



BNDH EWH04: Domestic Electric Water Heaters Government Standards Evidence Base 2009: Best Available Technology Scenario

Version 1.0

This Briefing Note and referenced information is a public consultation document and will be used to inform Government decisions. The information and analysis forms part of the Evidence Base created by Defra's Market Transformation Programme.

1 Introduction

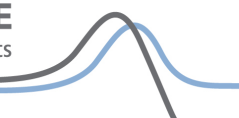
- The Best Available Technology (BAT) Scenario is a hypothetical projection of what would happen if the best available technologies on the (current and future) market were bought or installed from now on.
- The best available technologies are defined as the most efficient, or lowest energy consuming technologies available on the market, or those which are close to market (where the development stage is completed, but it is not necessary available as a designed product).

1.1 Product definition

- Products covered by this briefing note are **Dedicated Domestic Electric Water Heaters**, which are defined in the ErP¹ Working Document on possible Eco-design Energy labelling and Installation requirements for Water Heaters² as a “**product that is connected to a given external supply of drinking water and is equipped to generate heat and transfer this drinking water to desired temperature levels and at desired quantities, flow rates and intervals.**”

¹ The Energy related Products Directive, in this paper referring to the documents for Lot 2, Water heaters.

² July 2008 revision, page 5.



- Dedicated domestic water heaters can be distinguished by fuel (gas, electricity, solar, etc.) and functionality (storage and instantaneous). This briefing note covers instantaneous and storage electric water heaters and includes:
 1. Electric storage (kitchen heaters or small showers) water heaters [ES]
 2. Electric instantaneous water heaters and electric boiling water appliances (electronic) [EI]
 3. Electric showers (instantaneous hydraulic) [EIH].
- This brief does not include combination units for space and water heating, which are covered by the Domestic Boilers model described in BNDH B01: Domestic Boilers Government Standards Evidence Base 2009: Key Inputs.

1.1.1 Dedicated Domestic Electric Storage [ES] Water Heaters

- The **Dedicated Domestic Electric Storage [ES] Water Heaters** that have been modelled can be classified as follow:
 - Single point/non-pressurised with a capacity of less than 15 litres
 - Multi point/pressurised with a capacity of less than 15 litres
 - Large vented with a capacity bigger than 15 litres.
- **Single point/non-pressurised:** these are also named “displacement” or “point of use” water heaters (e.g. hand wash appliances) and have an open outlet. To displace the hot water they rely on the opening of a tap or a valve on the inlet side in the heater with incoming cold water. The open outlet ensures that any excess pressure in the heater is vented.³
- **Multi point/pressurised:** these are supplied directly from the mains under pressure and can deliver hot water to two or more outlets simultaneously.
- **Large vented:** these have a storage capacity that is above 15 litres and are mainly applied to supply multiple consumer points where supply from a cold-water storage tank is impractical.⁴ A vent pipe allows a safe route for excess pressure, air bubbles and steam should the system overheat; it runs from the top of the cylinder back up to the cold-water storage header tank where its open vent is located just above the water level.⁵

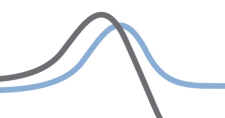
1.1.2 Dedicated Domestic Electric Instantaneous Water Heaters

- The instantaneous types of Dedicated Domestic Electric Water heaters are mainly used as point-of-use water heaters and are characterised by a number of elements: flow rate at a particular outlet temperature, flow rate control and water heater pressure.

³ BSRIA, March 2008, World heating 2007 – United Kingdom Water Heating – Report 50851/17

⁴ BSRIA, March 2008, World heating 2007 – United Kingdom Water Heating – Report 50851/17

