Octoply: Introduction to the TIDAL Transport Scheme 1.5

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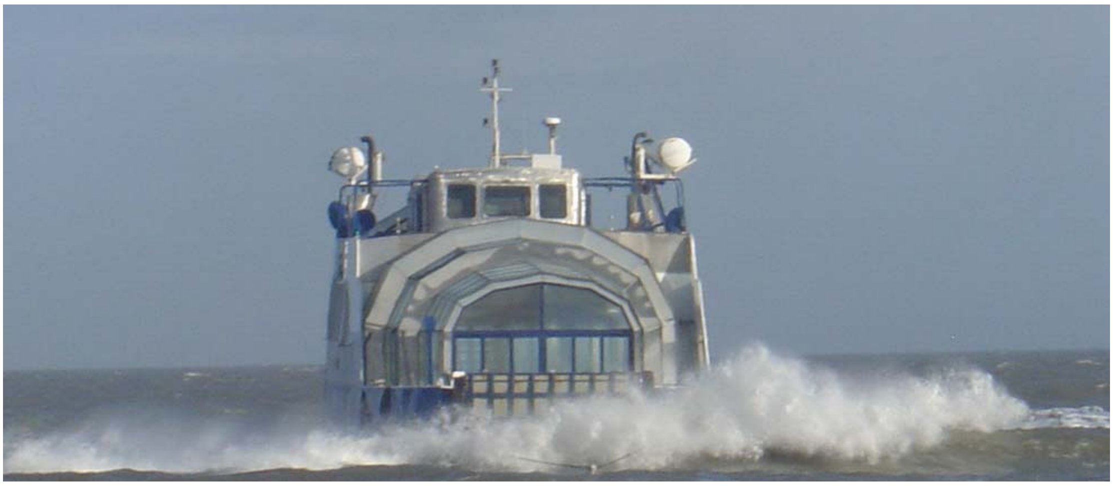
This draft paper is a discussion document that is written for the benefit of a general audience. It describes one possible line of investigation for the incorporation of river services into a sustainable transport infrastructure for London. However, this scheme is equally applicable to a number of river cities in Europe and around the world. The problems and opportunities identified in this paper are based on personal experience and published material. This paper is work in progress and content is copyright by the authors and belongs to Octoply Ltd (www.octoply.co.uk). Any comments happily received.



TIDAL Transport Scheme FAQ's

What is TIDAL?

TIDAL (Transport Integration Demonstration; an Alternative to a Land-only) Transport Scheme is a demonstration project that will will test the feasibility of integrating river services into the transport infrastructure. In the first instance, this will involve the incorporation of fuel cell propulsion systems on river vessels and to introduce an activities based service that will allow commuters to make the most out of their commuting time. It will demonstrate how river services can form an integral part of the transport infrastructure.

What are fuel Cells (FC)?

Fuel cells are like batteries in that they are modular in design and generate electricity. But unlike batteries and more like conventional engines, they require a constant supply of fuel – typically hydrogen. The problem with batteries is because they only store energy, they need to be re-charged. For transport applications, this can be time consuming and inconvenient. The duration/range of a journey will partly depend on the number of batteries in your vehicle as opposed to the size of fuel tank. Therefore if you wanted to improve the range of your electric vehicle, you might need lots of batteries and time enough to charge them.

Cost and convenience are the primary reason why we've stuck with conventional engines for transport. However as we all know, engines are noisy, very inefficient and polluting. Fuel cells (FCs) have been around for a while and offer a nice compromise between batteries and engines. However, being more expensive their application has been limited e.g. the space program. More recently, costs have reduced considerably, but there are still hurdles to cross before we see more widespread application, particularly for transport.

How will TIDAL work?

The aim is to make commuting other than by car more appealing. By focussing on river services, TIDAL will rely on the introduction of vessels that are suitably designed to host a variety of events and activities for commuters during morning and evening congestion hours, while also being economical to build, operate, maintain and modify. Activities could include hair dressing, a doctors surgery, language, music classes and gym. The intention is to make commuting time constructive. By freeing up time that would otherwise be used while at work or at home will (i) have a positive benefit to the individuals quality of life and (ii) ease congestion on other transport networks, allowing those with more pressing needs to get to and from work quicker. Outside of peak commuting hours, some of these vessels can be used as flexible venue spaces that will be available for hire.

Why consider an alternative commuting strategy?

Densely populated cities throughout the world face common challenges concerning their quality of life. Key indicators for ‘quality of life’ include education, employment, energy, transport, environment, public safety and recreation. These indicators act as guidelines and goals for governments in setting their policies. They are not to be viewed as distinct qualities as one indicator will have an influence on one or more of the other indicators.

