

Breaking down the bio

Dave Waterman talks to Richard Sadler about the issues surrounding the use of biofuel as a marine fuel



On 23 April, Richard Sadler, CEO of Lloyd's Register, delivered a groundbreaking lecture at The Institute of Marine Engineering, Science and Technology (IMarEST) entitled *Biofuels and their effect on the shipping industry*. The event kick-started a long-overdue debate on the effects of biofuels both as a cargo and as a fuel for ships. Richard Sadler kindly agreed to answer some questions for *Bunkerspot* after the lecture.

Dave Waterman (DW): You mentioned several operational problems in using biodiesel as a marine fuel. Which of these do you think presents the biggest barrier?

Richard Sadler (RS): I guess the biggest barrier is the fact that there's really no distribution method for it at the moment in terms of storage and bunkering barges, and that there is no standard for it. In terms of actually getting it to the ship, we would have to think about how that's going to work... are we going to distribute it mixed, or are we going to blend it on board?

DW: You talked about problems relating to the Cold Filter Plugging Point (at which biodiesel starts to gel). Since fuel oil engines generally heat the fuel before combustion, is this such a problem for large-scale shipping?

RS: Only in that biodiesel is more sensitive to the ambient temperatures, so certainly if it was to be used then you would require a modification to standard engine room designs. In colder temperatures you may have more significant problems.

DW: So as long as you follow the right procedures...?

RS: Yes, technically it's not an issue, we have all the technology we need to handle it, we just need to be well aware of the properties of biodiesel.

DW: Some in the bunkering industry think it may be possible to use the much cheaper, unrefined biodiesel in fuel oil engines, as they are designed to cope with higher viscosities. Given that this would mean a much higher presence of glycerol, do you think this is likely?

RS: We think it's technically feasible, but there are concerns. We would not be complacent though about the issue, especially on the deposits.

'The biggest barrier to the use of marine biodiesel is the technology involved in getting commercially available second and third generation biofuels to the market'

DW: So glycerol really isn't that much of a problem in fuel oil engines then?

RS: We think that there are technical solutions that could overcome those issues. As you rightly say, marine diesel engines are very flexible in their ability to burn, and we've got the ability to process in a large engine room, so therefore we would hope to be able to overcome that problem.

DW: You mentioned third generation biofuel crops such as algae, which can be designed in such a way that that their structure conforms to particular requirements. Is it likely that some of the operational barriers you have highlighted could be overcome through the use of certain third generation biodiesels?

RS: That's the beauty of them really. My understanding is that you can structure them to suit exactly what you want to do with them. In terms of third generation biofuels, algae certainly leads the way...The more we've investigated this subject the more fascinating it gets. There are lots of people holding onto information, rather than releasing it into a general pot.

DW: That information's worth a lot I suppose.

RS: Absolutely, but there again it's companies like Lloyd's Register that are going to have to be at the centre of making sure marine biodiesel is safe and that the risks are suitably covered. So we can't take too long in forming a view on what needs to be done.

DW: You also mentioned biomass-to-liquid fuel (BTL). Can you foresee any problems using Fisher-Tropsch synthetic fuels (XTL) in conjunction with fuel oil engines?

RS: From what we know, we don't, but that's a complex one – I would go to the suppliers to answer that.

Richard Sadler started his career in the Royal Navy before moving to study Naval Architecture and gain a Post Graduate Diploma in Welding. He worked for Lloyd's Register, then The Royal Bank of Scotland before moving back to Lloyd's Register in July 2006. He took over as Chief Executive Officer in July 2007.

Bunkerspot subscribers can access Sadler's full IMarEST lecture and accompanying slides on our website, www.bunkerspot.com.

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fuels barriers

DW: It also seems XTL fuels are of such high quality that they're likely to go to more profitable markets before they end up in the bunkering industry.