⁵ <http://www.plumbingpages.com/featurepages/HWopenvented.cfm>



- For the purpose of this study the **Dedicated Domestic Electric Instantaneous Water Heaters** have been split into groups:
 - Instantaneous water heating devices with “electronic” flow rate control **[EI]**, including non-pressurised single point ‘hand-wash’ units and pressurised in-line units (12 kW or less) which deliver heated water to multiple taps or showers. These products can maintain a set temperature throughout a range of flow rates and sometimes allow the user to preset temperature and/or flow rate through the electronic control. This group also includes instantaneous electric boiling water appliances⁶ which are water heaters designed to produce water up to the boiling point. For example these are used to supply hot water for consumption: tea, soup, etc.
 - Instantaneous water heating devices with “hydraulic” flow rate control **[EIH]**. This product type includes mainly electric showers and is controlled by a simple heating on/off switch dependant on the water pressure, but with a temperature limit override. Electric showers are fed with cold water only, which is heated instantaneously as the water flows. Flow rates are relatively low at about 4-9 litres per minute, depending on power rating and required temperature rise. These rates can also be affected by low mains pressure at peak times, diminishing performance. Electric showers typically use about 300 kWh per household per year. Running costs and associated CO₂ emissions of electric showers are much higher than mixer showers using water heated by gas.⁷

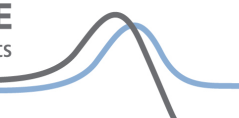


Figure 1 Example of a typical Electric Instantaneous Water Heater (Vaillant) and Electric Shower⁸

⁶ ErP Preparatory Study on Eco-design of Water Heaters – Task 4 Report Final, VHK, September 2007, p.145 <http://www.ecohotwater.org/>

⁷ Domestic heating and hot water – choice of fuel and system type - Good Practice Guide - GPG 301, Building Research Energy Conservation Support Unit, 2002

⁸ www.plumword.co.uk



2 Scenario outputs

- The graph below describes the BAT [Best Available Technology] Scenario for energy consumption of dedicated electric water heaters.

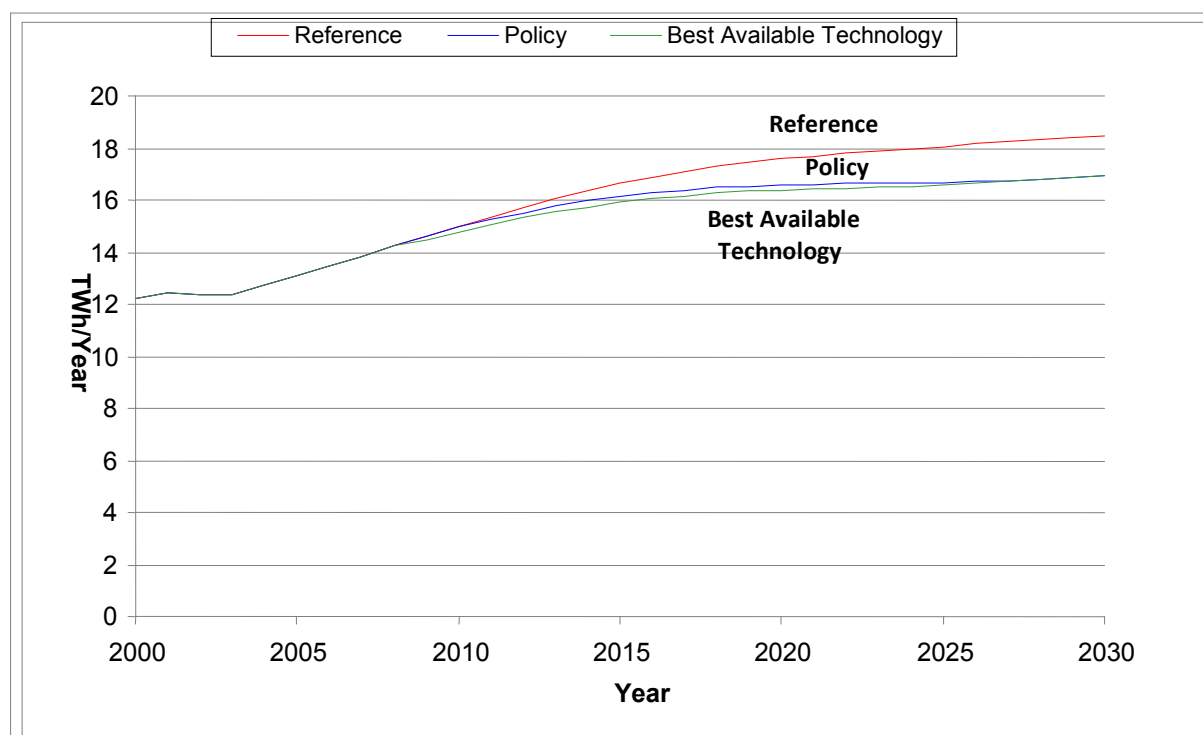


Figure 2 Dedicated Domestic Water Heaters (Electric) - Energy Consumption

Table 1 – Summary energy consumption and savings – Electric Storage (ES)

