

## BACKGROUND

There is substantial scope for the reduction in use of fossil fuels by converting UK vessels in the leisure and fishing fleets to biodiesel.

Emissions from conventional diesel engines on passenger and fishing vessels of similar size to HJALMAR BJØRGE are considerable equating to about 35 family cars per year (although one mustn't forget that in the case of our cruise vessels, every journey is made with around 15 people onboard). However it remains a fact that in our quest to enable passengers to view the unspoiled beauty of the Scottish islands – sometimes referred to as Europe's Last Great Wilderness we are burning sizeable quantities of non-sustainable fuels and HJALMAR BJØRGE is certainly not the least fuel efficient vessel in the marketplace. We are just one of many.

Northern Light Charters, has, for some years, been investing to reduce our fuel consumption. The main aim of this is to limit our impact on the environment. Since buying HJALMAR BJØRGE in 2002 we have refitted her with new generators, a new heating system and inverters and new five-bladed propellers. Consequently our fuel consumption has been significantly reduced. The vessel's main engines remain the obvious area where improvements can be made. The proposal to refurbish or replace the engines so that they become more fuel-efficient and environmentally friendly stems from the aspirations of the partners to deliver a product of excellence that is also sustainable.

The Carbon Trust helps business and the public sector cut carbon emissions, and supports the development of low carbon technologies. One way in which they do this is to offer interest free loans and we approached them with this assistance in mind. They were very helpful but unable to assist as we are in the "transport sector" and not within their criteria of buildings, accommodation, property etc. We then contacted the Energy Saving Trust, an organisation that specifically lists "transport" amongst its criteria. He, however, stated that his remit of "road transport"

excludes him from offering any assistance to marine transport.

A car owner could get a grant to convert his petrol vehicle to LPG (giving reduced emissions even if it not from a renewable source) yet we could reduce our emissions and use renewable energy but nobody is offering financial incentives to do so. In the fast growing marine (eco)tourism market it seems ridiculous and short-sighted that, so far as we have discovered, nobody exists to encourage boats to reduce their environmental impact.

Unlike the USA there currently appears to be no known proposals to demonstrate the opportunities for biodiesel in marine engines in Scottish waters although one report recognises "marine" is one of five main market segments.<sup>1</sup> The report goes on to make a number of recommendations with action required on two principal fronts, namely support for the development of a medium scale plant in Scotland and for pilot studies into small scale biodiesel schemes.

A second report from the USA attempts to quantify the actual number of marine charter vessels and their location to determine the potential for biodiesel sales in the marine market and further proposes how this may be achieved.<sup>2</sup>

In Canada, home based vessels using the St Lawrence Seaway have been encouraged to convert to biodiesel to contribute to Government targets for reduction in fossil fuel use and carbon emissions.<sup>3</sup>

Environmental issues are driving the development of liquid biofuels. The EU Renewable Fuels Directive states that biofuels in member states should achieve a 2% share of the mineral transport fuels market by the end of 2005 and 5.75% by 2010. In the UK, the government recommends that carbon dioxide emissions are reduced by 60% from current levels by 2050. In 2005 the UK will only achieve 0.3% of transport fuels from renewable sources.<sup>1</sup>

## BIODIESEL

Biodiesel is a fuel which is produced from organic sources rather than refined from fossil deposits. Made from either substandard vegetable oil, recycled cooking oil, animal fats or from rapeseed cultivation, it has primarily been used in road transport. In its purest form it is 10 times less toxic than table salt and 100% biodegradable. The market for biofuel is fast developing and FAME (Fatty Acid Methyl Ester) and RME (Rape Methyl Ester) fuels are now commercially available. In Scotland biodiesel is currently produced by Argent Energy at Motherwell and INEOS Enterprises are investing in a large scale production unit at Grangemouth. Three biodiesel plants are at the construction or planning stage in England.

The composition of biodiesel has a positive impact on diesel combustion. It is composed of 11% oxygen by mass and thus helps petrodiesel in blend burn better. This reduces substantially carbon monoxide (CO) emissions. This also reduces the emission of fine particulates and unburned hydrocarbons which can cause cancer.