Of the many indicators for ‘quality of life’, transport has the key role of connecting people and communities to services, jobs and recreation. Cities with well-developed transport systems tend to be attractive environments to visit, live and work. The inevitable consequence of a population influx is that the transport system will not be able to sustain the capacity that it was originally designed for.

To meet this capacity, land based transport networks are scaled to an extent that meets the demand for user accessibility. This strategy has its limitations.

(i) A continuous increase in the density of the transport network will eventually have a negative impact on traffic flow.

(ii) The financial investment required to build on prime land and within a crowded environment will make this strategy very costly.

(iii) Surges in demand during peak commuting hours account for approximately 20% of operating time during the year. Therefore the net benefits of investing in a transport system that satisfies these surges is diluted if that system is near redundant for the remaining 80% of the time.

Why has a constructive commuter service not been done before?

Over the years, commuting time has been on the increase, there has been a huge growth in riverside developments and office work is starting to relax its 9-5 regime. Along with the increase in commuting time has been an increase in the number of options for what commuters can do during their journey, brought about partly thanks to the electronics and telecommunication industries. Basically a change in attitudes, recent technological developments, problems with the current transport infrastructure, longer working hours, gym trips, mobile phones, multiplayer gadgets and cafe culture has prepared a segment of our population to experiment with commuting alternatives.

Could a constructive commuter service work on planes, trains and buses?

These days, it is not uncommon to see train passengers working on laptops or to find someone playing a networking game on a games console. In London, it is rare to find this during peak commuting periods, primarily because of a lack of space. Such is the congestion on some rail routes that it's nearly impossible to get even folding cycles into some carriages. So convincing rail operators to donate a carriage to test out this idea, with no proven commercial success during peak periods, may not go down so well.

Even if the train isn't jammed with passengers, there are restrictions on the type of activities that can be offered on a train or bus journey due to (i) constraints in cabin space; (ii) consideration of safety and (iii) duration and distance of the journey. While duration and distance are unlikely to be major considerations for individuals logging onto the internet, it may pose problems for organising performances and class based activities. This is because such activities usually depend on a collective engagement, a suitable space and an uninterrupted time frame. If the average activity lasts 30 minutes, then an uninterrupted journey of at least 35 minutes would be required to take into account boarding and seating. For commuter stretches like Brighton to London this time-scale is a rarity. At best, courses would run for 20 minutes, a period too short to be productive for a considerable number of subject areas. Longer uninterrupted journeys are rarely found on typical commuter routes.

While plane journeys tend to last more than an hour, with space and weight at a premium, the opportunities available are restricted to screen entertainment, reading material, staring at fluffy clouds and drinking the trolley bar.

Why not build more railways, cycle lanes and roads?

While the obvious solution would be to increase investment in the existing transport infrastructure so that there are twice as many roads, railways, buses and trains that travel twice as fast, twice as often and at half the cost. The problem is that:

(i) Most cities in Britain were not built/designed for such high traffic flow. Expanding the existing infrastructure may involve knocking down/displacing buildings/roads, reorganising supply lines – such as electric, gas and waterlines. This would in most cases be costly and would further add to transport delays.

(ii) A fast service is a self-limiting strategy particularly for transport systems carrying relatively small passenger numbers e.g. cars and motorbikes. Fast services benefit from using routes with limited/restricted traffic. As the traffic density on these routes increase, so do safety and congestion issues. The trade-off for increasing the packing density on any given route is to slow down traffic speed.

(iii) Environmental concerns over (a) the encouragement of car use and (b) the use of concrete in roads, the production of which is a major contributor of atmospheric CO_2.

(iv) Justifying the purchase of more trains and buses to accommodate a period during the day that accounts for no more than 20% utilisation during the week. This investment would be maximised if it were possible to use the extra buses and trains brought in for the peak period for other uses at other times in the day. Unfortunately, passenger buses and trains are designed for mass transit and outside of this, there is very little else you can do with them.

(v) By limiting investment in mass transport options to just road and rail through the use of cars, buses and trains means that should a main traffic artery become inoperable due to bad weather, accidents or terrorism, then the strain felt on the other network option could result in further paralysis. Increasing the number of options will reduce this risk.

While alternatives such as cycling exist, it does not suit all age groups, it can be inconvenient for many who have to wear suits, carry baggage or have to cycle long distances, particularly if there is no access to showering facilities at the end of the journey. Britain unlike some other countries where cycling is popular is moderately wetter, colder, windier and hillier. In addition, a reluctance by most train operators to allow cycles on trains during peak hours due to lack of space makes it even more awkward for long distance commuters.

Could a constructive commuter service work on the river?

