

Combination boilers now account for over 50% of the domestic boiler market. The Combi Club reckons that this figure is likely to rise to over 60% by the end of 2001 and break the 70% mark over the next four years. Combi boilers are here to stay – at least until gas supplies run out. If we want to use the gas efficiently in a combi, then it is worth investigating the condensing combi market. Energy

Consultant John Willoughby does just that...

Combined effort



There are about 23 gas condensing combis on the market. Obviously they are not all the same and vary between manufacturer and between models from the same manufacturer. This article looks at the various attributes of a range of condensing combis that are available in the UK. The list of boilers (see main table page 16) comes from the recent Energy Saving Trust grant scheme (see box right) with the addition of two manufacturers who did not appear on that list. To

The essential features of a condensing combi. This model has a fully modulating gas and air supply and a plate heat exchanger providing domestic hot water (DHW). (courtesy Vaillant Ltd)

understand this article you need to refer to the main table on page 14 while you read

Combi boilers provide heating and hot water from a single unit without the need to have a hot water cylinder. The heating side of the combi is very similar to an ordinary boiler - water is passed through a heat exchanger where it is heated by the gas flame. In the condensing version, the heat exchanger is extended so that the flue gases have a chance of being cooled down below their dew point temperature. When the flue gases are cooled below 57°C the water vapour in the flue gas condenses. The condensing boiler wins in two ways: a) extra 'sensible' heat is extracted from the burner by cooling the flue gases down from a typical temperature of 150°C to a much lower temperature and b) once the magic 57°C has been reached, 'latent' heat is extracted as the water vapour condenses to liquid water.

Ordinary boilers are designed to ensure that no condensation can occur on the heat exchanger. This is because the condensate is slightly acidic and might corrode the heat exchanger. The heat exchanger in the condensing boiler is made of aluminium or stainless steel, which is resistant to this potential corrosion.

A common misconception about condensing boilers is that they are only efficient when they are in condensing mode. It is often said that condensing boilers must be used with oversized radiators to ensure lower return temperatures.



But condensing boilers will always be more efficient than ordinary boilers because of the larger heat exchanger. Indeed the graph (below) shows that there is only a small increase in efficiency when going from non-condensing to condensing mode. Compared to an ordinary boiler the main improvement is in the increased 'sensible' heat transfer.

The most common way for combis to heat domestic hot water is either via a plate heat exchanger or via thermal store. One side of the plate heat exchanger is heated by boiler water which then heats the mains cold water on the other side of the plate. Most thermal stores, referred to as 'Primary Stores', contain boiler water and the mains cold water is heated as it passes through the store in an extended coil (see section on 'Hot water stores').

Having dealt with the basics, it is possible to look at each feature shown in the main table in turn.

Heating output

Generally the first issue when selecting a combi is its heat output. In particular the heat output to hot water. In the early days

the hot water production was not great and combis were generally seen as only being suited to one or two bedroom properties. All the combis in the survey use their maximum output to heat hot water. The range is from 22 kW to a massive 46 kW. This is often equated to a hot water flow rate at a given temperature rise. It is important to check the stated temperature rise as figures are quoted for 25K, 35K and 45K. Obviously the higher the temperature rise, the slower the flow rate. The figures quoted in the table are for a 35K rise and vary from just under 10 litres per minute to 21 l/min. With average mains cold water temperatures of around 10°C, a 35K rise would result in a temperature at the tap of 45°C – hot enough for a bath or shower. Using mains pressure water, the combi has the potential to provide a good shower facility. But obviously the flow rate is an

