National Calculation Methodology for Energy Rating Dwellings (SAP)

Storage Waste Water Heat Recovery Systems - Test Method

Contents

1 Introduction

The UK Government's Standard Assessment Procedure for Energy Rating of Dwellings (SAP), including Reduced Data SAP (RdSAP), is the UK's National Calculation Methodology (NCM) for dwellings. To assess a dwelling's energy performance data is needed that describes the dwelling in terms of the energy performance of the installed construction components and building services equipment. Such data is either generic, determined by the materials and type of product used ("type data") or specific, where validated individual branded product performance data has been made available ("product data").

Product data is held in either the SAP Appendix Q database or the Product Characteristics Database (PCDB). Since the incorporation of new technology types in the PCDB can only be undertaken when new versions of SAP are issued, product data for new technology types are held initially in the SAP Appendix Q database.

Appendix Q of SAP provides a means whereby validated individual branded product performance information can be accessed and used as an adjunct to the SAP calculation. A product's performance information is determined by testing against a specification that has been agreed by DECC's NCM contractor, the relevant manufacturer(s) and industry sector representatives. Product data that is listed in the SAP Appendix Q database may migrate to the PCDB when a new version of SAP, incorporating the relevant calculation process, is released. The data will also remain in the Appendix Q database until obsolete versions of SAP have been withdrawn or where it is impractical to include it within the PCDB.

Product data will be used in preference to any default value to determine the energy performance of the dwelling, providing the product is installed in the dwelling being assessed and can be recognised and identified by the Energy Assessor. Acceptance of product data as an input to the NCMs does not denote any form of endorsement, nor does it imply that the dwelling's energy performance rating is better than that obtained using alternative products.

This document describes the laboratory test method required for the testing of Storage Waste Water Heat Recovery Systems (WWHRS) to be recognised within SAP, either via the Appendix Q process or the Product Characteristics Database (PCDB).

A Storage WWHRS is a whole-house system whereby heat is extracted from waste water from baths and showers, and used to preheat the incoming cold water to a combination boiler or hot water system. The system may include a heat exchanger circulation pump and additional accessory pumps for satisfactory operation. Unlike an instantaneous WWHRS it does not require simultaneous waste and pre-heated water flow and so is able to recover heat from bath water.

Storage WWHRS may also function as a grey water recycling system by supplying grey water to toilets. The frequency of toilet flushes, where grey water of various temperatures is released from the system for toilet flushing before heat transfer to the hot water system has been achieved, is therefore a critical parameter defined in this test method. The energy consumption of such functions must be accounted for within this test method, even though any purported energy savings from the recycling of grey water are ignored.

Storage WWHRS incorporate a storage volume, Vww, dedicated to the recovered heat - there are two types:

- Combined: the dedicated storage volume is within the dwelling's hot water vessel
- Separate: the dedicated storage volume is a separate vessel (typically for connection to instantaneous hot water heaters such as a combination boiler)

This test method excludes the option for integrating Solar Thermal and Storage WWHRS.

2 Basis of test method

The basis of the method is to compare the electrical consumption of a hot water draw-off test using a modified tapping schedule with and without the Storage WWHRS connected.

The tapping schedule is based on BS EN13203-2:2006 *(Gas-fired domestic appliances producing hot water — Appliances not exceeding 70 kW heat input and 300 litres water storage capacity — Part 2: Assessment of energy consumption)*, but with a reduced draw-off temperature rise to be consistent with SAP 2009.

The Storage WWHRS may be connected to a hot water cylinder (unvented or vented) heated by a boiler. To increase the accuracy and reliability of the test an integral electric immersion heater will provide the heat input to the system instead of a gas boiler. To ensure any energy savings are solely due to the Storage WWHRS it is critical that the heat content of the system is the same at the start and the end of the test. To assess this, an unvented hot water cylinder will have temperature sensors fitted to the cylinder's external surface (below the insulation) at defined height intervals. Temperatures will be monitored throughout the test.

The test apparatus is described in Section 3 and 4, whilst Section 5 defines the required measurements and Section 6 defines the calculations necessary to process output test data for the purposes of SAP calculations.

Appendix A defines the parameters that must be reported from testing for the purposes of SAP recognition.

Appendix B outlines the additional test requirements for flushing the Storage WWHRS grey water vessel (if present) at defined time intervals. If present, this vessel supplies grey water to toilet cisterns for flushing purposes. This test method simulates the interaction of toilet flushing, via depletion of the grey water vessel, upon the system’s performance.

3 Test Arrangement

3.1 Test equipment

The testing of Storage Waste Water Heat Recovery Systems in accordance with this Test Standard shall be conducted by an independent Test Laboratory that meets the requirements of "ISO17025: General requirements for the competence of testing and calibration laboratories". The required test equipment for this procedure is:

1. A test rig with the capability to undertake hot water draw-off tests in accordance with EN13203-2:2006 with a suitable cold water supply vessel that can be maintained at 13ºC. The rig must be capable of completing the hot water draw-off schedule detailed in EN13203-2 *table 3, tapping cycle No 2*. The rig must also have the capability to reduce the temperature rise from inlet to outlet of the hot water cylinder from 50K (as required by EN13203) to 37K.

