Weighing up the options

Biomethane-powered Mercedes Benz Econic refuse trucks in Malmo, Sweden

John Baldwin, *natural gas consultant and Managing Director of CNG Services, provides a strong personal viewpoint on the 'pros and cons' of the various alternative fuels currently available on the market or under development.*

When a German engineer named Rudolf Diesel developed an engine in 1892 he intended it to use a variety of fuels, including peanut oil. At around the same time, his fellow Germans Gottlieb Daimler and Karl Benz were inventing the petrol engine. Some 120 years later, 99% of cars, buses and trucks continue to run on diesel and petrol. However, as the National Petroleum Council (NPC; **www.npc.org**) said in its July 2007 report on global energy supplies: 'We are facing the hard truths about energy' – which is code for 'Opec has got all the oil and won't sell it cheap to us anymore'.

According to the NPC, the world's most accessible oil supplies are in Opec countries that keep the oil majors out; pretty much the only places they can go now are to mine the tar sands in Canada and the US. Unfortunately, getting oil out of these rocks is a global warming nightmare. So, what options are there to start to reduce dependence on diesel and petrol derived from oil and, at the same time, reduce the carbon dioxide (CO_2) impact of transportation fuels (freeing up some CO_2 ullage to extract the tar from Canada)?

Biofuels

Wheat can be made into bioethanol, while palm oil or peanut oil can be made into biodiesel. Both these processes are possible today and the demand for these fuels is growing rapidly – in the US to keep farmers happy, in Europe to reduce CO_2/km. Vehicles can, and do, run on these fuels as 5% blends and future designs will progressively be able to run on higher 85% blends. Consultants acting for the UK government in relation to the introduction of the Renewable Transport Fuel Obligation (RTFO), identified an average reduction in emissions of 11% from bioethanol (compared to petrol) and 35% from biodiesel (compared to diesel).*

The third biofuel is biomethane, which is made in the same way as natural gas was made 200mn years ago, from dead green matter (see *Petroleum Review*, August 2007). Some 228 buses in Lille currently run on biomethane made from domestic green waste, which is collected by biomethane-powered refuse trucks. This is a great idea – and one that the UK should have adopted rather than subsidising bus travel by giving all the diesel duty back to the bus operator.

Natural gas as CNG or LNG

The NPC also says that we are running out of easy to access oil, but the natural gas picture is a lot healthier, maybe another 20 years to peak gas after peak oil. Vehicles can, and do, run on natural gas, but until recently oil and gas prices were linked so there was little underlying financial benefit in natural gas as a transport fuel. However, the divergence of oil and gas prices in Europe over the last three years has transformed the economic picture and is underpinning growth of 50% per annum in NGVs (natural gas vehicles) in Germany. On top of that, a CNG car has around a 25% better CO_2/km performance than a petrol one, while a dual-fuel (LNG-diesel) truck is around 30% better than the comparable diesel (see *Petroleum Review*, August 2007).

Economics and CO_2 are therefore driving significant growth, with the major OEMs (original equipment manufacturers) now making cars and vans specifically to run on natural gas rather than simply converting petrol vehicles. Germany's leading NGV van, the Volkswagen Caddy Ecofuel, is being trialled in right-hand drive models in the UK. It is claimed to offer 25% lower CO_2/km than petrol and very low NO_x (nitrous oxides) and particulates. By running this vehicle on biomethane CNG, a well-to-wheel reduction in CO_2 of around 70% can be achieved, it is claimed, which represents a transformational change from a vehicle that is OEM produced with the same performance and range of the equivalent fossil-fuelled version.

The transformation in world gas markets – which is seeing the development of more than 20 LNG regasification terminals in Western Europe, including three new ones in the UK being completed by end-2008 – means that LNG is now available fresh from Qatar. By running trucks on this fuel there are CO_2 savings of around

25% compared to diesel… no wonder Mercedes Benz is bringing out an LNG-fuelled Econic by the end of 2007. LNG has all the range advantages of liquid fuels but with much lower CO_2 impact – this fuel can be expected to grow rapidly in a CO_2 constrained world.

Middle East countries are leading the move to CNG for the obvious reason that they can make more money selling oil and petrol to the US and EU by giving their population cheap CNG from substantial local gas reserves. Abu Dhabi's move to CNG is also based on air quality, which is why by 2010 all new taxis will be CNG fuelled Mercedes Benz E-class vehicles. Be green, but do it in style!

PR fuels

There are five further alternative fuels that are of limited use commercially. They may even be positively harmful in CO_2 terms, but have been shown to be very resilient for 'greenwash' PR purposes.

The daftest fuel on the planet in my opinion is *hydrogen used in an internal combustion engine*. This has none of the range advantages of LNG and none of the efficiency benefits of a hydrogen fuel cell. In fact, its well-to-wheel CO_2 level is so bad that it's a fuel-engine combination that is the vehicle equivalent of flying a Jumbo jet to the US with one passenger onboard. To quote *Der Spiegel*: 'And so, in creating the Hydrogen 7, BMW is announcing a future of putatively clean, full-throttle driving. The new car caters to the pleasing fantasy of customers spoiled by high-horsepower engines. That they can conform to ecological standards without making any sacrifices, burning "clean" fuel to their heart's content. Advertising images display the Hydrogen 7 against a backdrop of wind turbines and solar panels. But the image is one of deceit. Because the hydrogen dispensed at the new filling station is generated primarily from petroleum and natural gas, the new car puts about as much strain on the environment as a heavy truck with a diesel engine.' This looks like the first BMW engine that is backfiring.