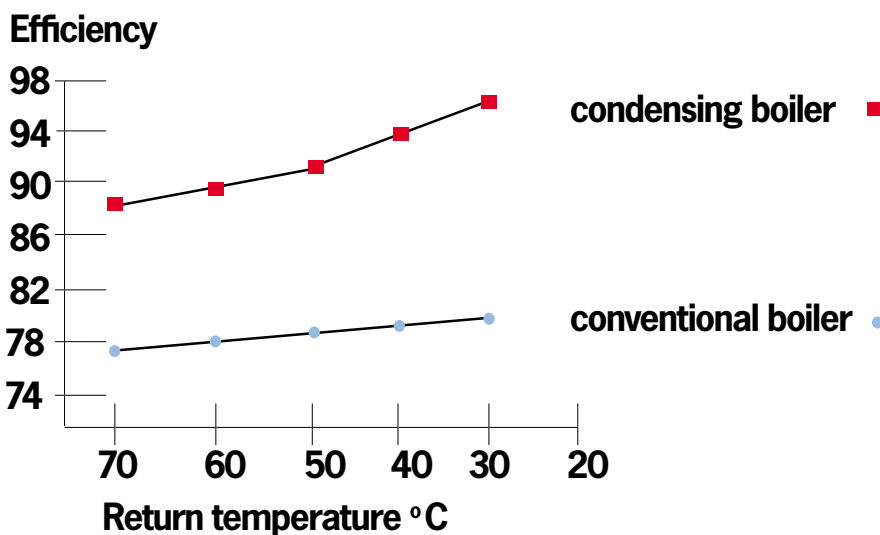
The Energy Saving Trust (EST) ran a grant scheme to encourage the uptake of condensing boilers. The scheme offered a grant of £200 to a householder who had a condensing boiler installation. The grant finished in March 2000. But it was replaced by another scheme which offered grants of £250 on new oil and LPG fired condensing boilers with upgraded heating controls. This grant expired on 31st March 2001. More information on possible future grants can be obtained by phoning the Energy Efficiency Hotline on 0345 277200.



issue. A 'power shower' can use as much as 20 l/min but a perfectly reasonable shower should be possible using 10 l/min. By using an aerating or atomising shower head this can be reduced to 6 or even 4 l/min. So if specifying one of the smaller boilers, it is important to check that the shower is not going to require too great a flow. In common with all combis the shower mixing valve must be designed for use with mains pressure hot and cold water.

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Efficiency / Temperature Graph



The graph shows that, while the efficiency of a condensing boiler does increase as the return temperature reduces, more than half the improvement over an ordinary boiler occurs above the dewpoint temperature and is due to the extended heat exchanger.

Condensing combination boilers

Make	Model	Heating output (kW at 50°C flow / 30° return)	Hot water output (max kW) / l/min at 35K rise	SEDBUK Efficiency (%) / Rating (A – G)	NOx emissions (mg/kWh)	Heat exchanger material ss=stainless steel Cu=copper Al=aluminium	Hot water store size (l) P=Primary, S=Secondary	Always condensing in hws mode?	Hot water separately programmable?	Fan stays on in hws mode?	Accepts solar preheated cw supply?	Size (h x w x d) (mm) ⁴
Eco Hometec	EC3-16S	3.1 – 15.8	22.0 / 9.8	89.9/B	20	ss	None ²	Y	Y	N	Y	980
Eco Hometec	EC4-23S	3.1 – 21.4	28.0 / 12.6	89.9/B	20	ss	None ²	Y	Y	N	Y	980
Eco Hometec	EC5-31S	4.5 – 28.4	36.0 / 16.5	90.2/A	20	ss	None ²	Y	Y	N	Y	980
Eco Hometec	EC7-38S	6.0 – 35.1	46.0 / 21.0	90.1/A	20	ss	10 P	Y	Y	N	Y	980
Glow-worm	Energysaver Combi 80	6.8 – 24.5	24.3 / 9.8	90.6 / A	<70	Cast Al	13 P	N	N	N	N	850
Glow-worm	Energysaver Combi 100	8.9 – 28.8	27.2 / 11.5	90.4 / A	<70	Cast Al	12.4 P	N	N	N	N	980
Ideal	Response SE	10.1 – 25.1	25.1 / 10.0	88.3 / B	70	Cast Al	None	Y	Y	N	N	800
Malvern	Combi	16.0 – 23.5	22.5 / 9.5	85.8 / C	N/A	Cu primary, Al sec	None	Y	N	N	Y	850
Potterton	Envoy Flowsure	25.0	25.0 / 12	88.7 / B	N/A	Cast al	20 P	N	N	N	Y	850
Potterton	Envoy Flowsure+	25.0	25.0 / 18	88.7 / B	N/A	Cast al	50 S	N	N	N	Y	850
Ravenheat	CSI 85	13.4 – 25.6	25.6 / 10.6	88.0 / B	N/A	Cu primary, Al sec	None	N	N	Y	N	850
Saunier Duval	24E Ecosy Combi	Same as Glow-worm										
Saunier Duval	28E Ecosy Combi	Same as Glow-worm										
Servowarm	Elite HE Combi	Same as Malvern										
Vaillant	ECOMax 824E	12.2 - 19.6	23 / 9.4	88.4 / B	64	ss	None ²	Y	N	N	N	800
Vaillant	ECOMax 828E	14.9 – 23.8	28 / 11.5	88.5 / B	55	ss	None ²	Y	N	N	N	800
Viessmann	Vitodens 100	8.0 – 24.0	24.0 / 9.8	90.0 / A	60	Coated cast Al	None ^{2,3}	Y	Y	N	Y	900
Warmworld	Combi	Same as Malvern										
Worcester/Bosch	26Cdi XTRA	6.7 – 26	24 / 9.5	85.8 / C	20	ss	None	N	N	N	N	850
Worcester/Bosch	RX2	Same as 26Cdi XTRA										
Worcester/Bosch	Greenstar	7.7 – 25.3	24 / 9.5	91.3 / A	20	Cast al	8 P ³	Y	Y	N	N	850

