The Inland Waterways Association

Future Propulsion for the Inland Waterways

A Vision

Background

Currently the overwhelming proportion of craft navigating the inland waterways of the UK are propelled by fossil fuels, mainly diesel but in many cases petrol. Whilst the overall contribution of inland waterways craft to UK carbon emissions is small, it will inevitably come under scrutiny in the near future and we also have a social responsibility to 'do our bit'. There are many things that boaters can do to reduce the carbon emissions from existing craft such as not running engines at locks etc. This is a very valid contribution but is not the subject of this paper.

This paper attempts to paint a picture of what sustainable propulsion on the inland waterways might look like in the coming decades. Technology will inevitably develop, possibly in ways we do not envisage. This paper looks at technologies that are currently available or close to being available. It does not try to cover 'blue skies' thinking.

There are many stakeholders in the inland waterways world. These include boaters, navigation authorities, boat builders, marinas, boatyards, hire companies, chandlers, marine surveyors, BSS inspectors and probably many others. Most will be required to make a significant (to them) investment if we are to resolve the issue. Society at large is also a stakeholder. It is hoped that a vision for the future, if ultimately validated, will allow the various stakeholders, particularly those who will need to invest financially in the future, to move forward with a degree of confidence.

This paper will look at steel, diesel powered canal craft, narrow and wide beam. The reason for this is the large number in the existing fleet, the large number within the IWA membership and the similarities of the basic design. The principles established will be applicable in some cases to other types of craft, including river boats, but not all.

This is not a technical paper but is assembled from my technical knowledge (limited), the useful email discussion that has taken place over the last month or two and some discussions with the 'trade'. Hopefully it will be the basis for others who are expert in the various technologies to do further work to validate or amend the vision. The problems are largely economic and logistical rather than technical.

The Problem

As with road vehicles, the problem, can be conveniently divided into three parts:

1. New build
2. The existing fleet
3. Refuelling/recharging of both.

1. New Build

It seems extremely likely that the canal boat of the future will be driven by an electric motor. The technology exists and is mature. Quite a few boats have been built over the years with electric motors and they work. Motor vehicle technology will lead development.

As with road vehicles, the problem is how to carry the energy around. Hydrocarbon liquids are a very efficient and effective method of transporting energy. There are two current solutions, both of which are being actively developed for road and rail vehicles:

a) **Batteries.** There are very few problems installing a battery bank in a narrow boat. Weight is not a problem and space is much more available than in a car. Power requirements are well within the range of the current technology and less than most road cars. The main drawback of batteries is range and recharge times. Both will improve. Batteries can be recharged using a shore connection, by onboard photo voltaic cells or small wind turbines. PV cells and wind turbines, given the current state of development will not be able to provide all the energy required. However, PV cells, are developing rapidly. Batteries can also be charged by hydrogen fuel cells, see below.

   Batteries are, of course, only 'green' if the electricity used to charge them is 'green' which is currently only partly true. This is a national problem and will not be addressed here. There are also environmental issues around the manufacture, recycling and disposal of batteries.

b) **Hydrogen.** Hydrogen is an efficient method of transporting energy but not as good as hydrocarbon liquids. The hydrogen is converted into electricity in a fuel cell. The technology is well developed (and will develop further) and the size of existing cells is well within that required to propel a narrowboat. Hydrogen, whilst potentially dangerous, can be engineered, in my opinion, to be no more hazardous than a petrol system. It will never be as intrinsically safe as a diesel system. California has 10,000 hydrogen cars and they are commercially available world wide. Germany has hydrogen trains and they will be on the UK rail system in a year or so. I assume they will be allowed in tunnels! Hydrogen engineering is well understood and mature.

   Currently hydrogen is not 'green' as it is mainly manufactured from hydrocarbon liquids and gases. This could be made 'semi green' with CO_2 capture. It can also be manufactured from 'green' electricity if available in sufficient quantity. Again, a national problem not confined to the waterways and not considered here.

Hydrogen can be used to power a conventional internal combustion engine in a similar manner to LPG. There are some environmental issues with this, like NOx emissions, but no significant technical concerns as far as I know. However, this is not being widely pursued and we need to understand the reasons.

My current vision for a new build future narrowboat (or broad beam) therefore looks like this:

- Powered by an electric motor
- Equipped with a battery bank large enough for canal cruising at normal speed
- Equipped with a hydrogen tank and a fuel cell powerful enough for canal cruising at normal speed.
- Both would be used when high power (stopping, starting, manoeuvring) is required. River use will need a bit more thought.
- Charging of the batteries would be by shore connection, onboard PV cells or the fuel cell.
- The combination of battery and hydrogen fuel cell gives flexibility and reduces the cost of the total installation because of the reduced size of the fuel cell.
- The cost would currently be higher than a diesel set-up but this will reduce and in any event is not a great percentage of the cost of a new boat.
- The batteries would be adequate for short trips. The hydrogen system would give range and fast refuelling capability.
- An electronic management system would be required but this is currently available.