There is growing interest in many river cities to revive their waterways for transport. River services at the moment do not suffer the extremes of congestion felt by land-based services. In addition, they are not constrained by the floor area space that limits road and rail vehicles to a certain width. So there is a very good chance a constructive commuter service on the river would be successful, but maybe not immediately.

While the novelty factor would appeal to many, long-term sustainability can only be achieved if (i) FC propulsion systems can be shown to demonstrate strong commercial benefits and (ii) issues such as riverside infrastructure and integration with other transport networks are addressed at an early stage. Recent investment in 'cleaning-up' inland waterways throughout the UK and developments in sustainable forms of marine propulsion has meant that the time is right to start planning a new future for river services on UK waterways.

What about river buses?

A good idea considering the rise and general appeal for passengers travelling by river. Unfortunately, the very nature of the river environment means that vessels cannot be packed into the same tight space as road and rail vehicles. In addition, the cost of widening waterways to accommodate growing traffic is currently not a viable option. This means that a fast service would benefit by having a waterway with limited activity if it is not to succumb to the same congestion problems blighting road and rail systems.

How would you find out if a constructive river commuter service could work?

Ask people. Ask as many people as you can. The only problem is that you could spend quite a while describing the service. And then the responses that you get will vary depending on the weather, cost, mood of the questioner/passer-by. Generally, the interest in a service is dependent on what's being offered, how long it would take and how much it would cost.

If a large enough segment of the commuting population decide to use a constructive commuter service, then it is quite feasible that certain road and rail networks could be freed up for those commuters in a hurry. And here lies the challenge – to create an environment that allows commuters to be productive with their time while also carrying large volumes of passengers. Should it be successful, the result we hope will be a more productive city that is less congested, polluted and frustrated.

Our plan is to use a recently renovated vessel, Sound as a demonstration for such a service and use this to gauge passenger interest. It is important that the service extends its appeal to commuters residing/working some distance away from the river so that the impact on commuter transport is more significant. Sound will be used to gather passenger feedback that will ultimately determine the engineering requirements to design a new breed of FC driven vessels. Lessons from this demonstration could also be used to test a constructive commuter service on land based transport.

What's the common misconception about a constructive commuter service?

There is a misconception that this scheme replaces a persons existing journey time with one which will take the same time but with the benefit of allowing you to engage in activities while on the river. While this might be the case for a few, the majority will find that their journey time is extended. The best approach to appreciate this concept as a potential user is to ask yourself how much would you benefit by taking this journey on an infrequent basis. This may depend on the activity that is being hosted on the vessel while commuting or the services that are on offer. For example a commuter living in Plumstead working in the city might cycle 20 minutes to the pier at the Woolwich Arsenal. By offering on-board showering facilities and giving her a membership option that allows her to leave a set of work clothes with the river operator will mean that by the time she arrives for work, she's had a good morning exercise, feeling fresh and joined like minded people for breakfast. Her service might also have a doctors surgery, which means that any health issues can be addressed while commuting rather than having to take a half-day off work. One can also see the benefit for companies to encourage their employees to use this service. Provided that the journey is treated as a once in a while alternative with clear benefits to the individual, the service should attract regular custom and contribute to a healthier and happier work force.

Where could we test this idea out?

The City of London is one of the major providers of world-class financial services and in 2012 will be host to the Olympics. There is currently a lot of talk about regenerating the Thames Gateway, a region heading East out of London along the Thames corridor. It is under development, poorly connected and as it straddles the river, it is ideally suited for testing out this transport scheme. Plans for regeneration while offering great opportunities also pose huge problems, key being transport. The objectives for regenerating the Thames Gateway and hosting the Olympics might not be met through current transport strategy alone, even if it includes land based initiatives such as Crossrail and buses driven by FCs.

The TIDAL scheme is an interesting investigation to address peak period congestion. By using developing technologies to demonstrate the integration of river vessels into a sustainable transport strategy will require a larger involvement by industry and other prime movers, from technology developers to manufacturers and service providers to government organisations. Timing is critical as London actively pursues a sustainable transport infrastructure.

Figure 1: View of the Thames from Woolwich showing the Woolwich Ferry, Docklands and Thames Tidal Barrier.

What are the challenges facing river commuter services?

