CBOA
freight by water
Commercial Boat Operators Association
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AGM April 2019

The Chairman introduced Bernard Hales (CBOA) – towards greener propulsion

Looking at the global impact of marine fuels on the environment, there are many factors which contribute to the overall picture, can be treated independently but not necessarily in tandem. There are 2 distinct emission groups, Green House Gases a global issue (CO2, Methane and N2O) and Pollutants a local issue (SOx, NOx and PM). But reports about total global emissions from worldwide shipping need to be put into perspective.

World wide shipping's contribution to **global warming** GHG is, what do you think? … between 2 and 3% of the total global man-made CO2.

Maritime transport is already by far the most energy efficient on a per tonne mile basis. However there are still substantial opportunities to improve environmental performance by technical and operational measures.

In the last five years there has been a vast amount of data gathered for analysis. This reveals the amount of greenhouse gases (GHG) generated by shipping worldwide and the areas most affected. Every large ship (over 100tonnes gross) transmits a package of data every 3 minutes from which it is possible to calculate its speed, position, and draft, fuel consumption, engine efficiency and actual emissions (see Ricardo report in Q2/2017).

On your behalf I attended the Westminster Energy Environment & Transport Forum (WEET) seminar 'Next steps for low-carbon fuels and emission reduction', set up for specialists from academia and industry to brief government policy makers and legislators. Also The Royal Institute of Naval Architects was addressed by Edmond Hughes, the IMO's Head of 'Air Pollution and Energy Efficiency' in the Marine Environment Division. These meetings gave me access to key contributions from Ricardo Consultants, the Tyndale Centre for Climate Change Research, and the IMO's strategy to reduce GHG emissions from ships, and a number of other sources (I will provide a list of these and notes to be included in the AGM minutes for your reference).

The public perception of water transport most often relates to locally tangible emissions, i.e. **pollution**. Wherever any water transport is visible to the public smoke can provoke scrutiny. Already regulated via the IMO, is the use of Low Sulphur Fuels in large ships [when in harbour, coastal or emission control areas].

IMO strategy is to further reduce CO2 emissions by 85% by 2050. The IMO also identifies barriers and supportive measures including building capacity, technical cooperation, research and development. Their "levels of ambition" target is to reduce total GHG emissions from international shipping (which is expected to peak very soon) by at least 50% by 2050 compared to 2008. At the same time there are efforts towards eliminating them entirely in this century. Go back 200 years and CO2 was zero, so why can't we go back to using sails?

Technological innovation and global introduction of alternative fuels and energy sources will be integral to achieving that ambition.

Operational Emissions (local **pollution**), idle time spent loading and unloading in port to be reduced by enhanced/speeded-up cargo handling methods and having shoreside plug-in electrical power.

There are several routes to gaining short term improvements by:

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Opportunities exist for optimisation of some technical aspects of propulsion engines and onboard power generation, including the use of cleaner fuels. The likelihood of any rapid departure from the use of existing prime movers [which rely heavily on liquid fuels] is unlikely. The developing science and technology of fuels will slowly introduce benefits, however attempts to make wide reaching and effective changes are thwarted as legislators are uncertain which of the multitude of alternatives to choose. This point has been made strongly recently by Christopher Snelling of the FTA at that WEETF, with a plea to government for policy decisions so that vehicle and engine manufacturers might direct their efforts appropriately. This has just happened with the National Infrastructure Commission recommendation to government that sale of new carbon fuelled HGVs should cease in 2040.

So whilst conventional engines using cleaner fuels will contribute towards the targets and remain the key power, the transport industry will be hard put to replace liquid fuels which are the most efficient means of storing and transporting a high density energy source. The literature narrows down the field to less than a dozen potential alternatives to conventional liquid fuels which give some regulated emission **pollution** benefits. They are:

LNG

LPG

Methanol

Biofuels + blends

Hydrogen

Fuel cells

Wind

Solar

Batteries

The difficulty in promoting these fuels lies in the attributional Life-Cycle Assessment (aLCA) expressed as emissions released per unit of power delivered by engines in grams emissions per kilowatt hour delivered to the shaft (or ancillary equipment). This is equivalent to the ‘well to wheel’ analysis already firmly established for road fuels.

So, in the meantime we seek increased fuel efficiency and decreasing pollutant emissions, not readily achieved at the same time or by the same measures.

However …. at the WEET forum Prof. Kevin Anderson, Director of the Tyndall Centre for Climate Change Research, made the comment that targets are not what we should be chasing. The crux of the matter is that CO2 accumulates in the atmosphere and if we do not reduce the existing total, it is predicted that a rise of 2 deg.C will be reached within 10 years! Implementation of Carbon Capture and storage, sequestration, utilising high stroke/bore ratios, supercharging and turbocharging are key to any improvements.

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Engine design optimisation

We can expect a number of advances in engine technology to break cover in the next 12 months. These include refinement of existing but sidelined engines employing historically well established principles. People with a keen sense of history may remember that back in 1936 an aircraft managed to fly to Brazil from Germany, over 6,000 miles without refueling. Perhaps surprisingly to some, this was using diesel engines!!! The design was developed by the German firm Junkers. The engines were opposed piston (OP) 2-stroke diesels. At this time other companies throughout the world worked on similar engines, notably in this country Tilling Stevens produced large numbers of electric vehicles and trolley buses which populated our streets in the 1930s; their OP 2 stroke diesels, known as the TS2 and TS3, were adopted by Commer Lorries and the Rootes Group, persisting into the early 1970s. Foden, General Motors and others produced conventional 2 strokes but in the United States Fairbanks-Morse produced OP engines to satisfy a number of military and naval applications. It is highly likely that within the next 12 months the Ford Motor Company, Cummins Engines and Fairbanks-Morse will be promoting their latest technology OP 2-stroke engines. (I don't intend to go into the finer details but refs. and links are shown at the end of this transcription).