RS: That's right, it seems there's so far to go in making that a commercial process, that with the scales involved, it's a long way from being one that shipping could use. But we could be in a position in the future where carbon dioxide (CO₂) and particle emissions aren't acceptable and much higher grades of fuel are forced upon us. And with these reports that 60,000 deaths are caused by shipping emissions, whether they're right or not, the mud sticks.

DW: As you said in your lecture, the MARPOL Annex VI definition of 'fuel oil' would allow for the use of biodiesel. Given that biodiesel is virtually free of sulphur, how much of a driver will the new Sulphur Emission Control Area (SECA) caps be in encouraging the use of biodiesel at sea?

RS: We think it's a huge driver, provided that the distribution and the standards are in place. I think it's inevitable that it will be seen as an option, but more likely second and third generation rather than first generation.

DW: But as far as the **International Maritime Organization (IMO)** is concerned, is biodiesel a legitimate fuel to meet emission caps?

RS: Yes, they've opened the door to allow it to happen, but if it were socially unacceptable in some other way then I would imagine the **United Nations (UN)** would be keen to prevent its use through some other means. Provided it's socially acceptable, I can definitely see it being used.

DW: How long do you think it will take the **International Organization of Standardization (ISO)** to produce marine fuel specifications for biodiesel?

RS: We're not sure – regulations do take time to produce. The advantage we have in the marine industry is that there's increasing experience in using it in land-based installations – **Wärtsilä** for example is installing biofuel engines in power stations – so at least we'll have a lot of practical experience on issues like injector performance.

DW: Has any organisation conducted an extensive sea trial using biodiesel in

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conjunction with a fuel oil engine on an ocean-going vessel?

RS: **Royal Caribbean Cruise Lines (RCCL)** is the only company that's done anything major, but we're not sure that was in conjunction with fuel oil engines [RCCL has trialled a palm-based biodiesel since 2005].

DW: When can we expect one, and from who?

RS: I would imagine that a company such as **Wärtsilä** would do that on a test bed and then a shipping company will try it in one of its engines with the advice of the engine manufacturer in terms of fuel management?

DW: So ISO essentially takes its lead from engine manufacturers?

RS: I think they need everybody's involvement. We need to understand the tolerance of the engine but also of things like fuel filters and centrifuges. It's not just the combustion in the engine; the ISO standard would have to take into account everything from bunkering right through to the injection. I would imagine they couldn't do that without the engine and component manufacturers' involvement.

DW: You said in your lecture that we would need to see the marine bunker supply market working closely with regulators to develop international marine standards. What can the bunkering industry do to influence this process?

RS: If standards are created for using the biodiesel on ships then that's all very well, but if the process of storing, blending and bunkering is not made available by the bunkering industry, there's little point in having those standards.

DW: Now that the debate has been kick-started, would you like to see a regular forum for the bunkering industry to discuss

the issues surrounding biodiesel?

RS: Without a doubt – they're central to it. I think even if there are things in this paper that aren't factually correct, it will provide a backbone that we can build on to make sure we've got it right for the next decade.

DW: What is more of a barrier to the use of marine biodiesel – operational issues, or legislative/regulatory bureaucracy?

RS: Probably neither; it's more the social impact of its production. The biggest barrier is the technology involved in getting commercially available second and third generation biofuels to the market.

DW: What is likely to be a bigger driver for the use of marine biodiesel – environmental legislation or rising oil prices?

RS: From the shipowner's point of view I think the main driver will be environmental because it's sure to be a more costly alternative.

DW: Unless it turns out that ships are in a position to burn the much cheaper unrefined plant oil?

RS: Yes, and at what price will fuel oil be in the future? What we haven't done yet is an analysis of the likely crossover point between the prices of the two fuels.

DW: But we're also at the mercy of **Organization of Petroleum Exporting Countries (OPEC)**. It would make sense for them to increase oil production to stifle biofuel demand before large-scale production it takes off.

RS: Yes, but then there's the peak oil theory to take into account as well. There are so many variables.