Notes

1. The maximum efficiency achievable by SEDBUK is about 92%.
2. Keep-warm facility
3. Thermal store or keep-warm facility can be by-passed
4. Size of casing only. Excludes flues or clearances
5. Except where indicated (6) the cost has been obtained from merchants as the best price for a one-off. It includes cost of standard flue. It does not include VAT or delivery charges



Size (h x w x d) (mm) ⁴	Max flue length (m)	Approx cost (£) ⁵	Country of manufacture	Telephone	Additional remarks	Model	Make
980 x 458 x 355	110	£1255 ⁶	Holland	01302 722 266	Built in weather compensation	EC3-16S	Eco Hometec
980 x 458 x 355	110	£1310 ⁶	Holland	01302 722 266		EC4-23S	Eco Hometec
980 x 458 x 355	110	£1425 ⁶	Holland	01302 722 266		EC5-31S	Eco Hometec
980 x 458 x 355	110	£1560 ⁶	Holland	01302 722 266		EC7-38S	Eco Hometec
890 x 520 x 373	3.0	£740	Holland	01773 824 141		Energysaver Combi 80	Glow-worm
985 x 520 x 373	3.0	£810	Holland	01773 824 141		Energysaver Combi 100	Glow-worm
800 x 450 x 300	3.0 / 9.0	£695	England	01482 492 251		Response SE	Ideal
890 x 500 x 340	2.0	£770 ⁶	England	01684 893 777		Combi	Malvern
815 x 740 x 384	3.0	£1025	England	01914 914 466		Envoy Flowsure	Potterton
815 x 830 x 384	3.0	£1130	England	01914 914 466		Envoy Flowsure+	Potterton
850 x 422 x 360	22.0	£710	Italy	0113 252 7007		CSI 85	Ravenheat
				01773 824 141		24E Ecosy Combi	Saunier Duval
						28E Ecosy Combi	Saunier Duval
		£1711 ^{6,7}	England	0845 602 2088	supply and install package	Elite HE Combi	Servowarm
800 x 480 x 300	10.0	£830	Germany	01634 292 310		ECOmax 824E	Vaillant
800 x 480 x 300	10.0	£890	Germany	01634 292 310		ECOmax 828E	Vaillant
900 x 500 x 406	6.0	£790 ⁶	Germany	01952 670 261	Switchable keep warm facility, Built in weather compensation	Vitodens 100	Viessmann
		£830 ⁶	England	01179 498 800	'badged' Malvern	Combi	Warmworld
850 x 450 x 360	2.0	£780	England	01905 754 624		26Cdi XTRA	Worcester / Bosch
						RX2	Worcester / Bosch
850 x 512 x 390	8.0 / 11.3	£885	Germany	01905 754 624	Switchable keep warm facility	Greenstar	Worcester / Bosch

6. Cost supplied by manufacturer

7. Includes installation, a two year warrantee and two free services



SEDBUK efficiency bands

SEDBUK figures are calculated by measuring the full load efficiency and the efficiency at 30% load. These figures are then used in a formula to calculate the likely seasonal efficiency depending on the boiler type (normal / combi / etc), whether it has a modulating or on/off burner and whether it has a heat store. Boilers are classified in bands A – G. The condensing combis surveyed have SEDBUK efficiencies in bands A – C. The best non-condensing combi is 'D' rated.