A study conducted by the London River Commuters Association (LORICA) [Tempest,P; 1974] led to the introduction of a hovercraft service. While the service was popular, it failed primarily because the cost of operating and maintaining the service could not be justified as popular demand was leaning towards car and rail use. Since then, circumstances have changed and any re-evaluation of a river commuter service would have to balance passenger convenience and cost benefits with the costs for further investment in road and rail infrastructure. In 1999, a £2m bid by Riverjet Ltd to introduce a hovercraft service between Southend, Kent and London had fallen through. While in Scotland, plans for a commuter service linking Glasgow to Dunoon along the River Clyde and another one across the

Forth, linking Edinburgh and Kirkcaldy are being proposed by Hoverlink and Stagecoach respectively. Thames Clippers is running a high-speed commuter service between central London and the Docklands. This service had received a £3m subsidy from Transport for London over a 10 year period along with £1m of private sector sponsorship from London First for a 5 year period. Carrying over 1500 passengers a day, it gives commuters a viable alternative to land based travel.

While the benefits for high-speed travel by river are clear, there are limitations to scalability (expanding the fleet) and long-term sustainability of this style of transport. For instance: (i) fuel inefficiency increases non-linearly at higher speeds resulting in higher costs and greater emissions; (ii) the wake generated can create instability to other floating structures; (iii) the wake can also be damaging to quay side walls and other fixed riverside fittings; (iv) as the number of high speed vessels increases so will the likelihood of collision; (v) at higher speeds it is advantageous for passengers to remain seated and to have fittings secured to the vessels structure; (vi) fast rotating propellers, high pressure water jets and sea water exhausts can be detrimental to marine life.

The question is whether:
(i) a slower service can in some instances be beneficial to passengers;
(ii) the investment in riverside infrastructure (RI) such as pontoons, ramps and servicing facilities for a commuter service can be justified using the same criteria used to finance land transport schemes.

Listed below are issues that will need to be considered if investment in a river transport infrastructure is to be taken seriously:

- Public accessibility: Installation of RI will be dependent on a variety of technical factors such as depth of water, flow rate, material composition of the bank-side and access to land transportation. These factors have to be taken into account when locating RI's so that they are easily accessible by the public.

- Annual maintenance cost of vessel: Underwater maintenance to any large vessel is more than likely to involve dry-docking, slipping or hoisting. With many of the old docks being transformed into residential and commercial spaces, vessels have to travel further for maintenance work. This adds to the running costs not only in terms of the cost to get to the facility, but also to lift the vessel out of the water, specialist labour costs to carry out work and loss of earnings due in part to lengthy downtimes.

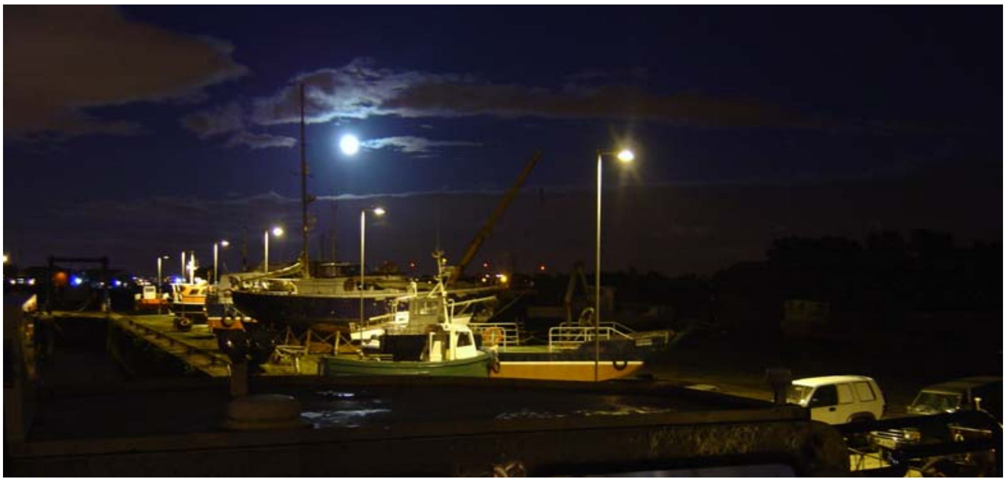


Figure 2: Purpose built boat yard with hoisting facilities.

- Cost of RI: The cost of installing pontoons and piers was not economically viable at one time primarily because the cost of land and the building of land based transport infrastructure was relatively cheaper. In addition, land transportation was considerably more cost effective for moving larger passenger volumes. While the increase in land price and an overcrowded transport system has made the cost benefit less distinct, the added problems of installing servicing facilities for refuelling does have serious environmental risk implications. This is particularly the case if a large number of vessels are expected to be un/docking on the pontoons.

- Travel time: Time is a major limitation when compared to other services. Physical limitations have always meant that marine vehicles tend to be slower than land based ones when taking account travel distance and passenger stops. Added to this are other factors such as tidal flow and docking/undocking procedures due to space limitations on piers will add more time to the journey. This adds to the cost of the service. While fast services are available, the imposition of speed restrictions to protect bank-side infrastructure and the stability of other river vessels will mean that river services will have great difficulty competing with land based services on speed.

