Bio or non-bio?

Bio energy plants are being touted as offering significant economic, as well as environmental, benefits. Steed Webzell explains the sustainable technologies involved and assesses what plant engineers need to know

Biomass plants are increasingly being recognised as providing primary routes to sustainability

Bio-energy, bio-fuel, biomass... We've all heard the terminology, but, in reality, precious few engineers appear genuinely to have explored the possibility of setting a meaningful 'bio agenda' for their plants. Why? Well, very likely because the mere thought conjures up presumptions of complexity, high capital cost and processes that sounds messy, at best.

But, as many of us will have discovered at one time or another, the presuming engineer is often the one who misses out. Even if bio-plants' transition to mainstream lies a few years down the track, now is the time to find out what this group of sustainable engineering technologies can offer – and to start thinking about where they might be applicable in our industry sectors.

To cut to the chase, bio-energy is essentially renewably-derived energy – generated from materials themselves produced via biological sources. Meanwhile, biomass (from which bio-energy is produced) is any organic material that has stored sunlight in the form of chemical energy. It includes waste wood and by-products from a variety of agricultural processes. As a result, some farming businesses and food manufacturing plants are among early converts to bio-energy production.

Enough of the basics: the burning question is probably what does it take to install a viable bio-energy plant? Well, first, much depends on the project scale. For instance, many small-to-medium size manufacturing plants might consider installing a biomass boiler, fuelled by logs, pellets or wood chips, for space heating or a contribution to their combined heat and power network. Physically, biomass boilers can be installed on most sites where there is a water-based heating system and where there is also enough space to store the pellets/chips required to fuel it.

But these can scale up: the UK's largest heat-only industrial biomass plant is at the Dairy Crest Davidstow site in Cornwall. Its creamery consumes 100,000 tonnes of steam per year in its cheese-making operations. Hence the biomass plant, which follows a pledge by the company to achieve a 28% carbon reduction by 2020. Moving to renewable energy for steam generation has cut site CO_2 emissions by a staggering 60% and is delivering a 12% reduction overall for the group.

For this project, Dairy Crest commissioned Dalkia, which has now installed more than 200 biomass plants, to design and construct a 12MW biomass steam generation plant, capable of supplying its steam requirements for the cheese pasteurising and drying processes.

Dalkia's solution is based on two wood pellet-fired boilers that replace clean fuel oil-fired equipment and reduce the factory's carbon emissions by 20,000 tonnes a year.

Step on the gas

An alternative to wood-based bio energy processes is, well, non-wood processes. Biodegradable outputs from agriculture, supermarkets, restaurants and even households can be used to feed anaerobic digestion (AD) fermenters, for example, that, in turn, produce bio-gas that can be burned to provide heat, electricity or both. Alternatively, it can be cleaned and pure methane used as a road fuel.

AD is the process where plant and animal material (biomass) is converted into useful products by micro-organisms in the absence of air. Biomass is pumped in to sealed tanks (the fermenters) where it is digested by naturally occurring micro-organisms, releasing methane that can, in turn, be used to provide clean, renewable energy.

The resulting bio-gas is a mix of 60% methane, 40% carbon dioxide and traces of contaminant gases, such as hydrogen sulphide and ammonia. Yes, the CO_2 component is a greenhouse gas, but it is offset, because the bio-gas replaces fossil fuels otherwise consumed for heat, power or transport. Unlike fossil fuels, this carbon does not contribute to climate change, because the CO_2 released by AD is reabsorbed by plants grown as part of the fuelling process. On the other hand, CO_2 released when fossil fuels are burned has been stored for

millions of years and plants present on the planet today simply cannot reabsorb it all.

As for access to adopting the technology, while biomass for AD can be purchased on the open market, farms and food plants have a clear advantage, due to their waste processing. Among the first in the UK to take advantage was Barfoots of Botley, the UK's largest sweet corn producer. The site at Pagham, near Chichester, is home to the UK's first sweet corn-fuelled (largely discarded husks) bio-gas plant. Three AD fermenters consume 25,000 tonnes of green waste per annum to generate fully three times more electricity and heat than is required to power the site, with the excess offered to the local community via the National Grid.

Not a single leaf of green waste leaves the site. As a result, there are now 5,000 fewer tractor journeys per year on the local roads. Moreover, this landmark plant also provides a water contribution for irrigation and fertiliser to feed further crops. To date, it has achieved a business CO_2 offset of 97%. Return on investment is calculated at approximately seven years.

Show me the maths

However, with both AD and wood-based biomass plants, it doesn't take a genius to see that there are significant environmental benefits. As bio-energy producers using renewable biomass fuels, many industrial plants could be playing a useful part in maintaining terrestrial carbon stocks, as well as in reducing fossil fuel emissions. So, then, what of the cost benefits?

Starting with wood-fuelled biomass boilers, according to a recent EC report, 'Biomass for heat and power – opportunity and economics', there is potential for huge savings in biomass-generated power and heat as volumes and experience grow. This study estimates 15 to 40% cost reductions, compared to today – a factor making it highly competitive with conventionally fuelled plants, using gas or oil.

That said, supply chain economics being what they are, rising spot prices for, say, wood pellets could offset some of the gains. Predicting market prices is never easy, but typical returns on investment in such a plant are cited as around the five to seven years' mark.

Bio-gas refuelling: a viable future for sustainable transportation?

This picture is similar for AD plants. Although dependent on the type and scale of biomass and digester deployed, as a rough guide, digesting a single tonne of food waste can generate about 300kWh of energy.

However, while the potential of biomass plants for renewable heat and power generation, alongside greenhouse gas reductions, looks convincing, it is still only slowly being realised. The fact is bio-energy technologies need to see more uptake from plant operators. Only then will the current barriers to adoption and further development be broken down. PE

Food, glorious food

For manufacturing plants without a ready supply of natural waste vegetation on site, one solution is to install a separate food waste processing plant. Wessex Water did exactly that at its Bristol Sewage Treatment Works in Avonmouth – building a facility capable of receiving up to 40,000 tonnes of food waste per year.

In brief detail, GENeco's anaerobic digestion plant will transform solid and liquid food waste into renewable energy and nutrient rich fertiliser. At full capacity, it will be capable of supplying the energy needs for around 3,000 homes. Wessex Water says it will also offer supermarkets, local authorities, food manufacturing facilities, hospitals, universities, catering establishments and waste management firms a cost-effective and sustainable solution for treating packaged and unpackaged waste.

A contract has been placed with Finning for the anaerobic digestion plant, and construction started in earnest last December (2011). Plant design and process engineering technology is being provided by Monsal, with civil engineering from Damar. The plant will begin accepting food waste deliveries from autumn this year.