Ultra Light Rail – the Fast Track to Fuel Cells

Introducing Fuel Cells to the Commercial Public Transport Market

Fuel cells are now recognised as the key technology in the process of weaning the modern world from its dependence on fossil fuels and leading it into a new age of hydrogen energy. The principal obstacle still to be overcome is the high cost of fuel cells. In transport, for example, one kilowatt from a fuel cell costs around $3,000, compared with $30 per kilowatt for an internal combustion engine. Somehow a reduction of two orders of magnitude has to be achieved if fuel cells are to compete with alternatives in the commercial market for transport.

There are two complementary approaches to achieving this reduction. The first and most obvious is to increase the efficiency of the fuel cell in producing electricity from hydrogen. But producing electricity is not an end in itself. It is rather a means to enable us to achieve the end objective, which is to provide people with useful services such as heat, light and mobility. The cost of mobility can therefore be reduced just as much by increasing the energy efficiency of the system in which the fuel cell is used, as by increasing the efficiency of the fuel cell itself.

Ultra Light Rail is a transport system designed to eliminate the two orders of magnitude gap between the fuel cell and the internal combustion engine. The first step is to increase the efficiency of the vehicle system in which the fuel cell is used. This can be done in a number of ways but the most dramatic "step change" in energy efficiency can be achieved by using a vehicle running with steel wheels on steel rails. This immediately reduces the energy requirement by a factor of three, since the lower rolling resistance allows a tram to use only one third of the energy required by a similar sized bus.

Further cost reductions in the vehicle system can be achieved by introducing an on-board energy storage system in a hybrid electric drive train, similar, in principle, to that used in the Toyota Prius and other cars and even in some buses. This makes possible a lower rating for the prime on-board power source which is required only to run at its optimum level, in order to keep the energy storage system topped up. It also allows for the energy from braking to be recaptured and used, rather than dissipated in heat vented to the atmosphere. Still more efficiency can be introduced by integrating the electric motors into the wheels. The overall weight of the vehicle can be reduced by each of these innovations whilst the body itself can be manufactured from carbon fibre composite materials in a monocoque form. The whole process, using standard proven technology, creates a spiralling cost reduction, resulting from each innovative feature.

Using only some of these features, recent practical test work carried out by Sustraco Ltd, with support from a Carbon Trust grant, has shown that a 25 kilowatt fuel cell would be sufficient to power a light tram with similar capacity to the fuel cell buses currently running in London under the EU's CUTE programme. These buses are doing an invaluable job in demonstrating to the public that fuel cells are no different to internal combustion engines in performance and safety. However the buses themselves are grossly inefficient in commercial terms, costing, as they do, some five times as much as a similar diesel bus and requiring 250 kilowatts fuel cell to operate them. The next logical step in commercialising the operation of fuel cell powered public transport vehicles must therefore be to integrate the fuel cell into an energy efficient tram. This will eliminate one order of magnitude in the cost differential.

Eliminating the second order of magnitude involves engineering down the cost of the transport system within which the vehicle operates. Conventional trams are, in effect, railway trains only slightly adapted to run on roads. Using overhead continuous electrification they have to earth the current through the rails. This necessitates underground insulation and removal of utility services from under their path. The excessive weight of the trams, together with their insulation needs, means that heavy rails and a massive substructure are required. Ultra Light Rail, using bus-type vehicles adapted to run on rails, does away with this needlessly expensive infrastructure. A further significant cost saving arises from the superior durability of trams which normally have a life of 30+ years as compared with 8-13 for buses. This has environmental advantages as well as sharply reducing the amortisation cost of operating trams as opposed to buses.

Installing an on-board power source allows the ULR system to eliminate continuous overhead electrification and the insulation that goes with it. The reduced weight of the tram means that light rail can be used, which is easy and relatively cheap to install and also to move when road excavations are necessary to service utilities, which do not therefore need to be moved. Light temporary track can easily and quickly be laid for diversions.

ULR is designed to be the natural, zero-emission, next-generation successor to the diesel bus as fossil fuels are phased out. The passenger capacity of the trams is therefore designed to be similar to the standard city buses currently in operation all over the world. Rather than increase the size, weight and obtrusiveness of the public transport vehicle it is often preferable to use vehicles with a passenger capacity of around 100 people, plus or minus 50%. As pedestrianised areas are extended in city centres, less obtrusive, pedestrian-friendly trams will increasingly be in demand. Passenger capacity can most easily be increased, with maximum flexibility, by increasing the frequency of the service, which is not a problem on a tram track. A 100-passenger tram every 3 minutes is more convenient and popular than a 200 passenger tram every 6 minutes. The extra driver cost provides additional employment and contributes more to the local economy than amortising heavier hardware. However much larger capacity vehicles can be developed, observing the same principles, at a substantially lower cost than Conventional Light Rail (CLR).

All these features, which differentiate ULR from CLR, result in massive savings in infrastructure costs. Typically a ULR system can be installed at a cost of around £1 to £1.5 million per kilometre as compared with £10 to £15 million per kilometre for CLR systems. This eliminates the second order of magnitude and delivers a highly energy efficient public transport system which is non-polluting, popular and low-cost, with essential flexibility in carrying capacity.

Light, zero-emission trams with on-board power generation can be used under cover, inside buildings such as stations and shopping malls, where buses cannot penetrate. A major advantage in planning to replace buses with light trams is that it does not involve persuading the public to accept a new unpopular transport system with which they are not familiar. On the contrary the reverse is true, as trams are universally more popular with the public than buses, as market studies around the world have shown. This popularity is conducive to higher levels of modal shift as people are more willing to leave their cars behind and travel on the tram system. This in turn has a positive knock-on effect on property values, which can be used to facilitate the funding of city regeneration projects.

ULR is designed to bridge the current cost gap between internal combustion engines and fuel cells by using standard production fuel cells more efficiently, rather than waiting for fuel cell prices to come down. However, as they do come down, ULR systems will simply become even more economical.

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