- Simplifying passenger safety regulations: Government regulatory bodies such as the MCA (Marine Coastguard Agency), overseeing passenger certification is seen by some river operators as being riddled with legislation which in some cases can be inappropriate, outdated and obstructive. While such criticisms are understandable in certain cases, it is equally important to appreciate the difficulties in regulating passenger safety and minimising the risk of environmental pollution, particularly when considering the size and variation in passenger vessels. It is however conceivable that a more efficient and economically viable approach can be reached without compromising on safety and environmental issues. Such approaches are being addressed both internally within the MCA and by membership bodies such as the PBA (Passenger Boat Association) that work closely with the MCA, Port Authorities and other organisations such as the tourist board.

- Reducing collision risks: As the number of vessels on the river increases, so does the likelihood of collisions. While major collisions that endanger passenger safety can be avoided, minor collisions with other vessels or against floating debris may cause damage to the vessels structure and in some cases will result in the release of marine oils into the environment. The environmental impact would depend on a number of factors including the quantity of oil being released and the tidal range. If remedial action is to be taken, it could be very expensive.

- Avoiding the need for dedicated lifeboat rescue stations: The cost of manning 24/7 river rescue stations is very expensive. The major costs are in the purchase of fast rescue vessels, maintenance for vessel and station, fuel consumption and ensuring that trained personnel are ready for operation at all times of the year. Their presence is of unquestionable value considering the relatively low volume of river traffic that run throughout the day. However, it is quite feasible that reliance on rescue vessels can be reduced as the number of local river services increases, provided that the crew on such services are adequately trained.

- Passenger waiting area: As the regularity of river services may never reach the frequency delivered by land based transportation, additional provisions should be offered on pontoons to maximise comfort and appeal to passengers while waiting for their service to arrive.

- Diversity: In order for river services to grow and attract business, more effort must be made to encourage diversity in services. River transport can be unique in that it can offer a variety of services that cannot be provided by road and rail due to height and width limitations.

Time, cost and legislation are probably the main reasons why river commuter services remain as ‘novelty’ services that in part serve to maintain the image of once busy waterways and also as a pleasant alternative to existing forms of transport. However with changes in lifestyle, advances in technology and the growing health and socio-economic problems with the present transport strategy, river services can still prove to be a viable option within an integrated transport strategy provided that the issues described above can be addressed.

Are fuel cells key to a constructive commuter service?

TIDAL relies on increasing the appeal of river transport so that it has an overall positive benefit for the passenger. This isn't difficult as rivers generally have a natural charm to them. The only problem is that running a river service is expensive and therefore requires subsidies if it is to transport commuters at an affordable rate. In many river cities, congestion hasn't reached a crisis point as in London where large subsidies for running a river commuter service can be justified. Therefore the question is can river commuter services be a cost effective mode of transport? TIDAL is a study that will be used to answer this question.

As it stands with conventional vessels and with the existing riverside infrastructure, the answer is probably no. The high cost of maintaining a vessel, fuelling it and then marketing it so that it appeals to passengers who would otherwise pay less to do what they do in a quieter setting, where there are no diesel fumes and where you are free to walk in and out of the building at your leisure will be difficult.

Over the years, advances in ship design and improvements to the efficiency of marine engines have helped ensure that annual running and maintenance costs are kept low. However these shifts pale in comparison to the costs incurred for a similar space on land. If at all, the only benefit of a river vessel is that the cost/sq ft of space may be less than certain areas in a city.

While a constructive commuter service may not be viable if we were to use conventional vessels under the existing infrastructure, the aim of the TIDAL demonstration will be to assess if and how such a service can be made to work. The nice thing about FCs and batteries is that they are relatively simple, with few moving parts and for that reason they tend to be easier to maintain. Also fixing a problem could be as simple as replacing one module with another and would not incur lengthy downtimes. More recently FC projects in transport have started sprouting. Most popular are hybrid and FC cars. The big problem with buying the latter is where you would fill up your hydrogen car? So what we need are hydrogen filling stations. The big problem here is, who is going to invest in setting up a hydrogen filling station if there are only a very few people with hydrogen based FC vehicles. Yes, the chicken and egg problem.

How does the chicken cross the road?