2. Electrically operated valves (and pipework) that can be operated via a computer program when shower draw-offs are specified. All other hot water draw-offs should be sent to waste.

3. Electrically operated valve (and pipework) connected to the cold water supply vessel. The cold water supply will be mixed with the hot water from the hot water cylinder to reduce the temperature of water to the defined shower temperature. It will be necessary to use a mixing vessel (a small vessel with an immersed temperature sensor) to determine and adjust the mixed temperature before it is discharged to the extended plastic water pipe (see item 4 below).

4. The test laboratory should include an extended plastic waste water pipe from the mixing vessel to the appliance grey water inlet connection. The total length of this pipe should be 3.0 metres. It must be possible to determine water temperature at the entry and exit of the plastic waste pipe by using sensors in contact with the water flow. A suitable arrangement would be to insert the sensor through a gland in the pipe wall or a pipe fitting.

5. The test laboratory must monitor the grey water vessel temperature (if present). A temperature sensor (T_{15}) should be mounted at a level corresponding to the level at which the operational system is filled with grey water (defined by manufacturer). This sensor will be used to confirm that the grey water vessel is at ambient temperature at the start and end of each test cycle.

6. The test laboratory must monitor at least 11 temperatures using sensors mounted on the surface of an unvented hot water cylinder throughout the test period. This arrangement is required such that the temperatures and hence heat stored can be monitored at the start and end of each 24 hour test period. Differences in the average cylinder temperature of more than 0.5ºC will invalidate the tests.

7. The test laboratory must separately monitor the electrical input of individual auxiliary electrical equipment, such as pumps, in addition to the electrical input to the immersion heater within the unvented hot water cylinder.

8. The cold water supply vessel must be capable of maintaining a supply temperature of 13±2ºC whilst delivering water for EN13203:2 hot water draw-off schedule *table 3, tapping cycle No 2* and also be capable of providing sufficient cold water to reduce the shower waste temperature to 34ºC.

9. The electrical input shall be determined using suitable meters, such as a digital power meter suitable for the voltage, current and frequency declared by the manufacturer. It shall measure power, voltage, current, power factor and calculate energy used. The voltage of

the unit, at the input/output terminals, shall be maintained by the test laboratory at the manufacturer's declared voltage, ±2.0% or ±1.0 volt, whichever is larger. Electrical energy shall be measured with an accuracy of ±2.0%.

The above arrangement assumes that it will be practicable to install temperature sensors on the surface of the hot water cylinder and underneath the insulation. If it is not possible, then the Storage WWHRS (including the hot water cylinder) will need to be connected to a separate hot water cylinder (with temperature sensors fitted) to act as a heat generator.

In the case of 'Separate' dedicated storage volumes, such as a small preheat vessel (normally connected to an instantaneous water heater), the criteria (see Section 3.2) for temperature sensor instrumentation and monitoring is identical to that for unvented hot water cylinders ('Combined' dedicated storage volumes), except that the number of temperature sensors can be reduced. A minimum of two temperature sensors are required for 'Separate' dedicated storage volumes, where the vertical spacing interval is a minimum of 125mm. For 'Separate' dedicated storage volumes the Storage WWHRS (including the preheat vessel) should be connected to a separate unvented hot water cylinder (with temperature sensors fitted as defined in Section 3.2) to act as a heat generator.

All instruments and sensors should be calibrated to traceable standards (UKAS or equivalent) and uncertainties should be no greater than stated in this test method or as specified in EN13203-2:2006 clause 4.2, whichever is the lowest.

3.2 Draw-off tests

Figure 1 shows a general test arrangement diagram (assuming no separate heat generator is required). It is assumed that the EN13203:2 test rig and measurement devices are within the box. The unvented hot water cylinder is also within this box (Item 11 from EN13203:2, example B1 on p24).

