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FAT LOTS OF GOOD

The UK is missing an opportunity to heat its buildings using waste cooking oil. Harry Howard, of Atlantic Boilers, explains why biodiesel could rival biomass as an alternative fuel source

> An environmentally friendly alternative to fossil fuels, biodiesel supports an economic cycle that creates a secondary use for a waste material

Worldwide consumption of biodiesel has been rising rapidly since the start of the new millennium, with global production increasing from 16bn litres in 2000 to more than 100bn litres in 2012[1]. However, the industry is still in its infancy in the UK.

Based on gross national product, the UK market ought to total three billion litres of biodiesel per year; however, the country consumed just 1.6m litres during 2010-2011[2]. The majority of this output went to road transport – because of a fuel-tax allowance – but biodiesel can also be used in well-designed boilers and burners.

An environmentally friendly alternative to fossil fuels, biodiesel is a transformed variety of used vegetable and raw oils that supports an economic cycle that creates a secondary use for a waste material. In 2011, around 89% of the biodiesel manufactured in the UK was produced from used cooking oil[3].

The UK Sustainable Biodiesel Alliance has calculated that 90,000 tonnes of used cooking oil were collected throughout the country during 2011, leaving an estimated 160,000 tonnes uncollected[4]. Together, the four main biodiesel production centres – in Teesside, North Lincolnshire, Liverpool and Bellshill – made 218,000 tonnes of fuel during 2011, against a full-production capacity of 574,000 tonnes[5]. This is a significant over-capacity, ensuring future output for new developments.

Raw oilseed rape is also a source of biodiesel in the UK. It is planted in around 0.6m hectares and, annually, yields 1.8m tonnes of seed – plus, 7.2m tonnes of cattle feed. Generally, there is a 5% to 10% surplus of this oilseed rape, which is exported. This yield rose by 60% between 2000 and 2010[6].

In a comparison of calorific value with biomass, 100% biodiesel (B100) – produced to the European standard EN 14214[7] – gives 37 megajoules/kg (MJ/kg), as against 17MJ/kg for good-standard wood with moisture content of less than 1% (moisture content can reach 30% and reduce the heat capacity). In addition, one cubic metre of B100 contains 39,600MJ, as against 9,770MJ for one cubic metre of timber – which means it has up to four times more heat per unit volume.

In the past seven years, approximately 100 commercial biodiesel boilers have been installed in the UK[8]. The cultivation and processing of biodiesel emits less climate-relevant carbon dioxide than that of fuels from fossil sources. When looking at energy sources overall – as well as the individually polluting dangers to water, the climate, and human health – biodiesels compare very favourably with fossil fuels.[9, 10]

Storage, pipes and pumps

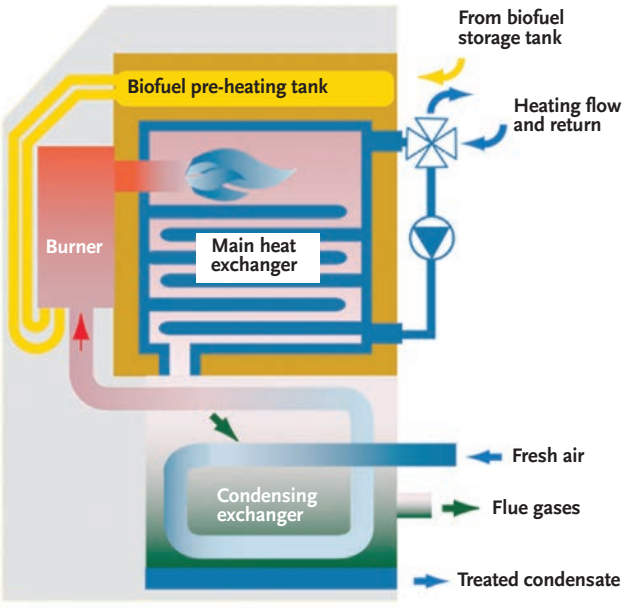
Provision must be made on site for B100 storage. General guidance for this is given by the Oftec OFST200 oil-firing equipment standard, and the Oftec SP697.432 oil-fired heating system design. It is usual to provide storage to enable the boiler plant to run at full load for a period of three weeks, plus a minimum of 10% extra to allow for a flooded sump, which covers against deposits in the bottom of the tank and against the total immersion of an electrical heater. This should allow for any disruption of supplies. For calculations, one litre of B100 is equivalent to 8kWHr.

Pipe sizing must be large enough to maintain a low pump suction head, and to avoid suction greater than minus 2kPA in the pipeline. B100 has a kinematic viscosity of 4.5 centistokes at 40°C, compared with 3.0 for diesel oil.[11]

Pipe materials must also be compatible with the B100 fuel – only carbon steel and, preferably, austenitic stainless steel materials are suitable. Pipe jointings and compounds must be carefully chosen; where valves, strainers and so on are fitted, they must not be brass, bronze or copper.