Cultivation of the oilseed rape crop has been shown to provide biodiversity benefits. A report (partly funded by Highlands & Islands Enterprise)<sup>1</sup> on the economic evaluation of

biodiesel production from oilseed rape grown in north and east Scotland states that a number of farmland birds favour the crop for nesting and feeding. In particular, oilseed rape is credited with helping to slow the decline in population of the linnet species.

Biodiesel is currently supplied for road fuel use within a blend. The fuel sold is made up of a low proportion of biodiesel and conventional petroleum diesel which permits the fuel to be used in existing engines. Typically this would be B5 (or 5% biodiesel combined with 95% fossil-fuel diesel). The general consensus is that B5 may be used within most existing and unadapted engines although this can cause filtration problems.

Biodiesel is an obvious candidate for marine applications. In addition to reduced emissions and environmental benefits the use of biodiesel and biodiesel blends result in a noticeable change in exhaust odour. This reduction is easier on ship workers and passengers who frequently feel nauseous if they inhale conventional diesel fumes. Independent tests have also found that biodiesel degrades about four times faster than petroleum diesel and that, when blended with biodiesel, the degradation rate of petrodiesel tripled when compared to petrodiesel alone.



AVERAGE BIODIESEL EMISSIONS COMPARED TO CONVENTIONAL DIESEL (ACCORDING TO EPA)		
EMISSION TYPE	B100	B20
<b>Regulated</b>		
Total unburned hydrocarbons	- 67%	- 20%
Carbon monoxide	- 48%	- 12%
Particulate matter	- 47%	- 12%
NOx	+ 10%	+2% to -2%
<b>Non-Regulated</b>		
Sulfates	- 100%	- 20%*
PAH (Polycyclic Aromatic Hydrocarbons)**	- 80%	- 13%
nPAH (nitrated PAH's)**	- 90%	- 50%***
Ozone potential of speciated HC	+ 50%	- 10%

\* Estimated from B100 result

\*\* Average reduction across all compounds measured

\*\*\* 2-nitroflourine results were within test method variability



Biodiesel is currently used as a very small proportion of petrodiesel but market demands have seen new engines developed which can use higher concentrations of biodiesel in blends and engines which can be fuelled on 100% biodiesel are slowly emerging from large manufacturers. To use B100 (100% biodiesel) on unaltered engines would likely be problematic<sup>4</sup> and would need in depth consultation with the relevant ships engine manufacturer. However, plant, with modifications, can be used with mixes such as B5, B10 or B20.

## BIODIESEL EMISSIONS

See table on previous page. Biodiesel is the first and only alternative fuel to have a complete evaluation of emission results and potential health effects submitted to the U.S. Environmental Protection Agency (EPA) under the Clean Air Act Section 211(b). These programs include the most stringent emissions testing protocols ever required by EPA for certification of fuels or fuel additives. The data gathered complete the most thorough inventory of the environmental and human health effects attributes that current technology will allow. EPA has surveyed the large body of biodiesel emissions studies and averaged the Health Effects testing results with other major studies. The results are seen in the table below. To view EPA's report titled "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions" visit [www.epa.gov/otaq/models/biodsl.htm](http://www.epa.gov/otaq/models/biodsl.htm).

**The ozone (smog) forming potential of biodiesel hydrocarbons is less than diesel fuel.** The ozone forming potential of the speciated hydrocarbon emissions is 50 percent less than that measured for diesel fuel.

**Sulfur emissions are essentially eliminated with pure biodiesel.** The exhaust emissions of sulfur oxides and sulfates (major components of acid rain) from biodiesel are essentially eliminated compared to diesel.

**Criteria pollutants are reduced with biodiesel use.** Tests show the use of biodiesel in diesel engines results in substantial reductions of unburned hydrocarbons, carbon monoxide, and particulate matter. Emissions of nitrogen

oxides stay the same or are slightly increased.

**Carbon Monoxide** -- The exhaust emissions of carbon monoxide (a poisonous gas) from biodiesel are on average 48 percent lower than carbon monoxide emissions from diesel.