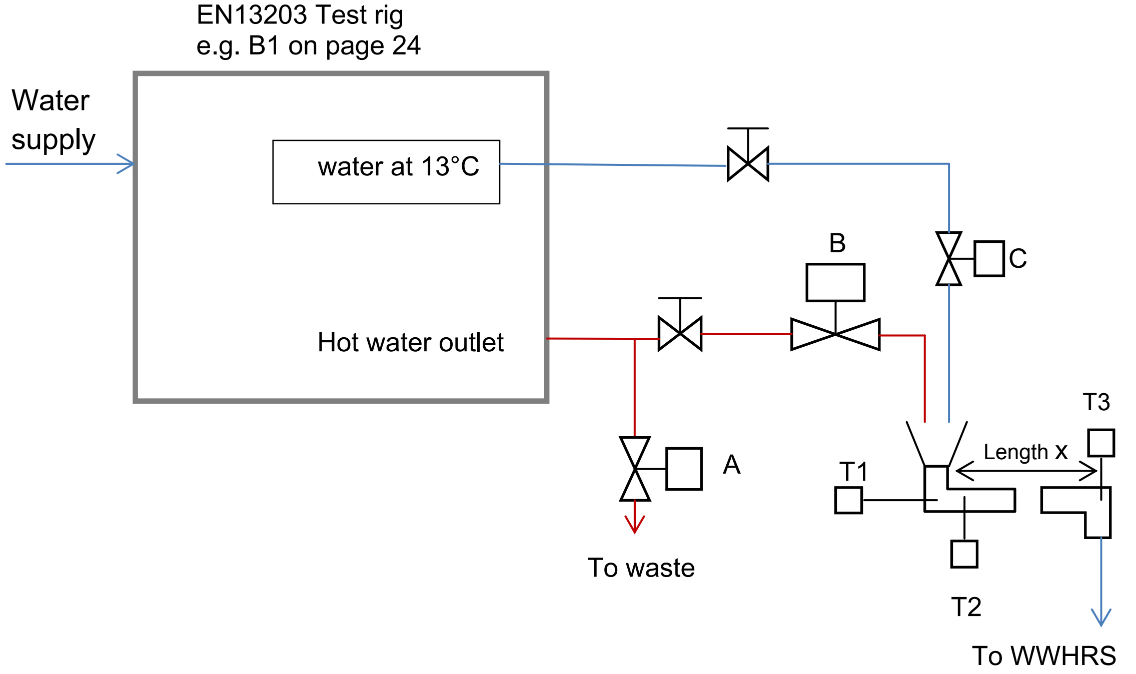

Figure 1 - Typical test configuration

The typical test arrangement shown above includes three additional fast-acting electrically operated valves. A computer program must control:

- Valve A in order for hot water to go to waste
- Valve B should allow hot water to pass to the mixing vessel (Valve A should always be closed when Valve B is open)
- Valve C should operate at the same time as Valve B to dilute the hot water supply to the defined shower and bath drain temperature, when required

The mixing vessel (shown as a funnel in Figure 1) should ensure the hot and cold water is fully mixed, and include a "rapid response" immersion thermometer (T_1). In addition the outlet from the mixing vessel is connected by a plastic drain pipe of 3m length (40mm diameter) to simulate a typical dwelling drain pipe installation for baths and showers. This drain pipe must be inclined downward towards the grey water inlet at 3º to horizontal. The inlet and outlet of the drain pipe should include temperature sensors in contact with the water flow for measurement of T_2 and $T_{3,}$ see Section 3.1.

Hot water draw-offs from the test rig must be arranged such that shower draw-offs, when undertaking *tapping cycle No 2*[1] can be directed to the mixing vessel. In addition, it must be possible for dilution cold water from the cold water supply vessel (at 13°C) to be directed to the mixing vessel to reduce the temperature of the hot water (shower) draw-off to the required shower waste temperature (34ºC). This dilution water should only operate when there is a shower draw-off. The test rig must be configured such that all draw-offs can go directly to waste in order that comparison tests are possible when required.

The outlet from the unvented hot water cylinder should be set to deliver a steady state temperature of 55±1ºC with the cylinder fully charged (for further explanation of "steady state" refer to EN13203:2 clause 4.3.4.).

For tests to EN13203:2 *tapping cycle No 2*, the steady state temperature at the mixing vessel (T_1), with the cylinder fully charged, should be set to 34±1ºC.

The temperature of the metal surface of the unvented hot water cylinder (i.e. the surface under any primary insulation) should be recorded using surface temperature sensors fixed to the cylinder surface. These should be mounted on the surface of the cylinder in a vertical plane containing the axis of the cylinder that lies at 90º to the plane containing the cold water feed and located at 11 positions as indicated below:

- The distance from the centre line of the immersion heater to the base of the unvented hot water cylinder is taken as "h_1", see Figure 2
- The distance from the centre line of the immersion heater to the top of the unvented hot water cylinder is taken as "h_2", see Figure 2
- h_1+ h_2 is the total height of the cylinder. The temperature resistance devices should be placed at heights of $0.005h_1$, $0.2h_1$, $0.4h_1$, $0.6h_1$, $0.8h_1$, h_1, $h_1+0.2h_2$, $h_1+0.4h_2$, $h_1+0.6h_2$, $h_1+0.8h_2$, and h_1+h_2.

[1] The shower draw-offs are the 2nd and 23rd draw-offs of tapping cycle No 2.