There is clearly a case for FCs in transportation. This has been documented in numerous articles and on web sites (http://www.fuelcelltoday.com). The main short-term barriers for the automotive industry include:

- High cost of changing the existing fuel supply infrastructure.
- Creating the demand for hydrogen to justify the investment in localised hydrogen generation plants.
- Designing refuelling stations that are quick and simple to operate.
- Engineering solutions that will reduce the volume and weight of the FC and storage tanks to fit in a car while not compromising on the range in which it can travel.
- The high cost of purchasing and installing FC stacks, storage systems and the hydrogen fuel.
- Testing and understanding the durability of the FC stack and storage system.
- Testing and accounting for relevant safety mechanisms.

Similar obstacles are also encountered in the aerospace and marine industries. For aerospace, the major benefits are that FC are more efficient and if the fuel in the form of hydrogen is liquefied, the available energy is considerably higher than conventional fuel. This means that smaller quantities of fuel can be used to propel an aircraft further. The only problem is that liquefying and storing hydrogen is very costly and therefore its application is currently only viable for the space program. In terms of trains, in the UK at least most rail networks are already electrified and therefore the benefits of installing them with FC is not currently of any commercial benefit. Within the marine industry, several demonstration vessels have already proved the efficacy of FC particularly for power generation for shipboard systems.

There is however a strong business case for testing FC on river vessels as the obstacles that have been described above are not only more manageable, but there are additional economic benefits for having electrically propelled vessels which include:

- FC being quieter makes travelling more comfortable for passengers and can contribute to passenger safety by alleviating passenger anxiety during an emergency situation.
- FC being more efficient than conventional engines will have greater environmental benefits particularly when considering that the fuel consumed to distance travelled is generally much greater on marine vessels than road vehicles.

- With high levels of fuel consumption, there will be sufficient demand for fuel to warrant the initial investment in a local hydrogen production facility.
- Most commercial vessels generally ply a particular stretch of river. They also possess ample space for storing fuel, which means that the provision of a single fuelling point along a stretch of river should be sufficient to service a number of vessels.
- Fuel for marine vessels is already subsidised. It would therefore make economic sense to offer similar subsidies for using hydrogen as a way of encouraging river operators to make the switch.
- Vibrations resulting from conventional engines can induce stresses on the vessels structure, opening them up to sources of corrosion (in the case of steel vessels) and therefore compromising the long term integrity of the structure. Therefore FCs can contribute to increasing the longevity and reduce maintenance costs.
- Eliminating the requirement for ancillary machine parts such as engine sea water pumps, so reducing complexity and installation cost. This can result in simpler vessel designs that are consequently cheaper to manufacture.
- Simple and modular design of FC should mean easier maintenance, better utilisation of space and less downtime for overhauling.
- Heat generated from FC can be used to drive onboard heating and cooling systems.
- Exhaust gasses from diesel engines create large gradients in temperature which can again induce localised stresses on the structure.
- Exhaust gasses can often linger around the vessel causing discomfort to passengers.

Besides safety, comfort, efficiency and lower maintenance costs, the success of this scheme will result in major benefits for commuters, FC R&D which will consequently result in significant cost savings to the UK economy.

Is hydrogen cost effective?

Fuel cells running on Hydrogen requires hydrogen. How do we obtain hydrogen? Hydrogen is a by-product of several industrial processes. It can also be manufactured using electricity by splitting water or converted from petroleum and other hydrocarbon rich sources. Either way, hydrogen does not exist naturally and therefore there is a cost associated with its manufacture.

One of the biggest challenges of judging hydrogen's cost-effectiveness is how to make fair comparisons with other types of energy carriers. For example, the running costs on Sound for diesel, oil and maintenance can be as much as £12,800 per week. On other vessels, this value can vary dramatically depending on a number of factors including size, type, age of vessel and the type of propulsion system. Hydrogen is comparatively more costly than diesel for the amount of power generated from equal quantities: the cost of hydrogen pure enough for FC is valued at ~£15/kg compared with red diesel (un-taxed) at £0.45/kg. Note that energy density of hydrogen is 33.3 kWh/kg compared with 11.6 kWh/kg for diesel. However with the other advantages that hydrogen has to offer, the initial high costs can be offset by the long-term benefits.

Theoretical calculations must be verified by practical implementation to allow for a realistic examination of the cost-effectiveness of this technology. By using Sound as a fuel cell demonstrator will allow direct comparisons to be made since the proposed FC system will be installed alongside existing generator sets.

The cost-effectiveness of FC application in waterborne transportation, particularly on river passenger ships is justified by the environmental and social gains, rational use of energy sources, advancement of technology and the anticipated rising cost of oil. Its demonstration in London could generate a stream of innovative designs, which could offer a sustainable, cost reducing solution to the rising cost of delivering cross London transportation for the 2012 Olympics.

The obstacles of fuelling a hydrogen future?

