



BNDH B04: Domestic Central Heating Government Standards Evidence Base 2009: Best Available Technology Scenario

Version 1.1

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

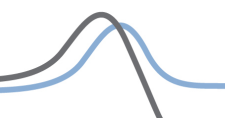
- The Best Available Technology (BAT) scenario is a hypothetical projection of what would happen if the best available technologies on the (current and future) market were bought or installed from now on.
- The best available technologies are defined as the most efficient, or lowest energy consuming 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

Conventional Central Heating (CH) Boiler

- This briefing note and related model include the energy consumed by domestic boilers to both heat domestic hot water and provide space heating. Dedicated water heaters are dealt in a separate set of briefing notes¹.
- The definition of a CH-boiler has been adopted from the ErP Working Document (published 29 Feb 2008) that: *A CH-boiler is a product that is equipped to generate heat and to transfer this heat to a heat transfer fluid (CH-water) circulating in a distribution system (CH distribution network) to which at least one heat exchanging*

¹ BNDH GWH01: Domestic Gas Water Heaters Government Standards Evidence Base 2009 and BNDH EWH01: Domestic Electric Water Heaters Government Standards Evidence Base 2009.



means is connected (CH-emitter) that is equipped to transfer the heating energy of the CH-water into space heating of (a part of) buildings.

- Domestic Boilers can be regular boilers (CH-boiler) or combi boilers (CH-combi)² type: A CH-boiler provides heating directly and can provide domestic hot water through a separate CH-water tank (i.e. Insulated storage tank or cylinder). A CH-combi is a product with the functionality of both a CH-Boiler and a Water Heater. CH-combi has the capability to provide domestic hot water directly. Some CH-combis, defined also as 'primary storage' combis, can include a small hot water store of up to 15 litres. Secondary storage CH-combis include a built in hot water store of 15 litres or more³ (Figure 1)

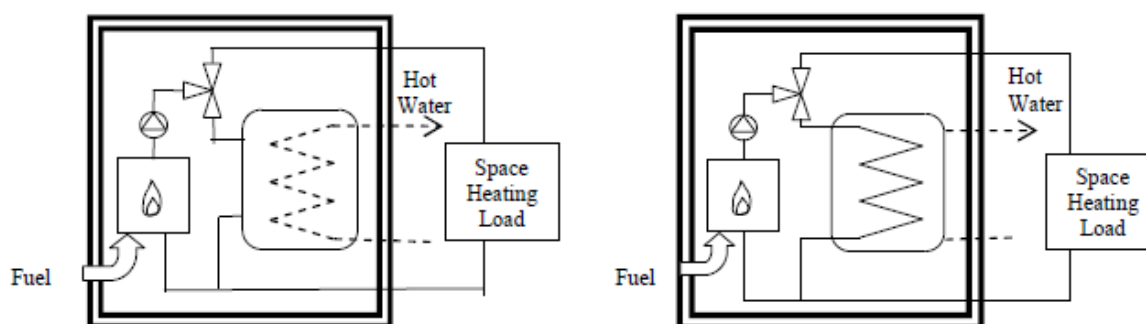


Figure 1 - Primary storage CH-combi (left) and Secondary storage CH-combi (right)⁴.

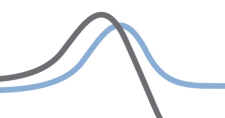
- Condensing boilers can achieve seasonal efficiencies (SEDBUK)⁵ between 83% and 92%. This is higher than for non-condensing boilers due to the extraction of latent heat by condensing water from the flue gases.
- Most boilers comprise a single combustion chamber enclosed by the waterways of the heat exchanger. Combustion gases are expelled through the flue having given up most of their heat to the water. The temperature at which these gases are expelled to atmosphere is a major determinant of the efficiency of the boiler.
- Non-condensing boilers expel these gases at around 180°C.
- Condensing boilers are designed to allow a reduction of the flue gas temperature to a much lower temperature, 55°C when other conditions permit. This reduction of

² Working document on possible Ecodesign Energy labelling and Installation requirements for Boilers and Water Heaters – February 2008 - page 5

³ Combination Boilers and Low Flow Fittings - Elemental Solutions 2007. www.environment-agency.gov.uk/savewater

⁴ The Government's Standard Assessment Procedure for Energy Rating of Dwellings 2005 (SAP 2005) edition revision 2.