Temperature measurements from the 11 sensors (T_4 to T_{14}) and the sensors of the dedicated storage vessel for 'Separate' WWHRS types (T_{16} to T_{17+n}) should be used to calculate a weighted mean instantaneous cylinder temperature $T_{\text{Content DHW}}$ using the weighting factors shown in Table 1 (WF_4 to WF_{14}) and Table 2 (WF_{16} to WF_{17+n}), if required, as follows

$$T_{\text{Content DHW}} = [(T_4 \text{ x } WF_4) + (T_5 \times WF_5) + ..+ (T_{14} \text{ x } WF_{14})] \text{ x } V_{cyl} / (V_{cyl} + V_{sep})$$

$$+ [(T_{16} \text{ x } WF_{16}) + ..+(T_{17+n} \text{ x } WF_{17+n})] V_{sep} / (V_{cyl} + V_{sep})$$

Where V_{cyl} and V_{sep} are respectively the volume of the unvented hot water cylinder (with immersion heater) and the 'Separate' preheat vessel, where applicable. If the Storage WWHRS to be tested is not a 'Separate' type, then $V_{sep} = 0$ and temperature measurements from the 'Separate' preheat vessel (T_{16}/WF_{16} and above) are not recorded and removed from above equation.

$T_{\text{Content DHW}}$ should be determined at the start and end (after 24 hours) of each test cycle.

Distance from cylinder base (lowest water level)	Recorded temperature	Weighting factor (WF)
h_1+h_2	T_{14}	$0.1h_2÷(h_1+h_2)$
$h_1+0.8h_2$	T_{13}	$0.2h_2÷(h_1+h_2)$
$h_1+0.6h_2$	T_{12}	$0.2h_2÷(h_1+h_2)$
$h_1+0.4h_2$	T_{11}	$0.2h_2÷(h_1+h_2)$
$h_1+0.2h_2$	T_{10}	$0.2h_2÷(h_1+h_2)$
h_1	T_9	$0.1h_1+0.2h_2÷(h_1+h_2)$
$0.8h_1$	T_8	$0.2h_1÷(h_1+h_2)$
$0.6h_1$	T_7	$0.2h_1÷(h_1+h_2)$
$0.4h_1$	T_6	$0.2h_1÷(h_1+h_2)$
$0.2h_1$	T_5	$0.2h_1÷(h_1+h_2)$
$0.005h_1$	T_4	$0.1h_1÷(h_1+h_2)$

Table 1 – Position and weighting factors for the evaluation of $T_{\text{ContentDHW}}$

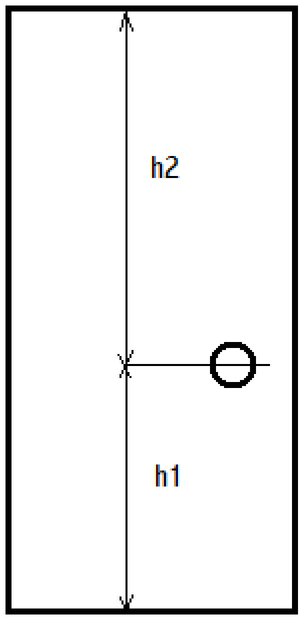

Figure 2 - Diagram of heights h_1 and h_2

Temperature recorded	Definition	Weighting factor (WF)
T_{17+n}	Temperature of the highest sensor, see Section 3.1, where ‘n’ ≥ 0 and defines the number of sensors in addition to the minimum requirement of 2.	Calculated as half of the height between the highest sensor and the sensor immediately below it, divided by the height between the highest and lowest sensor (WF_{17+n}).
T_{16+n}	Temperature of any intermediate sensors, see Section 3.1, where ‘n’ ≥ 0 and defines the number of sensors in addition to the minimum requirement of 2, where applicable.	Calculated as the sum of half of the height between the intermediate sensor and the sensor immediately above it and half of the height between the intermediate sensor and the sensor immediately below it, divided by the height between the highest and lowest sensors (WF_{16+n}). If there are no intermediate sensors a weighting factor is not applicable.
T_{16}	Temperature of lowest sensor, see Section 3.1	Calculated as half of the height between the lowest sensor and the sensor immediately above it, divided by the height between the highest and lowest sensor (WF_{16}).

Table 2 – Temperature and weighting factors for the evaluation of $T_{ContentDHW}$ (applicable to ‘Separate’ Storage WWHRS only)

Recorded temperature	Definition
T_1	Mixing vessel temperature
T_2	Drainpipe grey water inlet temperature
T_3	Drainpipe grey water outlet temperature
T_{15}	Grey water storage vessel temperature

Table 3 – Required temperatures in addition to those for $T_{\mathrm{ContentDHW}}$

4 Test procedure

Prior to the start of each EN13203:2 test, the following initial adjustments must be completed:

- The immediate outlet (outlet tap point) from the unvented hot water cylinder should be set to deliver a steady-state temperature of 55±1°C with the cylinder fully charged, i.e. with the immersion heater thermostat just satisfied (for "steady-state" refer to EN13203:2 clause 4.3.4).
- The flow rate of the diluting cold water is set to achieve the mixing vessel steady-state temperature (T_1) of 34±1°C when the cylinder satisfies the above.
- The temperature (T_{15}) of the grey water vessel contents should be at ambient temperature and must not differ from ambient temperature by more than 2.0°C.