DW: How long do you think it will be before biodiesel becomes available on the bunker markets?

RS: That's an impossible guess! I think because of the environmental pressures and increasing energy demand, by 2015 we will see some. But estimates are that even by then biofuels will only make up three or four percent of world demand.

DW: And do you think that limited supply will go to meeting government mandates in the automotive sector rather than going to the marine sector?

RS: The big driver for ships is the cost of the fuel, which is why we burn the lower grade fuels. Therefore I think we'll be at

the bottom of the supply chain, unless we get to the top because we can burn the far coarser biofuels.

Gathering the info

Richard Sadler welcomed the input of all concerned on this issue. The advantage of a classification society such as Lloyd's Register is that it collects relevant information and allows it to be accessed in a general pool. After the interview, Sadler's team forwarded a paper to *Bunkerspot* submitted by Norway to the **Marine Environment Protection Committee (MEPC)** in December 2007, which looks at the feasibility of using biofuels on the Norwegian domestic fleet. Carried out by the Norwegian foundation **ZERO**, the paper covers a whole range of technical, economic, environmental and social aspects, and draws on the experience of the two leaders in biofuel land-based power plants – **MAN B&W Diesel** and **Wärtsilä**. The paper concludes that:

- the use of biofuels in marine engines represents no operational problems, provided that the engines and the fuel treatment systems are prepared for such operation if and as required
- the greatest barrier today to the use of biofuels in ships is the substantial price gap between fossil fuels and biofuels
- a significant use of biofuels in the future depends therefore on closing the price gap as well as ensuring adequate supplies.

Comparison of biofuels and marine fuel properties (MAN B&W Diesel 2006)

	Vegetable oil treated, non transesterified	Bio Diesel EN 14214	Automotive diesel EN 590	Marine diesel ISO 8217 DMB	Heavy Fuel Oil ISO 8217 RM ..
Density/15 °C	920 - 960 kg/m ³	860 - 900 kg/m ³	820 - 845 kg/m ³	< 900 kg/m ³	975 - 1010 kg/m ³
Viscosity at 40 °C/ 50 °C	30 - 40 cSt	3.5 - 5 cSt	2 - 4.5 cSt	< 11 cSt	< 700 cSt /50 °C
Flashpoint	> 60 °C	> 120 °C	> 55 °C	> 60 °C	> 60 °C
Cetane no.	> 40	> 51	> 51	> 35	> 20
Ash content	< 0.01 %	< 0.01 %	< 0.01 %	< 0.01 %	< 0.2 %
Water content	< 500 ppm	< 500 ppm	< 200 ppm	< 300 ppm	< 5 000 ppm
Acid no. (TAN)	< 4	< 0.5	-	-	-
Sulphur content	< 10 ppm	< 10 ppm	< 350 ppm	< 20 000 ppm	< 50 000 ppm
Calorific value	ca. 37 MJ/kg	ca. 37.5 MJ/kg	ca. 43 MJ/kg	ca. 42 MJ/kg	ca. 40 MJ/kg

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The issues surrounding the use of biofuels for ships can be summarised as follows:

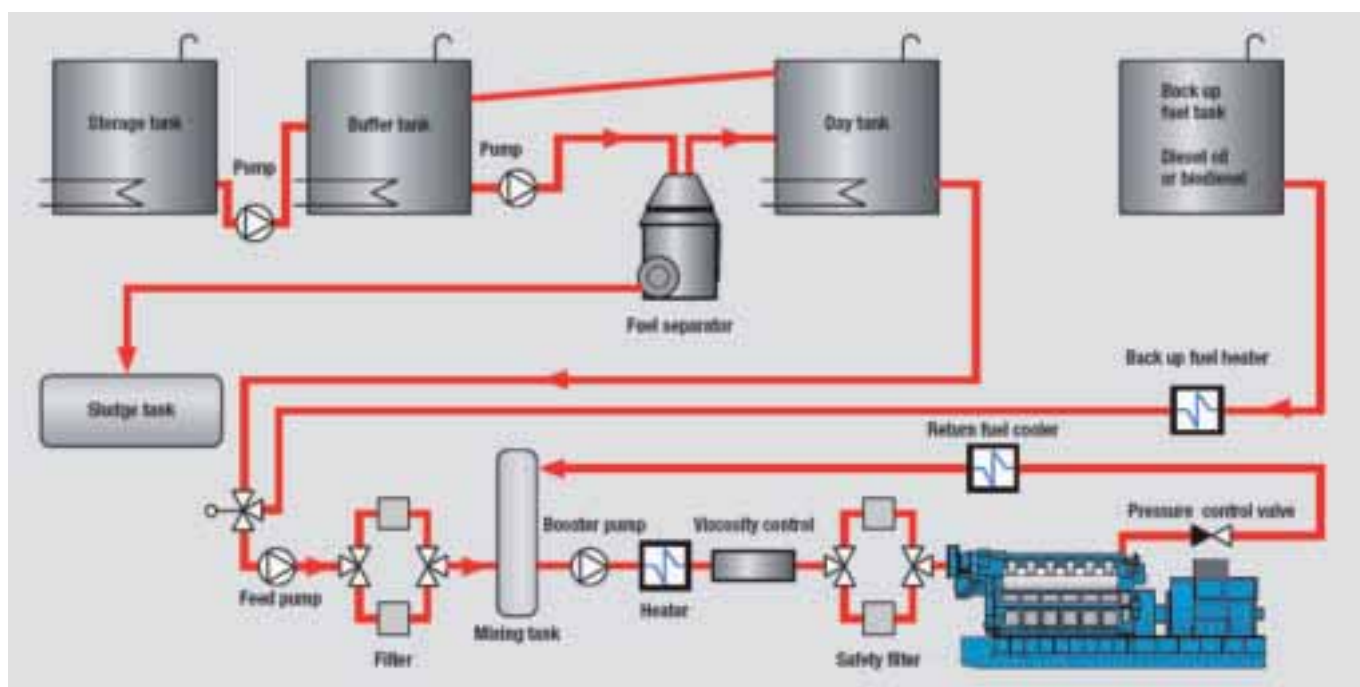
Technical issues

- storage – shorter shelf life presents risks for bunker suppliers. Stability depends on feedstock – biodiesels with high levels of saturated fatty acids are more stable with respect to oxidation (e.g. rapeseed). The ASTM standard suggests least stable biodiesel can be stored up to eight months. Longer storage would require oxidation preventative additive. Normal acid-proof tanks can be used without any major problems. Tanks should be thoroughly cleaned before switching from petroleum fuels to biodiesel (to reduce build up caused by biodiesel's solvent effects) – *BioMer*
- blending – limited experience in the marine industry – according to a study by the **Great Lakes Maritime Research Institute** blends of biodiesel up to 20% were said to cause no fuel system degradation

- multifuel – Switching between biofuels and heavy fuel oil (HFO) does not pose any problems with respect to the engine – *MAN B&W Diesel*
- fuel system – problems relating to cold flow properties of biodiesel/plant oil. Can be overcome with careful temperature control (fuel system may need extra heating components) and/or additives. HFO systems already require pre-treatment
- injector corrosion – can be overcome with adjustment of injector pump or replacing with more cavitation resistant pump – such pumps are used in plant oil power plants by *Wärtsilä*
- corrosion of elements – plant oil (see table) is within *Wärtsilä* and *MAN B&W Diesel* limits for Total Acid Number (TAN), but components such as rubber seals may have to be replaced with more resistant ones
- Thomas Knudsen, Senior Vice President of Research and Development at *MAN B & W Diesel*, estimates that an existing ship engine can be converted to run on biofuels for less than 5% of the engine cost
- engines designed for HFO can run on plant oil, but engines designed for marine diesel oil or marine gasoil (MDO/MGO) may have problems due to the higher viscosity – *MAN B&W Diesel*.