Band	SEDBUK efficiency
A	90 – 94%
B	86 – 90%
C	82 – 86%
D	78 – 82%
E	74 – 78%
F	70 – 74%
G	Below 70%

The efficiency of most domestic boilers can be found on the SEDBUK web site at www.sedbuk.com.

Another issue with combi boilers is the time taken to fill the bath. If a bath needs 80 or 100 litres of hot water from the combi, then it will take between 5 and 10 minutes to fill the bath depending on the output of the boiler. Whether this is acceptable is very much up to the householder. But of course the great advantage of the combi is that there is no limit to the number of baths that can be taken one after the other.

So if you are prepared to wait for 5 to 10 minutes for your bath and you select the shower head carefully, there is no reason why the condensing combi shouldn't serve a house with a bath and a couple of showers.

Most of the combis in the survey have modulating burners, which reduce the gas and air supply to the boiler in line with the heat load. Since the boilers are generally sized to provide hot water, this turndown ratio is often important for matching the heating load.

SEDBUK efficiency

The great advantage of a condensing combi is the enhanced boiler efficiency. But the term 'boiler efficiency' needs to be defined since many different values are quoted. These can be full load 'bench' efficiencies either using gross or net calorific values. Using net calorific values can result in efficiencies of over 100% because the latent heat from condensation is added to sensible heat output. The actual efficiency in use can be significantly below the full load efficiency. To standardise boiler efficiencies in the UK, a new method has been developed to classify boilers. This is called the Seasonal Efficiency of Domestic Boilers in the UK (SEDBUK). (see box left)

NOx emissions

Gas combustion produces oxides of nitrogen (NOx). Nitric Oxide (NO) and nitrogen dioxide (NO₂) are produced. Nitric oxide (NO) oxidises in the atmosphere to form NO₂. This in turn leads to the formation of nitric acid: the main contributor to acid rain.

Some boiler manufacturers have taken care to reduce NOx emissions. The main factor in reducing NOx is to reduce the flame temperature. This is done by pre-mixing the gas and combustion air before it is burnt and by the careful design of the combustion chamber. Many boiler manufacturers are unwilling to reveal their NOx emissions. They maintain that the boiler meets 'Class Approval' under BS EN 483 *Gas-fired central heating boilers*.

The most stringent Class under this Standard is Class 5. This requires NOx emissions of less than 70 mg/kWh. This is quite a good standard and can be compared to the Blue Angel certificate which requires a NOx output of less than 65 mg/kWh for a gas condensing boiler. A more stringent German standard is the Hamburg standard, which calls for emissions of less than 44 mg/kWh. The boilers in the survey with quoted NOx emissions have values between 20 and 64 mg/kWh. (See table bottom right)

Heat exchanger material

As with normal condensing boilers, the

choice of material for the heat exchanger is important. This is because the condensate is slightly acidic and can be corrosive. The main materials used are stainless steel and aluminium. In several boilers with aluminium heat exchangers, the aluminium covers copper water ways so that the water in the boiler doesn't come in contact with the aluminium.

Condensing in hot water mode?

Raising the temperature of mains cold water from around 10°C to 45 or 50°C is an ideal application for condensing technology, since these temperatures are all below the dew point temperature of the flue gases. However not all the condensing combis operate in condensing mode when heating hot water. For instance if the domestic hot water heat exchanger requires a flow temperature from the boiler of say 80°C and a return of 70°C, to raise the mains cold water temperature, the boiler will not be in condensing mode.