Note: The hot water volume drawn-off will be greater than the equivalent volume of water at 60°C stated in *tapping cycle No 2* of EN13203:2. Additionally, *tapping cycle No 2* of EN13203:2 includes a desired temperature rise of 45°C (from 10ºC) for dish washing draw-offs; this temperature requirement is removed for these tests, but the tapping energy requirement is retained.

Three consecutive 24 hour test cycles are to be completed for each test arrangement below:

1. Test arrangement with the Storage WWHRS not operating: EN13203:2 tests to hot water draw-off schedule *tapping cycle No 2:* All hot water draw-offs must be supplied directly to waste. Note that the EN13203:2 standard cold water supply temperature is revised to 13ºC (from 10ºC).
2. Test arrangement with the Storage WWHRS operating: Repeat tests from 1) with shower draw-offs (x2) directed to the mixing vessel. Water will pass though the extended drain waste pipe. Dilution cold water should also run during the shower draw-offs.

   An initial 24 hour test cycle should be completed prior to the measurement period in order to ensure that the heat recovery coil/vessel is preheated to a typical operating temperature. A further three 24 hour cycles are then conducted, where measurements will be used to determine the performance of the Storage WWHRS by comparison to the results from 1).

The test procedure should follow all specifications defined within EN13203-2:2006 except where this specification defines a variation. It must be ensured that for each 24 hour test cycle the heat content at the start and end of the test period is the same, with $T_{\text{Content DHW}}$ within ±0.5°C. The 11 surface temperatures measured on the unvented hot water cylinder should be recorded as detailed in Section 3 to determine the $T_{\text{Content DHW}}$ value.

5 Test result data

For each 24 hour test cycle the following measurements should be taken throughout the tests:

a) Electrical power consumption for the immersion heater in the unvented hot water cylinder (kWh)

b) Electrical power consumption to power the Storage WWHRS (excluding immersion heater) (kWh)

c) Values of T_4 to T_{16} and $T_{\text{Content DHW}}$ at start and end of test cycle (ºC) and recorded values at a minimum interval of 15 minutes throughout the tests

d) Values of ambient temperature during the test cycle (ºC) recorded at a minimum interval of 15 minutes throughout the tests

e) For all individual shower draw-offs, the water temperature at the inlet and outlet of the hot water cylinder ('Combined' or 'Separate' types). Note: For 'Separate' types the outlet measurements are taken at the outlet of the separate unvented hot water cylinder, which acts as a heat generator, not at the outlet of the 'Separate' preheat vessel. The useful heat output should also be measured (ºC, ºC, kWh)

f) For all individual shower draw-offs, the average mixing vessel (T_1) and plastic waste pipe temperatures T_2 and T_3 (ºC, ºC, ºC)

g) Average shower and bath flow rates for hot water draw-offs from the unvented DHW cylinder and corresponding dilution cold water flow rates (litre/minute, litre/minute)

h) All data required by EN13203:2 in addition to that listed above

Tapping	Tapping Cycle					Mean Temperature		Useful Heat Output	Ambient Temp	Additional temperatures																
	Start	End	Duration	Flow	Water Volume	Inlet	Outlet Tap Point	Outlet Tap Point		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	$T_{ContentDHW}$
		[s]		[litres/min]	[litres]	[°C]		[kJ]	[°C]					[°C]												
Start of test																										
1																										
2																										
3																										
4																										
5																										
6																										
7																										
8																										
9																										
10																										
11																										
12																										
13																										
14																										
15																										
16																										
17																										
18																										
19																										
20																										
21																										
22																										
23																										
24																										
End of test																										

tapping 1 to 23 required for table 3 tapping cycle No. 2
tapping " 24" only required for table 4 tapping cycle No 3.
T1, T2 and T3 only required for shower and bath draw-offs

Figure 3 - Example test sheet – NB other data 5a), 5b), 5g), and 5h) also required

6 SAP recognition data requirements

The Standard Assessment Procedure requires that the following information is derived from the test results and product manufacturer specifications:

a) Storage type (combined or separate)

b) Heat recovery efficiency (%)

c) Electrical consumption (kWh/day)

d) Actual dedicated storage volume (litres)

e) Lowest dedicated storage volume (litres)

f) Highest dedicated storage volume (litres)

6.1 Dedicated storage volume

Storage WWHRS incorporate a storage volume, Vww, dedicated to the recovered heat - there are two types:

- Combined: the dedicated storage volume is within the dwelling's hot water vessel
- Separate: the dedicated storage volume is a separate vessel (typically for connection to instantaneous hot water heaters such as a combination boiler)

The following chart shows the energy flows for both Storage WWHRS types. A separate efficiency test is required for each storage type; the following sections show how each parameter is derived.