BAT Scenario year	Total energy consumption (BAT, GWh)	Annual energy savings (Reference - BAT, GWh)	Annual CO ₂ Savings ⁹ (Reference - BAT, MtCO ₂)
2010	2,480	95	0.04
2020	2,070	621	0.27
2030	1,980	807	0.35

MARKET TRANSFORMATION PROGRAMME

Developing evidence for Government and business on energy using products

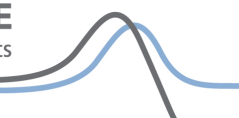


Table 2 – Summary energy consumption and savings – Electric Instantaneous (EI)

BAT Scenario year	Total energy consumption (BAT, GWh)	Annual energy savings (Reference - BAT, GWh)	Annual CO ₂ Savings (Reference - BAT, MtCO ₂)
2010	1,070	0	0.00
2020	1,250	- 64	-0.03
2030	1,330	- 95	-0.04

Table 3 – Summary energy consumption and savings – Electric Showers (EIH)

BAT Scenario year	Total energy consumption (BAT, GWh)	Annual energy savings (Reference - BAT, GWh)	Annual CO ₂ Savings (Reference - BAT, MtCO ₂)
2010	11,200	105	0.05
2020	13,100	646	0.28
2030	13,600	831	0.36



3 Efficiency

3.1 Summary

- The efficiency values utilised in the BAT scenario are the best possible for dedicated domestic electric water heaters and have been taken from the Task 6 of the Preparatory Study on Eco-design of Water Heaters¹⁰.
- Note that the ErP labelling scale extends to higher efficiency than those achievable by Best Available Technologies. This is partly because the maximum specific efficiency (in primary energy) that can be achieved by an electric heater of any type is 40%¹¹, whereas gas fired heaters, for example, can achieve much higher numbers in the same, common labelling scale.
- The efficiency improvements expected to be obtained by the best available technologies are related to the water heater's specific efficiency (or system efficiency).
- In the chart below, specific efficiency (%) for each size category of each product type has been multiplied by the corresponding sales, weighted by average usage, to display efficiency improvement in terms of average demand (kWh) per annum, for each product type.



¹⁰ ¹⁰ Preparatory Study on Eco-design of Water Heaters – Task 6 Report Final, VHK, September 2007

¹¹ Within the Ecohotwater model, the specific efficiencies calculated for electric hot water heaters a factor of 2.5 lower than the equivalent performance of a gas water heater to allow for the higher carbon content of the electrical energy.

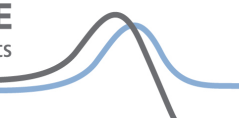
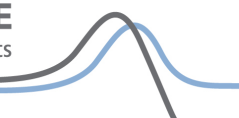


Figure 3 Sales-weighted average efficiency by product type

The characteristics of these more efficient products/systems are of the same kind as those found in the Policy Scenario:

- ES:
 - Improved heat loss
 - Improved electronic temperature sensors and control, varying temperature according to hot water demand
- EI:
 - Improved electronic control: conventional on-off heating elements depend on a minimum flow rate, and below a certain pressure the device does not activate these elements. Electronic control manages flow rate and temperature more efficiently.
 - Two-stage power control (summer/winter switch) accommodates the drop in incoming water temperature that occurs during winter times.
- EIH: electronic control
 - Control that maintains a set temperature throughout a certain range in flow rate and allows temperatures and flow rate to be pre-set.
 - Advanced electronic models offer preset buttons for specific temperatures
- The specific energy efficiency is described in Annex IV¹² of the working document for a specific load profile and is defined as the ratio of the minimum theoretical energy consumption to generate the required energy load to the actual primary energy consumption. The latter includes the impact of smart control and adjustments for distribution losses within the building.
- The Annex IV is supported by a calculation model, the “Ecohotwater model”, which calculates the efficiency and energy consumption of Domestic Dedicated Electric Water Heaters.
- Three Dedicated Domestic Electric Water Heater types (ES, EI and EIH) are modelled to reflect BAT scenario, classified according to Task 6 of the ErP Preparatory Study on Ecodesign of Water Heaters.
- In the Ecohotwater model water heaters are subdivided in size classes (kW) from 3XS (smallest) to XXL (biggest). For the purpose of this study, which focuses only on domestic electric water heaters, the relevant classes have been reduced to six for ES water heaters (from XXS to XL), to five for EI (from 3XS to M) and three for EIH (from 3XS to XS).

