine soil temperature - per day period	ºC
Tsrcwater	water soil temperature - per day period	ºC
ventex	available ventilation exhaust air flow	m^3/h
Tp	minimum water temperature to be achieved during tapping	ºC

ANNEX D		
a_c	resulting collector heat loss coefficient	W/m^2*K
ah	specific heat of air (0.33 Wh/Km^3)	Wh/K*m3
Asolh	space heating fraction of solar collector	m2
Ccap	Ccap value	- or m^2/ltr
qrecov	annual average heat recovery factor (water heater, with noisew)	-
qrecovb_summer	heat recovery factor summer months Jun - Aug	-
qrecovb_transit	heat recovery factor transit months May + Sep	-
qrecovb_winter	heat recovery factor winter months Oct - Apr	-
ηloop	solar collector loop efficiency	-

ANNEX E		
Asolw	water heating fraction of solar collector	m2
COPcorr2w	water heating final COP correction including part load - month	-
COPcorrw	water heating correction factor for nominal heat pump COP per day-period	-
COPcorrwm	water heating correction factor for nominal heat pump COP per month	-
COPpartcorrw	water heating COP part load correction - month	-
dQaload	water heating back-up calculation parameter	kWh
dQanet	water heating back-up calculation parameter	kWh
dQanetmax	water heating back-up calculation parameter	kWh
dQanetmin	water heating back-up calculation parameter	kWh
FCw	water heating load factor for heat pump - month	-
hppcorrw	correction factor for nominal heat pump power output per day-period	-
hppcorrwm	correction factor for nominal heat pump power output as monthly average	-
Inc	water heating accounting parameter for calculation of back-up heating	-
LHL	latent heat loss, depending on fuel (gas 10%, other 6%)	-
parthpw	partioning of heat pump load to water heating	-
partsolw	partitioning of solar system load to water heating	-
Qadistr	water heating distribution losses energy (primary)	kWh
Qaload	net water heating load in mathematical model	kWh
Qaloadmax	calculation parameter maximum water heating back-up load	kWh
Qanet	annual energy demand water heating based upon test pattern	kWh
Qanetmax	calculation parameter water heating back-up energy consumption at maximum load	kWh
Qanetmin	calculation parameter water heating back-up energy consumption at minimum load	kWh
Qaoadmin	calculation parameter minimum water heating back-up load	kWh
Qarecover	water heating heat loss recovery credit	kWh
Qatot	final energy consumption water heating	kWh
Qatot2	final energy consumption of water heating with renewables	kWh
Qawh	water heating load and distribution energy consumption	kWh
Qgrossrest	calculation parameter back-up water heating	kWh
Qhpauxw	water heating heat pump auxiliary	kWh
Qhpnetconsw	water heating net energy consumed - month	kWh
Qhprecovw	water heating auxiliary heat recovered	kWh
Qhptankw	standby heat losses heat pump water storage tank	kWh
Qhpw	water heating energy delivered by heat pump	kWh
Qhpwcons	water heating primary energy consumed by heat pump	kWh
Qloadrest	accounting parameter - water heating back-up	kWh
Qsolloadrestw	water heating load remaining after 2nd solar iteration	kWh
Qsolloadw	water heating load before solar contribution	kWh
Qsolloadw2	water heating load put on solar system, 2nd iteration	kWh
Qresthpw	water heating load after hp contribution	kWh
Qsolrestw	water heating load after solar contribution	kWh
Qrwaste	recoverable fraction from heat losses	kWh
Qsolnetsavew	water heating energy credits from solar contribution	kWh
Qsolpipew	pipe losses for solar water heating	kWh
Qsolauxlossw	water heating electric energy penalty for solar pump operation	kWh
Qsoltankrecovw	heating energy recovered from solar tank storage	kWh
Qsoltankw	water heating solar tank losses	kWh
Qsolw1	water heating energy from solar system, 1st iteration	kWh
Qsolw2	water heating energy from solar system, 2nd iteration	kWh
Qwaste	water heating initial energy losses	kWh
Qwdistr	water heating distribution losses	kWh
Trefw	water heating solar reference temperature	ºC
Tsinkhw	water heating heat pump sink temperature required by the tapping pattern	ºC
Tsnkw	water heating heat pump operational sink temperature	ºC
Tsrcw	water heating heat pump source temperature	ºC
Vsolw	water heating fraction of solar storage tank	ltr
Xw1	water heating solar X-value, 1st iteration	-
Xw2	water heating solar X-value, 2nd iteration	-
Yw1	water heating solar Y-factor, 1st iteration	-

	energy consumed (primary)				
Qhploadw	water heating load for heat pump	kWh	**Yw2**	water heating solar Y-value, 2nd iteration	-
Qhpmaxw	water heating hp maximum heat pump output available	kWh	**ηwh**	water heating efficiency	

ANNEX F					
Ploss	EIHW test parameter - measured power loss in EIWH	kW	**Qstart**	EIHW test parameter - energy loss during waiting time (varies per type of draw-off)	kWh
Ploss1	EIHW test parameter - measured power loss before power control unit	kW	**Qtaploss**	EIHW test parameter - energy loss during tapping (varies per type of draw-off)	kWh
Ploss2	EIHW test parameter - measured power loss after power control unit	kW	**t_start**	EIHW test parameter - waiting time (varies per type of draw-off)	s
Pstatic	EIHW test parameter - measured power loss in electronic controlled EIWH per tapping	kW			

ANNEX G					
CO2	volume of carbond-dioxide in dry flue gas (%)	%	**tA**	water heating flue gas temperature	ºC
O2	volume of oxygen in dry flue gas (%)	-	**tL**	combustion air supply temperature	ºC

ANNEX I					
Aij	relative surface area between zones	%	Tinsb	Indoor temperature at the end of a setback period after a cool-down	ºC

Annex L: References

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