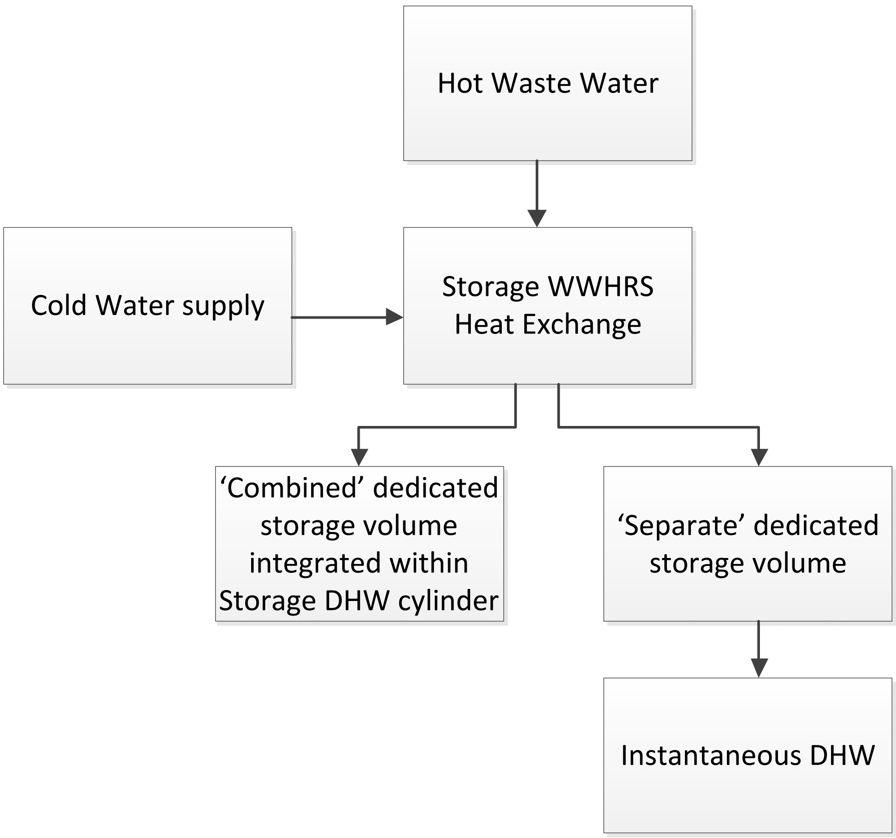

Figure 3 – Storage WWHRS - Types

6.2 Lowest dedicated volume

The lowest dedicated volume is defined as the minimum hot water vessel volume for which the test results are valid. During a hot water draw-off, the cold water flows into the base of the hot water cylinder, gradually flowing to the top as a cold front of rising water. When the rising cold front hits the cylinder thermostat it results in a command for heat from the heat source. Unlike solar water heating, where the amount of heat harvested can far exceed the demand, heat recovered from Storage WWHRS cannot exceed the energy content of the hot water used.

In defining the lowest dedicated volume, the critical factor is the volume of water used in a EN13203:2 shower draw-off and not the total daily volume of the hot water used. To capture all the heat from a bath[2] or shower water, the dedicated thermal capacity of the hot water vessel must be at least capable of storing the energy from a shower or bath that flows down the waste pipe. The lowest dedicated volume (V_{low}) has a thermal capacity that is equal to the amount of recoverable energy from a EN13203:2 shower draw-off. Below this volume only a portion of the energy can be recovered, which is expressed mathematically as:

$$V_{low} \times 4.19 \times (34 - 15) = 40 \times (52 - 15) \times 4.19 \times (1 - (40 - 34)/(40 - 15)) \times \textit{recovery efficiency}$$

Note:

- 40 litres is the volume of hot water used in the shower draw-off from EN13203 *number 2* tapping schedule
- 52ºC is the average delivery temperature of hot water in SAP 2009 (Table 1d)
- 15ºC is the average temperature of cold water in SAP 2009 (Table G2)
- 4.19 KJ/kg per K is the specific heat capacity of water
- 40ºC is the mixed water temperature
- 34ºC is the shower drainage temperature

The equation simplifies to:

$$V_{low} = 59.2 \text{ litres} \times \textit{recovery efficiency} \quad (2)$$

For example, if the heat recovery efficiency is 34% and the tested combined hot water vessel has a storage volume of 250 litres with 45 litres of dedicated storage, the lowest dedicated volume (V_{low}) would be 21 litres.

6.3 Highest dedicated volume

The highest dedicated volume (V_{high}) is the maximum volume for which the test results are valid. For 'Combined' hot water cylinders and for 'Separate' preheat vessels, as the dedicated volume of the vessel gets smaller (but still above V_{low}), the heat transfer efficiency increases because the temperature of the water surrounding the heat recovery coil will be lower. This is because the smaller the dedicated storage volume, the smaller the hot water draw-off required for the cold front to advance over the heat recovery coil. Therefore, larger dedicated volumes will have lower heat recovery efficiencies than smaller volumes and applying Storage WWHRS test results to installations with a smaller dedicated volume than that tested (but still above V_{low}) will not overestimate energy savings.