For smaller installations, an economic submersible pump will lift the B100 from the tank into the vicinity of the boiler and a pressure-balancing overflow valve. From there, the B100 is fed – at controlled pressure – to the boiler-burner assembly. For larger installations, of two boilers or more, a duplex in-line pumping system transfers the B100 to each boiler. Pressure

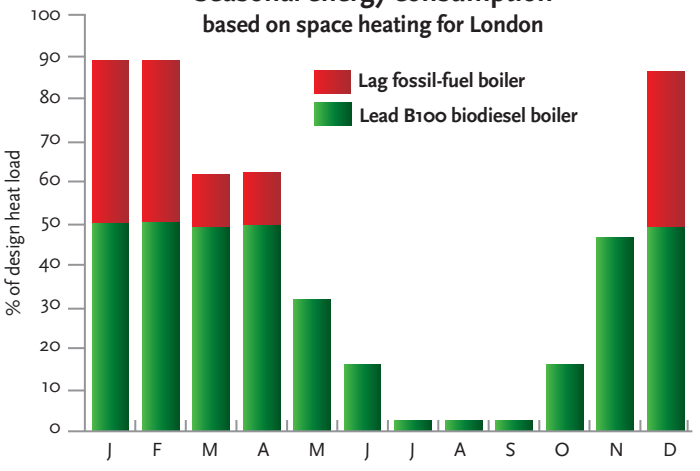
B100 biofuel condensing boiler



Biodiesel condensing[12] boilers recover most of the heat in the flue gases and, consequently, operate at much higher efficiencies. If the flue gases are cooled below their dew point, latent heat – as well as sensible heat – can be recovered.

- Maximum flow temperature 95°C; minimum return temperature 20°C
- Efficiency 92%GCV to 98%GCV

Seasonal energy consumption
based on space heating for London



In typical London weather, biodiesel boilers may meet the base load throughout the year

Turning chip fat into fuel

To turn vegetable oil into biodiesel fuel, a chemical reaction process called esterification (or transformation) takes place. With used cooking oil, this is preceded by fine filtering.

The whole process causes the physical properties of the vegetable oil – in particular, viscosity – to correspond to those of conventional diesel fuels. As a benefit, glycerine emerges as an additional product used in the food, pharmaceutical and personal care industries.

The development of the transformation process has resulted in a precision industry that converts used cooking oil into blended biodiesel, approved to EN 14214. This is a European standard that determines fatty acid methyl esters – the most common type of biodiesel. EN 14214 embodies strict quality controls, which are vital to maintain standards.

Biodiesel blends are designated as 'B', followed by a number indicating the percentage of biodiesel. For example, B99 is 99% biodiesel, 1% fossil diesel.

The method can transform a wide range of products, including animal fats and other raw vegetable oils.

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Biomass versus biodiesel

Biomass	B100 biodiesel
Risk of burn-back between fire zone and fuel store	Attacks rubber-based joints and seals
Unburned fuel clogging the ash zone	Attacks brass and copper materials
Difficulty of establishing fire rate	Low-temperature congealing (needs to be kept within the temperature range of 5°C to 15°C at all times)
Burden of handling the ash	Uncertainty over supply point
Fuel blockage in the wood screw	
Damp fuel in the store	
Particulate matter in the flue gases	
Incomplete combustion and excess CO	
Extended manual attendance	

Technical disadvantages of biomass and B100 biodiesel boilers

Initial and running costs (estimates) – typical 300kW boiler

Biomass	B100 biodiesel
Boiler + hopper space + undercover store £130,000 Annual fuel costs for winter space heating: Wood pellets – 1000 kgs for £250 or 17,000 MJ for £250 = 68MJ per £1 30 weeks x 60 hours x 300kW x 0.7 weather factor + 30 weeks x 48hours x 300kW x 0.1 Boiler base load = 378,000 + 54,000 divided by 80% Efficiency = **540,000 kWHr or 1,944,000MJ or £28,588**	**Biodiesel boiler + oil tank £35,000** Fuel – B100 – 75 pence per litre or 44MJ per £1 30 x 60 x 300 x 0.7 divided by 94%GCV **= 402,128 kWHr or 1,447,660MJ or £32,901**
Electric load – 5kW (burner + fuel handling) 30 x 60 x 0.7 x 3 + 30 x 48 x 0.1 x 3 = 3,780 + 432 = 4,212kWh 12.5kW per £1 = £337	**Electric load – 2kW (burner + oil pump)** 30 x 60 x 0.7 x 1 = 1,260 kWh or £101
Manual 30 wks x 4hrs = 30 x £120 = £3,600 Service boiler £900	**Attendance 30 wks x 1 hour** £900 **Service boiler** £900
Total first year – £163,465 **Total 20 years – £799,300**	**Total first year – £69,802** **Total 20 years – £731,040**