⁵ Seasonal Efficiency Domestic Boiler UK – this is an industry standard for measuring and publishing the thermal efficiency of a boiler.

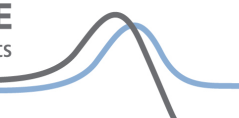


temperature causes some of the water vapour to condense and the remaining gases are expelled to the outside environment.

- According to The UK Government's Standard Assessment Procedure for Energy Rating of Dwellings 2005 [SAP 2005] a Condensing boiler is '*a boiler designed to make use of the latent heat released by the condensation of water vapour in the combustion flue products. The boiler must allow the condensate to leave the heat exchanger in liquid form by way of a condensate drain*'.
- SAP 2005 therefore defines Non-Condensing Boilers as boilers [...] without the means to remove the condensate in liquid form.
- The current domestic boiler stock in the UK is evenly split between regular and combi boilers. However, sales figures show that the latter are becoming increasingly popular in the UK, although these almost exclusively use gas.
- The Domestic CH-Boilers covered by this brief have been subdivided into three main categories:
 1. *Gas Fired – Regular Boilers (Condensing and Non-Condensing);*
 2. *Gas Fired – Combi Boilers (Condensing and Non-Condensing);*
 3. *Oil Fired – all boilers*

Alternative Heating Technologies

- Additionally, three groups of alternative technologies have been considered as likely replacements for boilers:
 4. *Alt- Elect - (alternative, electrically-driven systems: ground source heat pumps, air source heat pumps ...)*
 5. *Alt-Gas - (alternative, gas-driven systems: gas heat pumps, micro CHP...)*
 6. *Alt- Biomass - (alternative, biomass-fired systems: solid fuel boiler)*
- Heat pumps are identical in operation to refrigerators, incorporating an electrically driven compressor to create a pressure difference between two volumes of refrigerant. In the refrigerator the aim is to extract heat from the food compartment (i.e. cool it down) and reject this heat to atmosphere as waste heat. In the heat pump, the "waste heat" is transferred to a heating medium. Heat is extracted from a convenient source such as the atmosphere or the ground. In effect heat is "pumped" from a low temperature to a higher temperature.
- The main advantage of a heat pump is that it produces more useful heat (kW) than is used to drive the compressor. As such, the efficiency is greater than 100%.

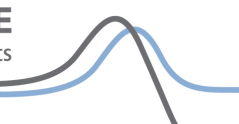


- Ground source heat pumps use buried pipes to extract heat from the ground, which is usually used to warm water for space heating systems. It can also pre-heat water before transferring it to a more conventional boiler.⁶
- Air source heat pumps absorb heat from the outside air. This heat can then warm water for radiators or underfloor heating systems, or warm the air directly.
- As both ground source and air source systems heat water to a lower temperature than a standard boiler system would, they are more suitable for under floor than radiator distribution systems. An air-to-air system produces warm air which circulates through a dwelling by fans.
- Micro CHP systems simultaneously generate usable heat and electricity in a single process. They are suited to single dwellings, and range in size from around 4kW heat output (suited to small, well-insulated dwellings) up to 36kW (these units will incorporate a supplementary boiler for additional heat output in larger or hard to heat dwellings). Electrical power output is typically 1kW to 3kW and can be grid-connected.⁷
- Biomass heating comprises a modified solid fuel boiler designed to operate on unprocessed wood chips or logs, or wood pellets (a processed form of waste wood and sawdust). Such boilers are available for individual dwellings or as community heating boilers.
- Biomass boilers reduce CO₂ emissions compared to conventional fossil-fuelled boilers by virtue of the comparatively low effective carbon content of the biomass. The residual effective carbon content is from the energy expended in harvesting, processing and transport.
- All of these alternative technologies utilise renewable energy sources that do not directly contribute to greenhouse gas emissions. They do however require conventional power sources to control and drive the equipment (mainly compressor, pumps and fans).⁸

⁶ <http://www.energysavingtrust.org.uk/>

⁷ <http://www.energysavingtrust.org.uk/>

⁸ UK Heating 2008 -BRG Consult; Section 3.124.