¹² ANNEX IV on Eco-design implementing measures for dedicated water heaters Draft v2 - European Commission - Brussels, (June 2008)



- Table 4,
- Table 5 and Table 6 below list energy efficiency and energy consumption for each of the BAT products split into ErP categories as obtained from Preparatory Study on Water Heaters-Task 6 Design Options (September 2007). In this table BAT specific efficiencies in the red shaded cells exceed the efficiency required in the Policy Scenario. It is assumed that the BAT values are achieved in 2009. No further improvements are envisaged.

Table 4 Efficiency and energy consumption (ES) - [BAT]

ELECTRIC STORAGE WATER HEATERS (ES)		XXS	XS	S	M	L	XL
Typical storage size (litres)		5-10	10-15	15-30	80	120	150
	% of sales	29.8	63.1	4.6	0.8	0.7	1.0
	Energy Consumption (kWh)	1,777	1,777	2,174	4,669	9,478	14,320
Reference	Specific Efficiency (%)	25	25	22	27	27	29
Policy 2011	Specific Efficiency (%)	32	32	32	27	27	29
Policy 2013	Specific Efficiency (%)	32	32	32	27	27	29
Policy 2015	Specific Efficiency (%)	32	34	34	27	27	29
BAT	Specific Efficiency (%)	32	34	34	35	34	38

Table 5 Efficiency and energy consumption (EI) - [BAT]

ELECTRIC INSTANT WATER HEATERS (EI)		XXS	XS	S	M
Min power ¹³ (kW)		6.3	12.5	15.7	18.8/23.3
	% of sales	90.0	3.7	3.8	2.5
	Energy Consumption (kWh)	1,348	1,369	1,350	3,400
Reference	Specific Efficiency (%)	34	34	34	38
Policy 2011	Specific Efficiency (%)	34	34	34	38
Policy 2013	Specific Efficiency (%)	34	34	34	38
Policy 2015	Specific Efficiency (%)	34	34	34	41
BAT	Specific Efficiency (%)	34	34	34	41

¹³ Quoted in the ErP Working Document on possible Ecodesign Energy labelling and Installation requirements for Water Heaters (July 2008): Minimum power of 100/80% efficiency at steady state.

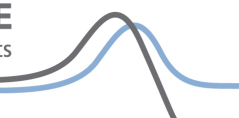


Table 6 Efficiency and energy consumption (EIH) - [BAT]

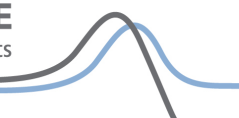
ELECTRIC INSTANT WATER HEATERS (EIH)		XXS	XS
Min power (kW)		6.3	12.5
	<i>% of sales</i>	90	10
	Energy Consumption (kWh)	1,513	1,348
Reference	Specific Efficiency (%)	30	34
Policy 2011	Specific Efficiency (%)	32	34
Policy 2013	Specific Efficiency (%)	32	34
Policy 2015	Specific Efficiency (%)	32	34
BAT	Specific Efficiency (%)	32	34

3.2 Data sources – efficiency

- All efficiency data have been estimated based on Preparatory Study on Water Heaters-Task 6 Design Options –(final) and historic data sources are included in BNDH EWH02: Reference Scenario

3.3 Methodology & key assumptions – efficiency

- This scenario assumes that all electric water heaters achieve the highest energy efficiency possible from 2009-2030, based on Preparatory Study on Water Heaters-Task 6 Design Options – (final) specific to the relevant products (Electric Storage Water Heaters, Electric Instantaneous Water Heaters and Electric Showers).
- Therefore the specific energy efficiency calculation has been based on the assumptions that the same efficiency levels recommended by ErP proposed for 2015 have been applied to the three product categories for all sizes.
- Products under size M to XL modelled in this study currently are still not succeeding in meeting the ErP requirements; they can achieve up to 27% specific efficiency.