Of the options available to the UK, reforming natural gas is possibly the most cost effective, however what is less certain is whether this option offers any financial or environmental benefit with what we have currently. In addition, as the UK currently imports natural gas, its energy security is reliant on the political and economic stability of those countries that it imports from. Ideally electricity generated from renewable sources would offer the best way forward for a secure, environmentally and financially viable future. The view by many experts is that the existing renewable sources (hydroelectric and wind in particular) cannot meet the energy requirements for the UK. This is one reason why the government have opted for the nuclear option, despite the high costs of implementation and management, and low abundance of uranium along with the associated security risks, it is believed to be Britain's best option for securing supply of energy. The heat generated from the thermonuclear reaction could be used to split water to generate hydrogen.

Wave and tidal energy have been given relatively little attention until recently and yet they have the potential for delivering much of the UK’s future energy requirements. There are five main reasons why the UK has much to benefit from this high energy density resource than most other countries around the world. (1) The British Isles is surrounded by over 15,000 km of coastline. This means that such devices can be installed away from land thereby avoiding planning opposition by residents and yet still be accessible to serve a vast majority of the population. (2) The UK is uniquely located within a geographical band particularly suited for wave energy schemes. (3) Wave energy devices can be scaled and distributed in sufficient quantity to meet growing energy demands. They can also be installed in a manner that has minimal impact to the underlying marine environment and in certain locations could protect coastlines and harbours from wave damage and flash floods. (4) Britain has a rich maritime history, which although diminishing, is till very strong both in research and in commerce. (5) The design and development of wave energy devices is still in its infancy, therefore a concerted effort could deliver a highly skilled workforce and highly valued patented units for export.

The British government has helped fund several pilot wave energy projects to test their commercial viability with other renewable sources. The main barriers to such projects are the high set-up and maintenance costs attributed mostly to the environment that they are installed. Added to this is the cost of cabling and the securing measures required to meet the most challenging of sea conditions and the problems associated with connecting to the national grid. The latter problems can be avoided if the wave energy devices were to be treated as stand-alone devices that used the generated electricity to produce hydrogen. These units could effectively act as fuelling stations for vessels plying coastal waters. This symbiotic relationship would offer a viable expansion of marine FC application and hydrogen energy production using wave energy. Within time it is conceivable that floating islands powered by wave energy would act like service stations for ocean crossing vessels offering huge commercial and environmental benefits to shipping.

What are the carbon dioxide (CO2) reduction benefits

International shipping consumes about 6 per cent (some 150 million tons) of world annual liquid fuels and is predicted to double in the next 10 years. Emissions from ships entering and leaving Britain have more than doubled since 1990 and are expected to double again within a decade. Most recently, the UK government has published a review of climate change policies intended by 2010 to reduce carbon dioxide (CO2) emissions by 20 per cent on 1990 levels. While emissions from road transport is a major source of atmospheric CO2, the actual cement used to make the roads can also release the equivalent of its own weight in emissions. Similarly, the manufacture of steel (used in railways) is an energy intensive process as is the energy required to build them. Waterways on the other hand already exist and while dredging and bank side maintenance also requires energy, this has to be done regardless of the number of vessels plying. Diverting traffic from road to water will make a significant contribution to emission reduction.

Of the conventional fuels used in transport applications, diesel emits the most CO2, estimated at 2.7 kg/l fuel consumed, compared with 2.3 kg/l for petrol. Most marine vessels including MV Sound run on diesel and once our service begins, it could be producing several tons of CO2 emission per week.

While CO2 reduction benefits would be significant if FCs were installed on MV Sound, it is insignificant when compared with CO2 generated at a national and international level by marine vessels and offshore structures. If it can be shown that FCs are more economically viable to run, operate and maintain than conventional engines, then it is conceivable that widespread adoption would soon follow internationally, making international treaties on emission control more attainable.

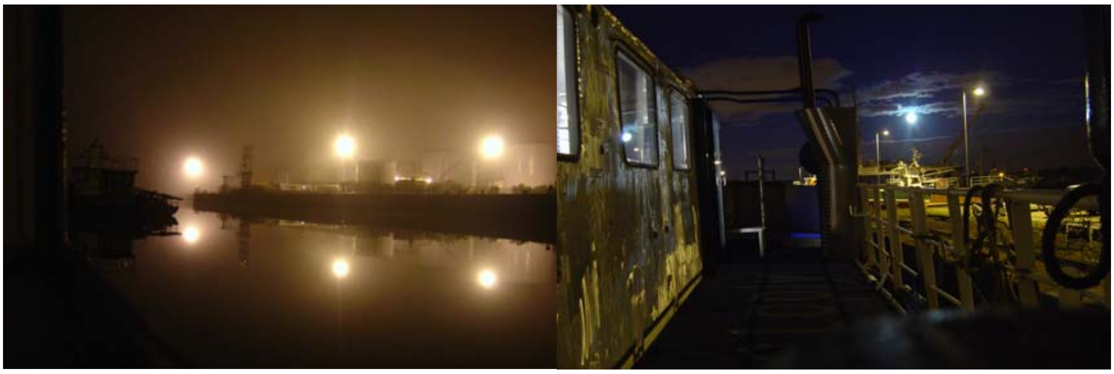


Figure 3: Oil storage facility and ship exhaust

Why use Sound?