2 Scenario outputs

- The Best Available Technology (BAT) Scenario for CH-boilers is based on an evaluation of the current, best-performing products in the international market. The best-performing conventional boiler technology that is currently commercially viable has a System Efficiency⁹ of 80%. This is discussed in more detail in section 3.3 below.

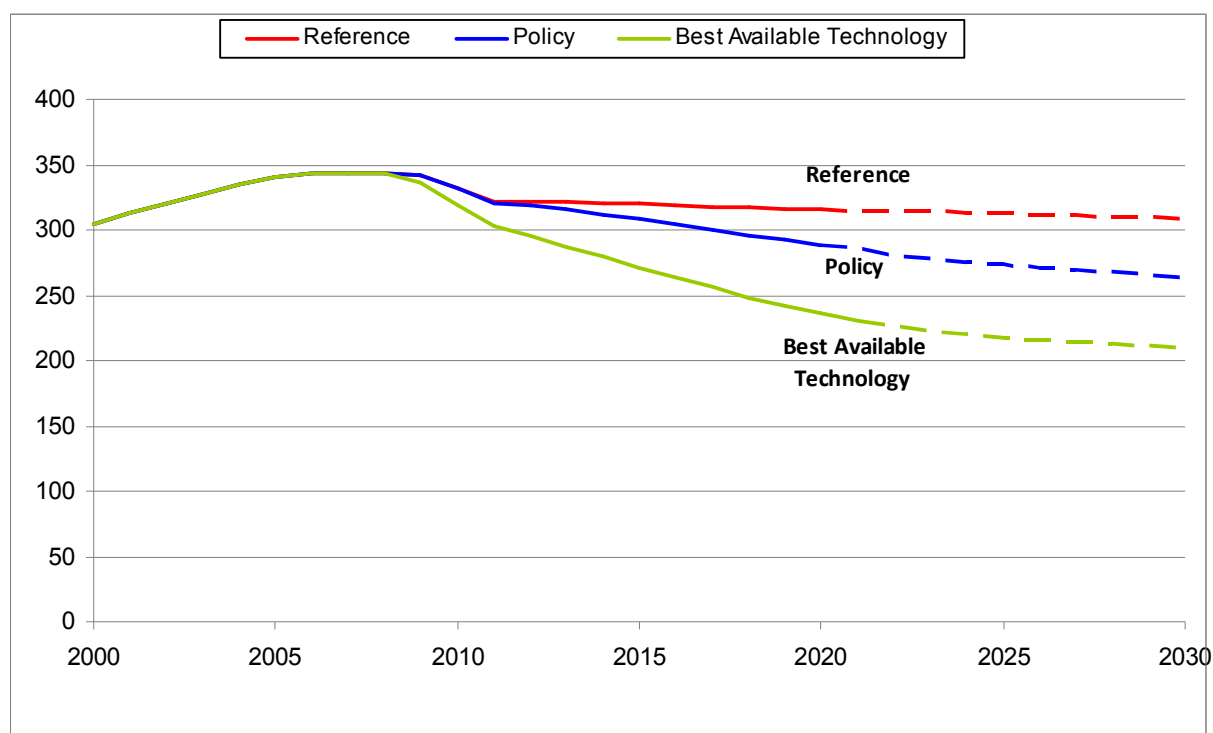


Figure 2 - Summary Graph Energy Consumption – Domestic Central Heating (TWh/year)

Table 1 – Summary energy consumption and savings – Domestic Oil CH-boiler

Policy Scenario year	Total energy consumption (BAT, GWh)	Annual energy savings (Reference - BAT, GWh)	Annual CO ₂ Savings ¹⁰ (Reference - BAT, MtCO ₂)
2010	27,100	2,200	0.58
2020	13,700	13,800	3.66
2030	10,700	15,500	41.10

⁹ System efficiency refers to the efficiency achieved by the entire heating and hot water system in serving the needs of the building. It requires modelling the demand of the building to be heated and comparison of that with the fuel required by the boiler and heating system. The methodology used for calculating this is described in Task 5 of the ErP Preparatory Study on Ecodesign of Boilers. See <http://www.ecoboiler.org/>

¹⁰ It assumes conversion factor for savings from MTP Briefing Note BNXS01

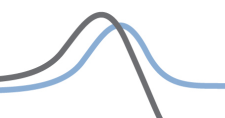


Table 2 – Summary energy consumption and savings – Domestic Gas Regular CH-boiler