- The energy efficiency for each of the BAT products was only changed if the efficiency was greater than the values used for the reference scenario.
- However, it is recognised that other water heater products (e.g. ground source heat pumps) are more energy efficient and are likely to replace electric water heater products in the future, although these have not been modelled in this study.
- The Reference Scenario, as defined in Preparatory Study on Water Heaters-Task 5 Definition of Base Case – (final) was used to evaluate and determine the medium-term BAT values.

3.3.1 Future analysis

Table 7 Extrapolation & background calculations – efficiency

Year	Methodology & assumptions
2009 - 2030	BAT design options from Ecohotwater/Preparatory Study on Water Heaters-Task 6 Report –(final) has been applied to sales from BRG C report ¹⁴ to calculate weighted average energy efficiency

- No BAT energy efficiency data were available for Electric Storage Water Heaters sizes L and XL from the Preparatory Study on Water Heaters-Task 6 Design Options – (final). For example the same energy output provided by a storage electric water heater can be generated with much higher efficiency by solar thermal system, although these have not been modelled in this study.

3.4 Data issues – efficiency

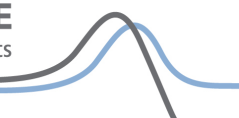
- Ecohotwater is a complex tool and it is still in draft format. The regulations are also at present in draft form¹⁵.

Table 8 Data issues – efficiency

Issue/risk	Approach taken/rationale
Electric water heaters will potentially be replaced by more efficient alternative products (gas water heaters, ground source heat pumps)	The highest possible energy efficiency values have been applied from 2009-2030 based on Preparatory Study on Water Heaters-Task 6 Design Options – (final). In future all dedicated water heating technologies might be considered together so that switching between technologies and fuel types to improve energy efficiency can be taken into account.

¹⁴ BRG Consult UK-5-1, July 2008, UK Heating 2008 –International market strategy – United Kingdom

¹⁵ Working document on possible Ecodesign Energy labelling and Installation requirements for Dedicated Water Heaters (June 2008)



Issue/risk	Approach taken/rationale
No BAT energy efficiency data available specifically for electric storage water heaters for ErP sizes L and XL	As a closest comparison, an electric storage water heater with 3.6m ² solar system was used.

3.5 Confidence level – efficiency

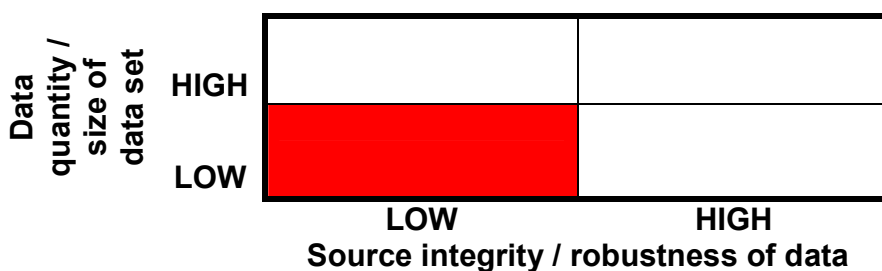
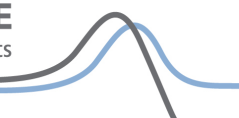


Figure 4 Confidence indicator for efficiency data



Related MTP information

- BNDH EWH01: Domestic Electric Water Heaters Government Standards Evidence Base 2009: Key Inputs
- BNDH EWH02: Domestic Electric Water Heaters Government Standards Evidence Base 2009: Reference Scenario
- BNDH EWH03: Domestic Electric Water Heaters Government Standards Evidence Base 2009: Policy Scenario
- BNDH KO01: Domestic Central Heating Government Standards Evidence Base 2009: Key outputs

Changes from previous version

- None. This is the first published version

Consultation and further information

Stakeholders are encouraged to review this document and provide suggestions that may improve the quality of information provided, email info@mtprog.com quoting the document reference, or call the MTP enquiry line on +44 (0) 845 600 8951.

For further information on related issues visit <http://efficient-products.defra.gov.uk>