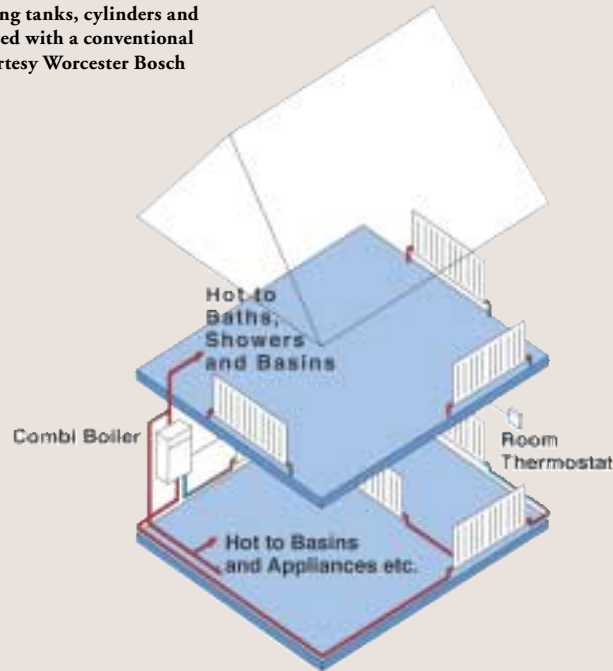
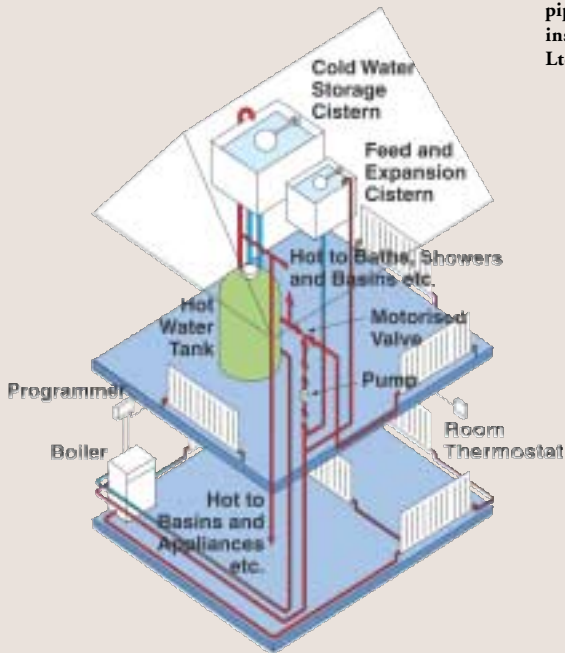
Several of the boilers do not always operate in condensing mode while producing hot water. In old, poorly insulated buildings, this may not cause too large a penalty. But it is much more important in new build situations where fuel used for hot water production is likely to be of the same order as fuel used for heating.

Hot water stores

A problem with combi boilers is that it can take a long time for hot water to reach the tap. After the tap is turned on, a pressure sensor tells the boiler to fire in hot water mode. The boiler goes through a purge cycle and fires. The primary water is heated up and then the mains cold (secondary) water is heated and flows to the tap. It can take as much as a minute before hot water has reached the tap. This is not only frustrating but also wastes large quantities of energy and water. With a long dead leg, 5 or 7 litres might be wasted every time a hot water tap is used. This could amount to a waste of as much as 50 or more litres per day. It doesn't sound much but over the year 18,000 litres of water would be wasted. If you are on a metered supply this could cost around £20



The combi boiler saves on installation costs by eliminating tanks, cylinders and pipework associated with a conventional installation. (courtesy Worcester Bosch Ltd)



and the energy loss could add another £15 in gas costs.

Manufacturers have responded to this problem in different ways. A common feature is to leave the combustion fan running when the boiler is in 'hot water stand-by' mode. This saves a few seconds by avoiding the purge cycle. But, not only is this a waste of expensive electricity, the fan noise can also be really annoying, particularly if the boiler is sited in a quiet room. The other way of reducing the cold water draw-off is to keep the secondary water warm. This is either done by keeping the heat exchanger warm or by using a small water store.