**Particulate Matter** -- Breathing particulate has been shown to be a human health hazard. The exhaust emissions of particulate matter from biodiesel are about 47 percent lower than overall particulate matter emissions from diesel.

**Hydrocarbons** -- The exhaust emissions of total hydrocarbons (a contributing factor in the localized formation of smog and ozone) are on average 67 percent lower for biodiesel than diesel fuel.

**Nitrogen Oxides** -- NOx emissions from biodiesel increase or decrease depending on the engine family and testing procedures. NOx emissions (a contributing factor in the localized formation of smog and ozone) from pure (100%) biodiesel increase on average by 10 percent. However, biodiesel's lack of sulfur allows the use of NOx control technologies that cannot be used with conventional diesel. Additionally, some companies have successfully developed additives to reduce Nox emissions in biodiesel blends.

**Biodiesel reduces the health risks associated with petroleum diesel.** Biodiesel emissions show decreased levels of polycyclic aromatic hydrocarbons (PAH) and nitrated polycyclic aromatic hydrocarbons (nPAH), which have been identified as potential cancer causing compounds. In Health Effects testing, PAH compounds were reduced by 75 to 85 percent, with the exception of benzo(a)anthracene, which was reduced by roughly 50 percent. Targeted nPAH compounds were also reduced dramatically with biodiesel, with 2-nitrofluorene and 1-nitropyrene reduced by 90 percent, and the rest of the nPAH compounds reduced to only trace levels.

## ENVIRONMENTAL BENEFITS



### Emissions

Biodiesel is the only alternative fuel to voluntarily perform EPA Tier I and Tier II testing to quantify emission characteristics and health effects. That study found that B20 (20% biodiesel blended with 80% conventional diesel fuel) reduced total hydrocarbons by up to 30%, Carbon Monoxide up to 20%, and total particulate matter up to 15%. Typically, emissions of nitrogen oxides are either slightly reduced or slightly increased depending on the duty cycle of the engine and testing methods used. Increases in NOx can be effectively eliminated with the use of normal mechanical remediation techniques (e.g. catalysts or timing changes). Research also documents the fact that the ozone forming potential of the hydrocarbon emissions of pure biodiesel is nearly 50% less than that of petroleum fuel. Pure biodiesel does not contain sulfur and therefore reduces sulfur dioxide exhaust from diesel engines to virtually zero. Biodiesel can also help meet national goals for the net reduction of atmospheric carbon. As a renewable fuel derived from organic materials, biodiesel and blends of biodiesel reduce the net amount of carbon dioxide in the biosphere. A study by the US Department of Energy has found that biodiesel production and use, in comparison to petroleum diesel, produces 78.5% less CO2 emissions. Carbon dioxide is "taken up" by the annual production of crops such as soybeans and then released when vegetable oil based biodiesel is combusted. This makes biodiesel the best technology

currently available for heavy-duty diesel applications to reduce atmospheric carbon.

### Health Effects

Biodiesel is safer for people to breathe. Research conducted in the US shows biodiesel emissions have decreased levels of all target polycyclic aromatic hydrocarbons (PAH) and nitrated PAH compounds, as compared to petroleum diesel exhaust. PAH and nPAH compounds have been identified as potential cancer causing compounds. Targeted PAH compounds were reduced by 75 to 85 percent, with the exception of benzo(a)anthracene, which was reduced by roughly 50 percent. Target nPAH compounds were also reduced dramatically with biodiesel fuel, with 2-nitrofluorene and 1-nitropyrene reduced by 90 percent, and the rest of the nPAH compounds reduced to only trace levels. All of these reductions are due to the fact the biodiesel fuel contains no aromatic compounds.

### Energy Balance

Biodiesel helps preserve and protect natural resources. For every one unit of energy needed to produce biodiesel, 3.24 units of energy are gained. This is the highest energy balance of any fuel. Because of this high energy balance and since it is domestically produced, biodiesel use can greatly contribute to domestic energy security.