Next daftest is GTL (*gas-to-liquids*), where natural gas is taken and converted, at enormous cost in both capital and CO_2 terms, into a diesel that is then blended with normal diesel at EU refineries. The wellhead CO_2 impact of natural gas to GTL to refinery for blending to vehicle is around 30% worse than natural gas to LNG to vehicle (as LNG or CNG).

Prior to 1999, Nigeria had no LNG business at all and vast quantities of natural gas arising as a by-product of oil were flared off. Some 20mn tonnes of this gas is being captured in 2007 and made into LNG, earning around $10bn for Nigeria, with plans to double this production by 2012. Given that the enormous growth in world LNG trade means there is very little 'stranded gas' anymore, the number of GTL projects has fallen dramatically, with only the Shell Pearl project left standing in any material way and projects abandoned in Qatar (ExxonMobil) and Algeria. Instead of costing $8bn, Pearl is now forecast to cost $18bn – which means there will not be any more GTL projects for a while, even at $70/b oil. Why bother with GTL when you can chill gas into LNG and sell into buoyant world markets?

To quote Richard Pike, Chief Executive, Royal Society of Chemistry: 'The manufacture of GTL is extremely energy-intensive. In, say, a tonne of natural gas, almost 40% is used for heating and electricity to convert the remaining 60% to a liquid fuel.' GTL is on the 'naughty step' with the hydrogen internal combustion engine.

A GTL-like fuel is *biomass-to-liquids* (BTL), which starts as vegetation, is converted to a mixture of methane, carbon monoxide and hydrogen, and then further converted to a manufactured diesel. It seems a great idea but appears doomed because the UK government is proposing to offer double ROCs (Renewable Obligation Certificates) for electricity generated from biomass CHP (combined heat and power), which equates to around £75/MWh extra income compared to electricity generated from natural gas CHP (which earns around £35/MWh). UK energy companies are all looking at biomass CHP projects because of these highly attractive economics that avoid the huge capital expenditure associated with gasification of biomass and Fischer-Tropsch plants. The UK government believes that BTL is not an efficient pathway for reduction of CO_2 compared to straightforward electricity generation and, so, by incentivising biomass CHP, it means that BTL will not be an economic option in the UK.

BTL's equivalent petrol alternative is *cellulosic ethanol*, which is ethanol made not from wheat but from straw and other sources of biomass (can be the same as for BTL). This is a fuel that has been five to 10 years away from commerciality for the last 20 years and, like BTL, is not economic due to the UK government's support for burning biomass to make electricity.

Which leads on to *hydrogen fuel cells*, which will always be five to 10 years away but provide work for car company graduate trainees. If only we could crack open the laws of physics to allow hydrogen to be made easily and cheaply we could see vehicles running on the 'fuel cell battery'. But we can't and the fuel cell (invented in 1839) is manifestly an idea whose time will never come unless you live in a place with a surplus of renewable electricity and/or nuclear generated electricity. The UK is aiming for 20% renewable energy consumption (including transport, heat and electricity) by 2020, which is a long way from closing down all gas- and coal-fired plant necessary to make the hydrogen fuel cell work in CO_2 terms. Still, you cannot beat a fuel cell bus for giving you an excuse to carry on using diesel buses and greenwashing the environment – you will struggle to open the London *Standard* without finding a reference to the fuel cell buses in London, the diesel bus capital of the world.

Hybrids and plug-in hybrids

It is obviously a good idea for new homes to have to install 90% efficient condensing boilers rather than 50% efficient ones. Similarly, capturing electricity from vehicle braking makes a lot of sense for cars that go into cities and for all buses. The case for *plug-ins* is weaker as the vehicle will have a petrol engine, an electric motor and a means of capturing braking energy – all adding significantly to weight, which hits efficiency. In addition, the overall efficiency of centrally generated electricity is not great – so, *hybrids* yes, plug-ins maybe, but they are not obviously a lower CO_2 option when all well-to-wheel emissions (from making the vehicle and the fuel) are taken into account.

A final word

Transportation is not rocket science. To address the global warming and the Opec issues requires the same set of policies – improving the fuel efficiency of vehicles, encouraging diesel for cars, encouraging dual-fuel natural gas diesel for trucks, running buses on biomethane, introducing hybrids and supporting biofuels where they are sustainable.

It also means we have to be more assertive in challenging the nonsense of hydrogen internal combustion engines, GTL, and hydrogen fuel cells. All these PR fuels do is give us an excuse to do nothing – which is no longer acceptable. They should be placed on the 'naughty step'.

Visit* **www.dft.gov.uk/consultations/open/rtforeporting/