2. The Existing Fleet

Boats last a long time, as do their diesel engines. Owners, especially those (majority?) who do few engine hours a year, will be reluctant to convert from diesel to electric drive unless required by legislation to do so, which is unlikely. It therefore follows that most of the existing diesel fleet will be with us for many years.

Given that we don't wish boats to be made obsolete by legislation or owners being forced into expensive conversions, we need to find a way of significantly reducing the environmental impact of the existing diesel engines.

One possible way is to use biodiesel, which whilst not 100% 'green' is a significant improvement over mineral diesel.

Using biodiesel at 100% concentration has a number of disadvantages and problems which I believe are capable of being mitigated or overcome in the inland waterways environment. These are:

a) Biodiesel is manufactured from vegetable oil and almost any vegetable oil can be used. The commonest oil used is palm oil which makes a biodiesel which thickens at the winter temperatures found in the UK This is not a problem when used at low percentages in mineral diesel, as in current road diesel, but is definitely a problem at 100%, particularly when fuel lies unused in tanks for a significant period. Some oils are available which produce a biodiesel that does not suffer from this problem. Proprietary biodiesels are now being produced which can resist northern Europe winter temperatures, using a blend of oils. One such biodiesel is being imported by Crown Oils under the trade name 'HVO'.

b) Pure biodiesel burns at a slower rate than mineral diesel and hence high revving turbocharged road diesels can struggle on 100% biodiesel. This also is not a problem when blended at low percentages into mineral diesel. Most, if not all, canal boat engines are low revving and not turbocharged and hence I would not expect this to be a problem for most inland waterways craft.

c) Some engines have rubber seals and similar components, mainly in their fuel systems, which are not fully resistant to 100% biodiesel. This can be corrected at a cost. Work would need to be done to identify and convert these engines. It is believed that most modern engines are biodiesel resistant.

d) Biodiesel is currently, and perhaps inherently, more expensive than mineral diesel, perhaps at the level of 10p/litre before tax. Canal boats however use low volumes of fuel.

e) The manufacture of biodiesel does require the use of a small quantity of hydrocarbon and is hence not 100% green. It is significantly better however than using mineral diesel.

f) Biodiesel is manufactured from vegetable oils which means that the production of this oil normally uses land which otherwise could be given over to food production and in the case of most oils, the oil is itself a foodstuff. For this reason biodiesel has not become the universal solution to the road transport environmental problem. The use of diesel on the inland waterways is relatively small in the big picture, so this may be acceptable.

Hydrogen could also be a partial solution here. As noted above, it can fuel a conventional internal combustion engine but it would need to be spark ignition ('petrol') rather than diesel. More work needs to be done to understand the issue.

3. Refuelling and Recharging.

a) The Existing Fleet

Assuming this can be converted to biodiesel, the current refuelling infrastructure can be used. It may be necessary to replace some rubber seals and components.

b) The Future Narrowboat

Refuelling is the major problem and it is economic and logistical rather than technical. Whether we are considering an electric recharging infrastructure or a hydrogen refuelling infrastructure significant capital investment will be required. Commercial operators will not invest until the boats to use it exist and private owners will not invest in the boats until the infrastructure is available. A classic 'chicken and egg' situation. It is unlikely that government will provide the finance as is currently happening, to some extent, with road transport.

Currently electric recharging is slow whereas hydrogen refuelling can be accomplished in a similar time to hydrocarbon liquid refuelling.

An electric charging infrastructure already exists in most marinas and this will be adequate for slow charging of boats moored for significant periods. It would require upgrading for fast charging. This could be adequate for most 'hybrid' (hydrogen/electric) boats as envisaged in 1. above. It is difficult to imagine every visitor mooring on the system being equipped with charging points.

Hydrogen refuelling stations are more problematic. None currently exist on the system as far as I know. They will also need a distribution system, probably tankers, to service them. They will be more costly than red diesel pumps and tanks, but the technology is available. Work is currently being done to develop a hydrogen infrastructure in the UK, for road and rail transport and for domestic use, but this is some way off. The natural gas industry is actively looking at using the gas grid to distribute hydrogen for domestic use. This may ultimately develop into a partial solution.

It may be possible to develop a network of hydrogen refuelling stations around hire fleet bases, if enough hire companies could be persuaded to use hydrogen boats. Hire boats are typically refuelled at base, sent out for one or two weeks and refuelled at the same base on their return. Hire boats are also replaced at relatively frequent intervals when compared with private boats. This combination could make installing a hydrogen fuelling station at a hire base reasonably economic with a hydrogen fleet being available in a reasonably short period of time.

If sufficient bases could be 'converted' this would provide a basic network for private boaters to use and hence encourage the purchase of hydrogen boats, leading to further developments of the hydrogen refuelling infrastructure. This would only apply to the 'central' part of the system where hire bases are common and leave a problem for outlying waterways, at least initially.

Ex hire hydrogen boats would find their way into the private market in a fairly short time, but the residual value to the hire company would probably be reduced initially.

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