Six boilers in the survey have hot water stores. Of these all but one are primary stores. This means that they store the primary water from the boiler circuit and pass the mains cold water through an extended surface coil in the store. All the primary stores are less than 20

Maximum NOx emissions from BS EN 483

Class 5	Class 4	Class 3	Class 2	Class 1
70mg/kWh	100 mg/kWh	150 mg/kWh	200 mg/kWh	260 mg/kWh

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heating feature

condensing combi boilers

litres and presumably are insulated. It is not known whether this is more energy efficient than having a keep-warm facility on a plate heat exchanger. The volume of water in the heat exchanger is much smaller but it is unlikely to be insulated. Two of the boilers have keep-warm facilities that can be switched off. These are both German boilers. It should be noted that the keep-warm facility is not reflected in the SEDBUK efficiency figure. In fact a keep-warm facility can have the effect of reducing boiler efficiencies by 5 – 10%.

In a busy kitchen with long hours of use and a high demand for hot water, the overall effect of the keep-warm facility might not be too significant. But in a household where everyone is out at work and hot water use is much less, the waste of energy could be much more significant in terms of the overall hot water fuel use. It is important therefore that the hot water side of a combi is programmable. Nine boilers in the survey have stores or keep-warm facilities. Only five of these have programmable hot water production.

Solar preheating

Further savings in hot water fuel use can be achieved by using solar panels to preheat domestic hot water. If this preheated water can be supplied at mains pressure, then it might be thought that this water could be used to feed a combi boiler. But very few manufacturers condone this approach. In the survey only three said that their boilers could be used with a solar preheated mains pressure water supply.

Size

The physical size of the boiler is sometimes an issue. Particularly if it is to be contained under a worktop or in line with kitchen cabinets. Most are between 800 and 980 mm high. Several are 300 mm deep which will line up with typical kitchen cupboards but many of the boilers have depths between 300 and 390 mm. Widths vary between 422 and 830 mm.

Flues

All condensing combis have fan flues which mean that the diameter is relatively small – typi-

cally 100 – 110 mm diameter. Fan flueing also means that longer lengths of flue can be used. Many manufacturers can accommodate flues between 6 and 20 meters with one offering a staggering 110 m flue length.

Cost

The most difficult thing to establish is the cost. The common boilers can be bought through builders merchants and costs for these have been obtained on a 'best price for a one-off cash purchase' basis. Other costs have been obtained from the manufacturers where they are willing to sell direct to the customer. Prices vary from just under £700 to over £1500. The prices include the cost of a standard flue but exclude delivery and VAT charges.

Country of manufacture

Five boilers are made in England. The rest are manufactured in Holland, Italy and Germany. This can be an issue when considering servicing and spares. It might pay to be cautious when dealing with importers who have only one base in the UK.

Other features

Three manufacturers offer a built-in weather compensator. This reduces the heating flow temperature as the outside temperature rises. This is a useful feature in a condensing boiler as it increases the length of time the boiler will be condensing.

Two boilers, both made in Germany, have a feature which allows the store or keep-warm facility to be by-passed or switched off. This eliminates the standing losses associated with keeping the domestic hot water warm all the time.

Conclusions

Condensing combis all work at higher efficiencies than ordinary boilers. This is not only when condensing but in all conditions right across the season. It seems a pity that not all the boilers condense when producing domestic hot water.

Combi boilers can now be found with an

output to satisfy most demands – from the small flat to the large house. Improvements in part-load efficiencies and large turn down ratios mean that oversized boilers can still perform efficiently at low heating loads.

Thermal stores and keep-warm facilities will result in energy losses from the boilers. Losses associated with keep-warm facilities are not at present reflected in the SEDBUK efficiencies. In boilers with a store or a keep-warm facility it seems sensible to include a time control which can be used to switch the heating and the hot water supply off.

If you are looking for an 'A' or 'B' rated appliance with low NOx emissions, that condenses when producing hot water, then you will probably be looking at six manufacturers. If you want the fan off during stand-by mode and a programmable hot water supply, your choice is further reduced to four makes. The cost of these boilers varies between £700 and £1600.

John Willoughby

While every care has been taken in preparing this information neither the author or BFF can be held responsible for any errors. New boilers are coming onto the market all the time. It is almost inevitable that we will have missed some. To these suppliers we apologise.

John Willoughby is an energy consultant based in Gloucestershire and is currently a member of the AECB steering committee.