Costs are based on market prices

Pure biodiesel combustion process

Two chemical reactions take place

A. **Carbon + Air > Carbon dioxide + Nitrogen + Heat & Light**: Carbon in the B100 combines with oxygen in the air. If carbon/air mix is incorrect, carbon monoxide (CO) is formed

B. **Hydrogen + Air > Water + Nitrogen + Heat and Light:** Hydrogen in the B100 combines with the oxygen in air. If the nitrogen gets too hot, NOx is formed. Sulphur is almost negligible (0.002%) as against 0.29% in diesel fuel.

B100 biodiesel combustion – typical conditions

- CO lower than 20ppm
- Presently, NOx from 2 mg/kWHr to 40 mg/kWHr
- No lead, no sulphur, no benzene, no tuolene, no xylene, no particulate matter (soot)
- Pleasant odour
- Efficiency greater than 80% GCV and up to 98% GCV
- Boiler temperature range more than 20°C less than 95°C

in the feed circuit is regulated by the in-line pumps, and an overflow valve placed in the return.

Biodiesel boilers will operate efficiently down to 10% of output, and are capable of close control throughout the year. For example, in typical London weather, the biodiesel boilers may meet the base load throughout the year. Other fuels or forms of energy may be used to meet the extra demand of the peak winter months (see graph on page 59).

The B100 biodiesel boilers can have conventional or balanced flues. These are graded to the boilers to allow the condensate to drain to the rear of the boilers. The flues are precision-made from polyvinylidene fluoride (PVDF), which is extremely corrosion-resistant, hard-wearing, and not affected by ultra-violet radiation.

Hours of operations

Biodiesel boilers are particularly relevant for use in buildings that require long hours of boiler operation. The longer a biodiesel boiler runs, the larger the energy load it takes, and the greater the environmental advantage.

The Annual Hours table (see page 62) identifies different types of building and, in each case, gives an indication of the annual equivalent, full-load hours of boiler operation. Buildings of a similar heat load will probably require similar-size boilers, but these may run for vastly different lengths of time depending upon the use of each building. In each case, the biodiesel boiler must always be the lead boiler; two or three biodiesel lead boilers may be justified in the case of four- or five-boiler installations.

Biodiesel boilers can, therefore, be used to provide environmentally friendly space heating in the majority of buildings. They can be even more effective when space heating and centralised domestic hot water are considered together.

In a two-boiler installation, the lag boiler will be needed in the winter months. The lead boiler will also do 70% of its work in the five months from November to March, so both need to be at maximum efficiency in winter months.

Conclusion

Biodiesel boilers are cleaner and more efficient than biomass ones, and more environmentally friendly than traditional fuels. In addition, the material needed to produce it – waste oils – are readily

available in the UK, whereas biomass relies heavily on shipping wood from Europe.

What is required for the market in Britain to grow further, is for biodiesel to be fairly priced – unlike biomass it is not supported by the Renewable Heat Incentive scheme – to reflect its potential as a reliable energy source. **CJ**

Annual hours table

Annual operation
1,800hrs
Hospitals, old people's homes, residential nursing homes

Annual operation
1,400hrs
Boarding schools, children's homes, greenhouses, botanical gardens, halls of residence, hotels, leisure and sports centres, motorway services, prisons, swimming pools, colleges and universities, fire stations

Annual operation
1,000hrs
Airport terminals, clinics and health centres, day nurseries and schools, factories and warehouses, libraries and museums, retail units, shopping centres, department stores, theatres and cinemas, bingo halls

Annual operation
700hrs
Cafés, coffee bars, pubs, restaurants, banks, churches, small shops, supermarkets, surgeries

Annual equivalent, full-load hours of boiler operation for buildings with varying uses

Bibliography

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3 Renewable Transport Fuels Obligation (RTFO) data, 15 April 2011 to 14 December 2011

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8 *Key facts: Combustion, biofuels and and zero net carbon*, Dunphy **http://bit.ly/1pABRe7**

9 *Biodiesel – growing a new energy economy*, Greg Pahl 2005 p.7 et alia

10 *Planning & Installing Bioenergy Systems*, German Energy Society 2005 p.2 et alia

11 Altantic Boiler data sheet: TDS 102.B100 **www.atlanticboilers.com/manual/ATLANTIC_BIOFUEL.pdf**

12 **http://www.atlanticboilers.com/bio-diesel-boilers.html**