[2] Note: Baths are not included within the EN13203 hot water draw-off schedule tapping cycle No 2

Test results can therefore be applied to dedicated volumes up to the size of that tested without overestimating energy savings. The highest permitted volume is therefore:

V_{hign} = Dedicated volume of vessel tested

Note: Low and High dedicated volumes are used by SAP to determine whether test results are valid with respect to the actual hot water vessel installed. To prevent cut-off boundaries, outside this range Storage WWHRS energy savings are reduced linearly until they are zero at zero volume and zero at twice the volume.

6.4 Heat recovery efficiency

For each test, with and without heat recovery, calculate the weighted average temperature of the cylinder at the beginning and end of each 24 hour test period using the weighting factors in Table 1 and Table 2 for the 'Separate' storage type. Only include in the subsequent analysis the days of data where the weighted average temperature of the cylinder(s) has not deviated by more than ±0.2ºC.

Calculate the change in the energy content of the hot water cylinder(s) in kWh from the start to end of each 24 hour measurement period from the following:

(Cylinder temperature at end of day – Cylinder temperature at the start of the day) x 4.19 x V ÷ 3600

Note: 'V' is the total volume of the cylinder containing the waste heat recovery coil or the separate dedicated storage vessel in litres, 4.19 is heat capacity of water in kJ/litres/K, and the division by 3600 seconds converts to kWh.

Subtract the change in the energy content of the hot water cylinder or the separate dedicated storage vessel from the recorded energy content of the water drawn-off in each valid 24 hour test cycle to obtain the adjusted tapping energy.

Calculate the efficiency of the Storage WWHRS by dividing the sum of the adjusted tapping energy over all valid measurement cycles by the sum of the immersion heater input for the same measurement cycles.

Calculate the recovery efficiency from the following:

[(1 ÷ efficiency with no heat recovery) – (1 ÷ efficiency with heat recovery)] x 5.845 ÷ 2.8

5.845 kWh is the nominal heat content of the number *2* tapping schedule and 2.8KWh (2 x 1.4 kWh) is the nominal heat content of the two shower draw-offs within the *number 2* tapping schedule.

Rather than include the electrical heat gain of any pumps and controls as a separate heat gain elsewhere in SAP, the heat replacement effect is added to the heat recovery efficiency and named the uplifted recovery efficiency*.* Therefore, obtain the total daily electrical consumption from test data for the heat recovery pump and any additional pumps and controls to calculate the uplifted recovery efficiency from the following*:*

Recovery efficiency[3] + (0.66 x 0.975 x 0.80 x (total electrical consumption – heat recovery pump consumption x 0.8)/2.8

Multiply the result by 100 to express as percentage and round to the nearest 0.1%.

The uplifted recovery efficiency is the value required for SAP calculations.

---

[3] Expressed as fraction

Notes:

- 0.66 is the heating season expressed as a fraction of the year (240 days), since heat gains are not beneficial during the summer.
- 0.975 is a typical annual utilisation factor for well insulated dwellings, it will be higher for less well insulated dwellings.
- The first 0.80 is a factor applied by SAP to all electrical heat gains.
- The second 0.80 is the typical fraction of the heat recovery pump electrical energy that is transferred to circulation water as heat and is therefore already included in the recovery efficiency.
- 2.8 kWh per day is the nominal thermal energy content of a shower draw-off (within EN13203 tapping cycle No. 2)

6.5 Electrical consumption

The total electrical consumption of the Storage WWHRS must be recorded during the test. For the test where the Storage WWHRS is operational, calculate the average total daily electrical consumption associated with the Storage WWHRS when measured over the valid test days and where the deviation in $T_{Content\ DHW}$ is within ±0.5°C. This is the daily electrical consumption to be used in the SAP calculation. If SAP recognition of a Storage WWHRS product variant is sought and this product features an identical specification to that tested, except for a reduced number of accessory pumps (e.g. toilet lift pumps), the daily consumption of these components must be subtracted from the measured average total daily electrical consumption.

7 References

Water Heat Recovery Systems (Instantaneous Shower): Method statement for recognition in SAP

BS EN 13203-2:2006 Gas-fired domestic appliances producing hot water — Appliances not exceeding 70 kW heat input and 300 l water storage capacity — Part 2: Assessment of energy consumption.

PAS 67:2008 Laboratory tests to determine the heating and electrical performance of heat-led micro-cogeneration packages primarily intended for heating dwellings.

Appendix A – Manufacturer declared parameters

Storage WWHRS type: Combined or Separate	
Total storage volume (litres)	
Volume dedicated to the Storage WWHRS (litres)	
If Combined type, maximum height of WWHRS coil (mm)	

Table 4 – Storage WWHRS parameters required for SAP recognition

Appendix B – Toilet flushing schedule

A toilet flushing schedule is required to supplement the tapping patterns defined within this document when testing Storage WWHRS which recycle waste water for use in flushing toilets. This is required because the grey water vessel would overflow if not flushed during the 24 hour test, resulting in warm waste water being rejected directly to drain and therefore reducing potential energy savings.