Policy Scenario year	Total energy consumption (BAT, GWh)	Annual energy savings (Reference - BAT, GWh)	Annual CO ₂ Savings (Reference - BAT, MtCO ₂)
2010	151,700	4,000	0.74
2020	77,200	28,400	5.23
2030	44,400	40,600	7.47

Table 3 – Summary energy consumption and savings – Domestic Gas CH-Combi Boiler

Policy Scenario year	Total energy consumption (BAT, GWh)	Annual energy savings (Reference - BAT, GWh)	Annual CO ₂ Savings (Reference - BAT, MtCO ₂)
2010	137,100	10,200	1.88
2020	109,600	71,300	13.10
2030	100,600	91,400	16.8

- Note in tables 4-7 below, due to the accelerated displacement of conventional boilers, energy consumption of alternative technologies *increases*, as compared to the Reference Scenario. Therefore savings for these technologies appear negative. However total savings are positive.

Table 4 – Summary energy consumption and savings – Alt - Electric

Policy Scenario year	Total energy consumption (BAT, GWh)	Annual energy savings (Reference - BAT, GWh)	Annual CO ₂ Savings (Reference - BAT, MtCO ₂)
2010	1,200	-1,200	-0.52
2020	12,100	-11,500	-4.95
2030	18,900	-16,700	-7.18

Table 5 – Summary energy consumption and savings – Alt - Gas

Policy Scenario year	Total energy consumption (BAT, GWh)	Annual energy savings (Reference - BAT, GWh)	Annual CO ₂ Savings (Reference - BAT, MtCO ₂)
2010	980	-980	-0.18
2020	10,400	-9,800	-1.80
2030	16,500	-14,100	-2.59

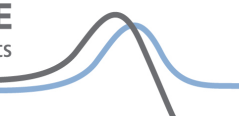


Table 6 – Summary energy consumption and savings – Alt - Biomass

Policy Scenario year	Total energy consumption (BAT, GWh)	Annual energy savings (Reference - BAT, GWh)	Annual CO ₂ Savings (Reference - BAT, MtCO ₂)
2010	1,200	-1,200	0
2020	12,800	-12,300	0
2030	19,400	-17,700	0

Table 7 – Summary energy consumption and savings – All

Policy Scenario year	Total energy consumption (Policy, GWh)	Annual energy savings (Reference - Policy, GWh)	Annual CO ₂ Savings (Reference - Policy, MtCO ₂)
2010	319,000	13,000	2.50
2020	236,000	80,000	15.24
2030	210,000	99,000	55.60

- Two key assumptions underpin these outputs:
 - From 2009, only the most efficient (best available) of each boiler type is sold.
 - From 2009, displacement of conventional boilers by alternative technologies accelerates.

Table 8 – Summary Stock – Domestic CH-boilers and alternative technologies: BAT Scenario (000's)

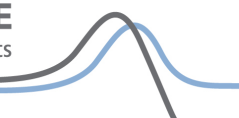
	Oil Boilers	Gas Regular	Gas Combi	Alt Electric	Alt Gas	Alt Biomass	Total ¹¹
2010	1,500	10,800	11,100	200	130	100	23,800
2020	1,100	6,900	12,400	2,500	1,500	1,100	25,500
2030	1000	5,100	12,100	4,000	2,400	1,800	26,400

Table 9 – Summary Sales - Domestic CH-boilers and alternative technologies: BAT Scenario Sales (000's)

	Oil Boilers	Gas Regular	Gas Combi	Alt Electric	Alt Gas	Alt Biomass	Total ¹²
2010	130	210	870	220	130	110	1,660
2020	72	230	1,170	250	150	110	1,990
2030	77	280	1,160	270	160	120	2,070

¹¹ Totals may differ from sum due to rounding

¹² Totals may differ from sum due to rounding



3 Efficiency

3.1 Summary

- Average system efficiency in the BAT scenario improves considerably, driven by an immediate shift to the sale of the most efficient conventional boiler systems, and accelerated take up of alternative technologies.
- See Section 4.1 of BNDH B02: Domestic Boilers Government Standards Evidence Base 2009: Reference Scenario, for description of general approach to modelling system efficiency