Any boat with a reasonable floor space and sufficient safety/backup measures in case of installation problems or failures should suffice for such a service. Octoply have been involved in the renovation of Sound and have developed the TIDAL (Transport Integration Demonstration; an Alternative to a Land-only) Transport Scheme. They are working with other organisations involved in small scale electric power generation applications and marine propulsion systems that are also interested in developing innovative solutions for transport and communication.

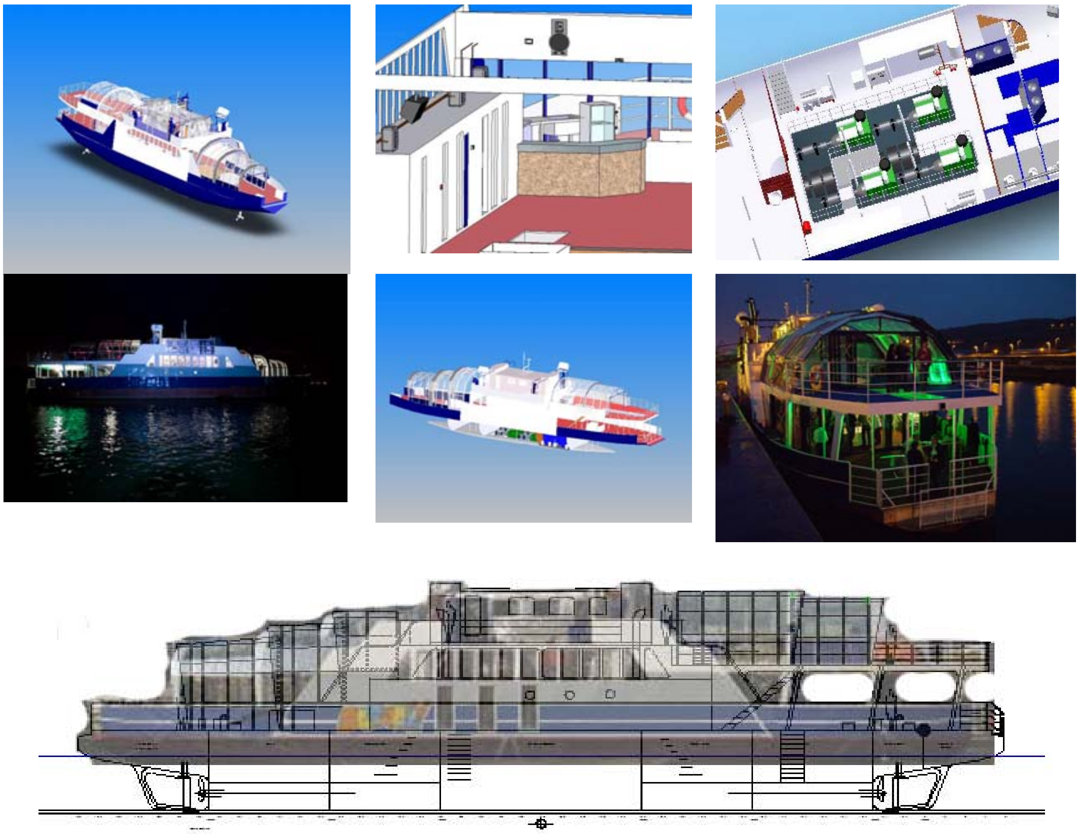


Figure 4: Pictures and models of Sound (External, maindeck, engine room)

Simply put we are keen to see traffic congestion, a major contributor of green house gasses, a waste of fuel and money and an annoyance to drivers and pedestrians, reduced. A possible route that also makes financial sense would be to incorporate river services as an integral part in a river city's transport infrastructure. By applying this idea on river services will also help to generate the initial demand for supporting local hydrogen generation schemes. So now imagine this, you are travelling to work on a really quiet boat (she's not called Sound for nothing), hearing the splash of water in the knowledge that it is running more than twice as efficient as an engine operated vehicle and emitting pure water out of its exhaust. Ok, so we're not there yet, but that's the short-term goal.