A reliable source of data regarding the water consumption of toilets is *"BNWAT28: Water consumption in new and existing homes, briefing note 1, 2008, Market Transformation Programme"*. It provides data for 70 newer properties (40% flats and 60% houses) built since 2001 Building Regulations, where toilet flushes are limited to a nominal 6 litres per flush. The source also provides data for older properties (1989 or older).

Fitting	Ownership	Frequency of use (uses/property/day)	Volume per use (litre/day)	Household consumption (litres/property/day)	% of total
Toilet	100%	9.06	5.67	51.4	18.05
Internal tap	100%	38.81	1.81	70.2	24.68
Bath	57%	1.1	65.71	41.2	14.48
Washing machine	96%	0.55	50.92	26.9	9.45
Shower	93%	1.34	34.37	42.8	15.05
External tap	11%	0.76	176.14	14.7	5.17
Dishwasher	18%	0.43	13.67	1.1	0.37
Other appliances	39%	20.09	4.63	36.3	12.75
Total				284.59	100

Table 5 - Data for newer flats built since 2001 Building Regulations introduced (source: MTP 2008)

Fitting	Ownership	frequency of use (uses/property/day)	volume per use (litre/day)	Household consumption (litres/property/day)	% of total
Toilet	100%	11.67	6.62	77.3	19.76
Internal tap	100%	57.93	1.69	97.9	25.04
Bath	62%	1.22	80.86	61.2	15.65
Washing machine	100%	0.96	50.71	48.7	12.45
Shower	98%	2.2	39.96	86.2	22.04
External tap	12%	0.43	118.98	6.1	1.57
Dishwasher	60%	0.78	16.18	7.6	1.94
Other appliances	17%	11.92	2.99	6.1	1.55
Total				390.93	100

Table 6 - Data for newer houses built since 2001 Building Regulations introduced (source: MTP 2008)

Fitting	Ownership	Frequency of use (uses/property/day)	Volume per use (litre/day)	Household consumption (litres/property/day)	% of total
Toilet	100%	11.52	9.4	108.29	29.2
Internal tap	100%	37.9	2.3	87.17	23.5
Bath	88%	0.95	73.3	61.35	16.5
Washing machine	94%	0.81	61	46.3	12.5
Shower	85%	1.46	25.7	31.97	8.6
External tap	65%	0.89	46.7	27.1	7.3
Dishwasher	37%	0.71	21.3	5.6	1.5
Other appliances	21%	0.92	202.9	3.22	1.2
Total				371	100

Table 7 - Data for unmetered properties built before 1989 (source: MTP 2008)

For newer properties (post 2001) about 20% of water is used by WCs and in older properties the figure is nearly 30%.

According to the water industry, the average consumption of water in older properties is 150 litres/person/day; making 371 litres in Table 7 equivalent to 2.5 occupants.

The average total consumption of water in newer properties is about 125 litres/person/day; making 285 litres equivalent to 2.3 occupants (Table 5) and 391 litres equivalent to 3.2 occupants (Table 6).

This means that for newer installations there were an average of 4.0 and 3.7 flushes per occupant per day for flats and houses respectively. For older properties it is 4.6 flushes per person per day. Therefore, around 4 flushes per person per day is a reasonable average, particularly since properties may be unoccupied during part of the day.

The energy content of the EN13203 number 2 tapping schedule is equivalent to the energy contained in 135.4 litres of water heated by 37ºC. This is calculated from: 100.2 x 50/37, where '100.2' is defined by EN13203 and represents the equivalent volume of hot water in Litres at 60°C and '50' represents the temperature increase from a cold inlet temperature of 10°C.

In SAP the daily volume of hot water used, including distribution losses is:

$V_{d,average} = (25 \times N) + 36$ litres/day where N is the number of occupants

Therefore, the number 2 tapping schedule is equivalent to hot water usage by 4 occupants (i.e. (135.4 – 36)/25) and hence 16 flushes per day.

The average flush volume is 6.6 litres for installations in 2001 or later and 9.4 litres in older installations.

Assuming newer installations are of prime concern, this test specification requires 16 flushes of 6.6 litres to be made in conjunction with EN13203-2:2006 tapping schedule number 2. The supplementary toilet flushing schedule is tabled below.

Flush Start Time	Flush number	Volume (Lit)
06:55:00	1	6.6
07:40:00	2	6.6
08:25:00	3	6.6
08:40:00	4	6.6
10:10:00	5	6.6
12:10:00	6	6.6
13:10:00		
14:10:00	7	6.6
15:10:00		
16:10:00	8	6.6
17:10:00		
17:40:00	9	6.6
18:10:00	10	6.6
19:10:00	11	6.6
20:10:00	12	6.6
21:10:00		
22:40:00	13	6.6
23:10:00	14	6.6
23:40:00	15	6.6
00:10:00	16	6.6
Total		105.6

Table 8 - EN13203-2:2006 - Tapping number 2 – Supplementary toilet flushing schedule