Table 10 Summary - Average system efficiency sold – all scenarios

Scenario	Average heating system efficiency		
	Reference	Policy	BAT
2010	0.57	0.59	0.93
2020	0.59	0.70	0.92
2030	0.60	0.75	0.92

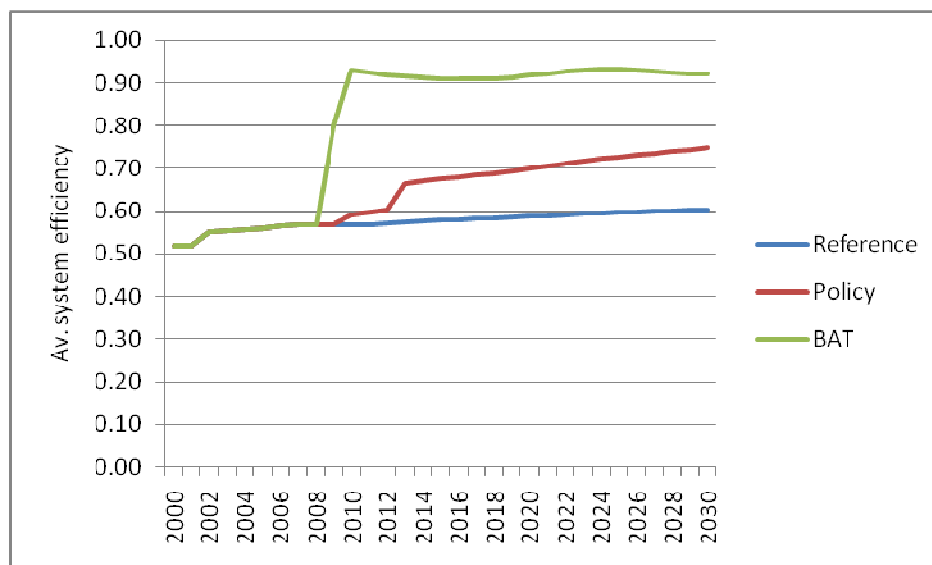
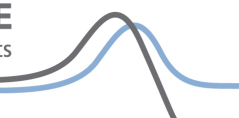


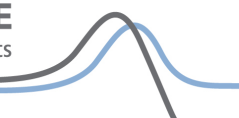
Figure 3 - Summary - Average system efficiency sold – all scenarios



3.2 Data sources – efficiency

Table 11 Efficiency data sources – CH-boilers and alternative technologies

Year	Reference	Ref date	Author	Justification	Confidence in sources (High/Low)
1970-2030	ErP Preparatory Study on Ecodesign of Boilers Task 6 Report – final, Design options – pp 12- 41,	30 September 2007	Van Holsteijn en Kenma (VHK)	Good source of data, based on market research	High



3.3 Methodology & key assumptions – efficiency

- This section describes assumptions and approach taken for each product in evaluating the system efficiency for the BAT scenario.
- The BAT efficiency values for conventional boilers are derived from the Preparatory Study on Ecodesign of Boilers¹³.

Table 12 Summary BAT system efficiency – by technology type (%)

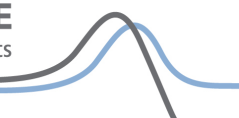
Product	2010	2020	2030
Oil Boilers	80	80	80
Gas Regular Boilers	80	80	80
Gas Combi Boilers	80	80	80
Alt - Electric	160	160	160
Alt – Gas systems	110	110	110
Alt - Biomass	70	70	70

- Efficiency levels are determined for each ErP product size, from XXS to XL¹⁴.
- System efficiencies are achievable assuming the following equipment:
 - Size XXS and XS – system includes: boiler with steady state-efficiency of 89/97¹⁵; modulating burner; class “A” variable speed pump; low power fan; CPU with low standby power losses (2-3 watts); standby heat loss reduced to 0.5% and; turndown improved to 10%.
 - Size S – system efficiency is similar to XXS and XS above achieving 79% including: a boiler with steady state-efficiency of 89/97; modulating burner; class “A” variable speed pump; low power fan; CPU with low standby power losses (2 - 3 watts); standby heat loss reduced to 0.5%; improved turndown ratio of 10% and; tertiary heat exchanger with ionisation based lambda control.
 - Size M - system efficiency of 82% including: a condensing boiler; modulating burner; improved steady-state efficiency using tertiary heat exchanger with lambda-control and; class “A” variable speed pump.
 - Size L - system efficiency of 78% including: a boiler with steady state-efficiency of 89/97; modulating burner; motorised valve with PID loop; low power fan; 95 W