### Biodegradability and Toxicity

Biodiesel is nontoxic and biodegradable. Tests sponsored by the United States Department of Agriculture confirm that biodiesel is ten times less toxic than table salt and biodegrades as fast as dextrose (a test sugar).

A future development, or possible Phase II of this project, would see us locating our own biodiesel storage facility which we envisage being available to other vessels both within NLC and other marine users. The identification of a site and agreement for dedicated storage of biodiesel in the Loch Linnhe / Firth of Lorne area requires further research.

With the provision of a storage facility we would anticipate working with our existing fuel supplier by encouraging them to make

provision for the supply of biodiesel as a co-operative agreement with an existing retailer of marine diesel would be an advantage. Initially it is likely this would be a B5 blend which would allow other vessels to trial the use of the fuel. With four motor vessels in total we are one of the largest users of marine diesel on the west coast (in charter boat terms) and initial discussions indicate our current supplier would be happy to negotiate this facility with us.

## BENEFITS

The main benefits in implementing this proposal are:

- ✂ lower emissions and reduced environmental impact arising from the benefits of using biofuel for vessel crew, passengers, marine life and the wider environment
- ✂ operating as a responsible marine eco-tourism provider and thus gaining a market advantage for the company in offering true eco-cruises in a highly competitive arena
- ✂ becoming market leader in the field and consequently encouraging other operators to switch to biodiesel
- ✂ the ability to increase pressure on biodiesel manufacturers to supply the west coast of Scotland
- ✂ potentially in the future becoming a supplier of biodiesel to offer practical support to other small marine users who wish to try biodiesel but whom cannot currently access the fuel

Of the main two markets in which we work – wildlife cruise charters and dive charter – it is the cruise market which is growing fastest. In 1998 one study estimated that the revenue generated by marine wildlife tourism in the Highlands & Islands was £57 million a year<sup>5</sup> and furthermore whale and dolphin watching alone is estimated to be growing at 10% a year.<sup>6</sup>

By their very nature the guests attracted to wildlife cruises have a concern about adverse impacts on the environment. One tour operator, from the San Juan Islands where operators are competing to be the most environmentally responsible, says:

*" As a charter boat, the public entrust us as stewards of these waters. It's our responsibility to pursue clean burning, 100% biodegradable fuels in an environmentally sensitive marine ecosystem. "* <sup>7</sup>

He also states that the waters in and around the San Juan Islands are home to orcas, eagles, porpoise, seals, sea lions, seabirds and numerous other animals. Take away the sea lions and add dolphins, basking shark, sunfish, otters and a whole host of other marine life and he could be talking about the seas off the Hebrides.

Northern Light Charters is recognised as a main player in this field. We work hard to maintain our position by responding to customer feedback and tweaking the product where necessary. We are hopeful that in addressing the least green aspect of our business, e.g. thirsty diesel engines, it will reap rewards in a market where we face competition from foreign registered boats and UK vessels that are known to cut corners when it comes to customer service and care of the environment.

## Credits and References

- 1 Booth E, Booth J, Cook P, Ferguson B, and Walker K, Scottish Agricultural College Consultancy Division (October 2005) "Economic Evaluation of Biodiesel Production from Oilseed Rape grown in North and East Scotland: Executive Summary" <http://www.hie.co.uk/HIE-economic-reports-2005/sac-biodiesel-executive-summary.pdf>
- 2 Market Analysis of the United States Charter Boat and Marina Industries: Biodiesel Use Potential, a report to the National Biodiesel Board August 31, 2006
- 3 Steven Watson at <http://www.alienergy.co.uk>; also assistance with research
- 4 See report at <http://www.biomer.ca/en>
- 5 Issue 6 newsletter published by the Tourism and Environment Forum; study commissioned by the Tourism and Environment Forum and Scottish Natural Heritage
- 6 META (Marine Ecotourism for the Atlantic Area) Project, c/o Centre for Research, Innovation and Industry (CRII), University of the West of England, Bristol Frenchay Campus, Coldharbour Lane, Bristol BS16 1QY
- 7 Patrick Pillsbury, captain Bon Accord <http://www.bonaccord.com>