These opposed piston 2-stroke engines using the latest in electronically controlled fuel injection and engine management systems, materials and manufacturing techniques, are claimed to provide significant improvements in specific power output to meet the tightest current emissions legislation, including noise and also overcome the historical concerns about oil consumption.

Utilising high stroke/bore ratios, supercharging and turbocharging, a faster and cleaner burn generates less NOx and particulate matter (PM). They cost no more to manufacture, with obvious savings in component count (with no valve train, cylinder heads or gaskets) and potentially offer enhanced reliability. Compared to current equivalent 4-stroke engines both fuel consumption and heat rejection are improved by 25% with considerable weight reductions in about two-thirds of the volume.

Cummins claim their new ACE 4-cylinder (8 piston) 14.3 litre OP 2-stroke develops 1,000 hp in the same space as their conventional 750 hp V6 14.8 litre 4-stroke.

This year Ford are expecting to launch an SUV with (Achates designed) 2.7 litre 3 cylinder (6 piston) OP 2-stroke giving 270 hp and achieves 37 mpg on gasoline or 42 mpg on diesel, 50% more efficient than its current gasoline equivalent. Alternative fuel use and no spark ignition. Watch this space ….

Alternative fuels

The major problem associated with power derived on board from alternative fuels is, needless to say, still the availability and infrastructure for the fuels.

It is also rather doubtful that all the requirements dictated by aLCA, i.e. including evaluating the impact on GHG of the production of those fuels, be they gaseous hydrogen, derived from crops or synthesized, etc., etc., can be achieved by 2025!

Concluding

My view is that, in the short term, inland water transporters using up to around 600HP should consider retro-fitting suitably adapted Euro 6+ heavy duty truck engines similar to those already installed in their vessels. Note that the reduction in NoX between Euro 5 and Euro 6 is 80%. The application of such Volvo, Scania , Cummins and other engines to boat propulsion systems, most likely incorporating a generator, motor and batteries can provide a relatively easy retro-fit hybrid solution, similar to those now applied to new buses.

Zero emission in port/urban areas is feasible.

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CBOA - Additional briefing notes and references

Fuel consumption – the direct contributing factor to GHGs

370m metric tonnes p.a. bunker fuel **(global GHG)**

of which

30-50m metric tonnes burned in emission control areas (ECAs) **(local pollution)**

Large container ship: 2-3 grams per tonne km (Maersk Line average)

Road truck: 15g per tonne km (global average)

IMO update:

An EU alternative marine fuels directive 2014/94

EMSA (European Marine Safety Agency)

Marex (Maritime Executive) 2018 0417 DNV GL up-to-date assessment of most promising fuels

GIA (Global Industry Alliance) (Maritime private industry champions). Positive initiative for global dialogue - focus on priority areas of energy efficiency and operational best practices, alternative fuels and energy carriers.

GAG (Global Automotive Group (similar to GIA)

NAEI National Atmospheric Emissions Inventory http://naei.beis.gov.uk/index (extremely useful data source)

Alternative fuels (see previous list)

Maersk want to use 10% biofuel by 2030

At more than 10% biofuel stability is a big issue – storage is a nightmare, only 2 months for B100, anti-oxidants are available to help but it is also sensitive to temperature.

Methane slip (I'm only just getting a grip on this one!) an acknowledged problem with Otto Cycle spark ignition. Basically emission of unburnt fuel.

To meet IMO target, either use of LSF or scrubbers to allow continued use of HFO will affect 4,000 vessels by 2020. On inshore waters – will HFO still be available to smaller users?

LNG – favourite due to lowest carbon footprint of any fossil fuel and readily available. But most of it is shipped from the Middle East !

For inland shipping, LNG installations would be too expensive (Ricardo report).

LNG – trial by TOTE (Totem Ocean Trailer Express) Washington, US ferries.

Stena Line – 25 vessels to be converted to methane by 2018.

2012-2020 ~ 15-20% of new ships for LNGH propulsion (approx 1,000 ships).

TE Transport Engineer 02/19 Iveco CEng fleet for Ocado, CO2 reductions 29%.

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Useful links to OP 2-stroke developments

https://www.youtube.com/watch?v=Mfy05zqn324

Fairbanks Morse have been making medium diesels for many years, including OP high efficiency units for submarines, power stations and backup power. Here is their latest offering
https://www.fairbanksmorse.com/trident-op

https://www.youtube.com/watch?v=usmauFigpzk

https://www.youtube.com/watch?v=oppAkM8H_kU

https://www.youtube.com/watch?v=UxON-HIlz5E&t=287s

The last one is the best

https://youtu.be/o9AecNLjYI4

The engine is on trial in a Ford 150 half ton pickup and returns 37 mpg petrol. (US gallons). The diesel should do 42. Similar outputs in conventional 4 strokes (Ecoboost, Powerstroke) on sale now make about 20-25 mpg.

Ford claim to sell a 150 ever 30 seconds!

Such an improvement seems to involve the very long stroke, high temperature piston crowns and other factors. The usual scavenging issue with 2 strokes is practically eliminated.

Bernard C Hales - C.Eng MIMechE, MIRTE, MEI 30 April 2019

Also member of CBOA, HNBC, Maritime Heritage Trust