¹³ Eco-design of Boilers, Task 5, Final - Base case | 30 September 2007 | VHK for European Commission

¹⁴ Ecodesign of Boilers, Task 6 Report – final, Design options – pp 12- 41, 30 September 2007

¹⁵ The first number refers to the steady-state boiler efficiency at full load and the second number is the efficiency at 30% load



pump; electronic optimiser, CPU 14/16; standby heat loss reduced to 0.5% and; improved turndown ratio of 10%.

- Size XL – system efficiency of 77% including: a boiler with steady state-efficiency of 89/97, modulating burner, PID loop; low power fan; class “B” variable speed pump; electronic optimiser; standby heat loss reduced to 0.5% and; improved turndown ratio of 10%.

3.3.1 Future analysis

- It is assumed that all the new CH-systems, including alternative technologies, achieve the highest energy efficiency possible from 2009 to 2030. System efficiency is based on Preparatory Study on Ecodesign of Boilers -Task 6; Design Options (final).

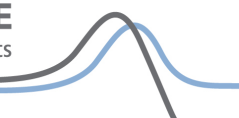
Table 13 Extrapolation & background calculations – efficiency

Year	Methodology & assumptions
2009-2030	Output from Eco boiler elaborated in MTP Boiler Model (2009) for and averaged based on sales and boiler size
2009-2030	Assumed CH-boiler system efficiency increases to 80%
	Assumed Alt Electric system efficiency to be constant at 160%
	Assumed Alt Gas system efficiency to be constant at 110%
	Assumed Alt Biomass system efficiency to be constant at 70%

3.4 Data issues – efficiency

Table 14 Data issues – efficiency

Issue/risk	Approach taken/rationale
Eco boiler v5b used is a draft model. Method for calculating system efficiency may change in future revisions of this model	Model is best equipped to calculate impacts of dominant, ErP policy for central heating systems. Tool is publicly available, and transparent
Efficiency calculated in the Task 6 of the Preparatory study by VHK uses Eco boiler version 5a	Careful comparison of this model has been undertaken to understand the calculation methodology and assumptions as compared to the MTP Boiler model (based on Eco boiler 5b)



3.5 Confidence level – efficiency

- Although the data available are robust and based on a research by VHK¹⁶ for the European Commission, some assumptions have been required regarding alternative technologies, since the data range available is small.

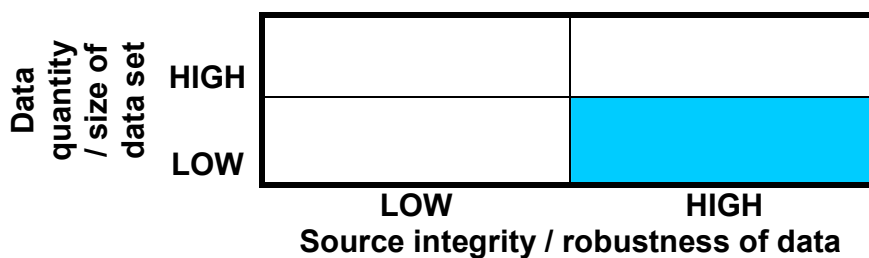
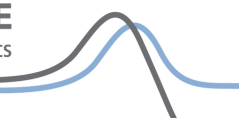


Figure 4 Confidence indicator for efficiency data

¹⁶ Van Holsteijn en Kemna



Related MTP information

- BNDH B01: Domestic Boilers Government Standards Evidence Base 2009: Key Inputs
- BNDH B02: Domestic Boilers Government Standards Evidence Base 2009: Reference Scenario
- BNDH B03: Domestic Boilers Government Standards Evidence Base 2009: Policy Scenario
- BNDH KO01: Domestic Central Heating Government Standards Evidence Base 2009: Key outputs

Changes from version 1.0

- Reference to obsolete Briefing note removed
- Data in table 6 completed
- Minor changes to template

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.

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