Types of fuel

- palm oil – the cheapest plant oil so far, but has replaced rainforest in some areas
- other first generation feedstocks – subject to food versus fuel debate
- jatropha – drought resistant – suitable for areas where other crops won't grow
- algae – has the potential to produce 100-200 times the yield of other energy crops in a given area – *Global Green Solutions*. Closed-loop systems absorb CO₂ emissions which facilitate the growth of feedstock. **Origo Industries** has developed technology that traps CO₂ emissions from transport engines which is then used for this purpose. The company is actively looking for a marine partner



- BTL – not yet commercially viable for the shipping industry
- pyrolysis fuel oil – produced from biomass. Poor quality fuel with limited applications (potentially very inexpensive) that HFO engines might be able to handle.

Emissions of biodiesel

- CO₂ – potentially carbon neutral. The US Department of Energy showed that the production and combustion of biodiesel resulted in a 75.8% reduction in CO₂ emissions compared to petroleum diesel
- Carbon monoxide (CO) reduced by 48% when compared to petroleum diesel – **US Environmental Protection Agency (EPA)**
- Particulate matter (PM) reduced by 47%, and total unburned hydrocarbons reduced by 67% when compared to petroleum diesel – **EPA**
- Polycyclic Aromatic Hydrocarbons (PAH) reduced by 80% when compared to petroleum diesel – **EPA**. Likely to be reduced even greater when compared with HFO. Inhaling air containing PAH can cause serious health problems such as cancer – **ZERO**
- NOx – slight increase in biodiesel (approx 10%) compared to petroleum diesel – **EPA**. This is probably because of the low levels of PM, which increases the combustion temperature. Even so, engines can be adjusted to counter the increase in NOx. Another question is whether these settings would have to be approved by the **International Council on Combustion Engines**

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(CIMAC). Rapeseed oil may have similar NOx emissions to HFO when used in a ship engine – **ZERO**

- essentially free of sulphur (less than 10 parts per million).

Other drivers

- fuel spills – because they are biodegradable, a spill involving biofuels would be much easier to cope with – **ZERO**. If governments and maritime insurance providers recognise this fact, this will provide a big driver for shipowners. The recent *Cosco Busan* incident cost the shipowner alone \$80 million
- bunker handling can be made safer using biofuels (far less PAH than in HFO) – **ZERO**
- cost – ships with fuel oil engines are the only mode of transport that is likely to be able to effectively burn unrefined plant oil (roughly 75% of the cost of biodiesel)
- SECA regulations allow for unrefined plant oil to be used in place of low-sulphur distillate – the former may well become the cheaper option
- so far, economics have favoured the export of unrefined plant oil. The shipping sector is likely to become

the major link between the feedstock producers and the biodiesel refiners. One can envisage that the first ships to bunker with unrefined plant oil will be the ones visiting major feedstock export hubs where delivery infrastructure will already be in place.

The consensus seems to be that it's a question of when, not if, ocean-going vessels will be burning biofuels. The modifications required in order for these ships to use plant oil or biodiesel seem to be quite minimal. The biggest barriers seem to be the cost/availability, lack of ISO standards, and the shelf-life of biofuels.

There are still many more questions need to be answered:

- what will the properties of blended fuel oil and plant oil mean for the bunkering industry?
- who is going to be the first to take the lead and adapt a ship to burn plant oil in its HFO engine?
- will governments support shipping in an attempt to get plant oil to the marine markets, as opposed to inland power generation (which could make use of other renewable energy sources)?

'Whatever the technological developments, shipping will be at the absolute centre of the biofuel logistics chain, as will the bunker suppliers be at the end of that distribution chain to supply it to ships,' says Sadler. 'There's no point in politicians and technologists agreeing on things that can't be coped with by the marine industry. The shipping industry must be heavily involved in the policy-making process.'