Hydrogen Bus Alliance

Industry Dialogue

Mapping the Route to Commercialisation: An invitation to the hydrogen bus and hydrogen refuelling industries to input into a strategy for the commercialisation of hydrogen bus technology

24 September 2007

Introduction

A number of international cities and regions with large bus fleets formed the Hydrogen Bus Alliance on 6 October 2006. These cities and regions represent leading adopters of new bus technologies on their respective continents and plan to act as leaders in the move to cleaner fuels for urban public transit. At present, the Alliance represents a cumulative fleet of over 12,000 buses and an average yearly purchase of over 1,200 city buses each year. A number of other cities and regions are keen to join the Alliance and we expect the size of the combined fleet to grow accordingly.

The Alliance includes the public transit agencies from:

- Amsterdam (GVB)
- Barcelona (TNB)
- Berlin (BVG)
- British Columbia (BC Transit)
- Cologne (Regionalverkehr Köln)
- Hamburg (Hamburger Hochbahn)
- London (Transport for London)
- South Tyrol
- Western Australia (Public Transport Authority of Western Australia)

All of these cities and regions are characterised by high level political support for hydrogen bus deployment and active programmes to demonstrate new hydrogen buses by 2012. The Alliance members all intend to move towards procuring hydrogen buses on a continuous basis as hydrogen buses move towards commercial viability in the 2010-2015 timescale.

The Alliance will act as the leading end-user base in the push for commercial hydrogen fuelled public transit. The Alliance will first demonstrate buses in their fleets in order to gain confidence in the technology and share the knowledge achieved amongst members and with the relevant industries. The demonstration phase will be followed by a deployment phase in which the cities and regions will deploy vehicles in partnership with the bus and refuelling supply industries, with a view to achieving sufficient volume to reduce cost to acceptable levels. The Alliance will strengthen customer acceptance for the technology and help establish hydrogen as an energy carrier.

To date, the Alliance has focussed on sharing of information about each member's demonstration activities. Each member will purchase and operate at least five new demonstration hydrogen vehicles in the period from 2008 to 2012 and the sharing of procurement and performance information has already been invaluable. The demonstration projects are being carried out separately, with no attempt to coordinate procurement. In the future, the partners are determined to maximise the commercial benefit of their joint demand, including co-ordinated or joint procurement (of vehicles or components) when it is advantageous.

The Alliance is now developing its coordinated procurement plans for the period 2010 to 2015. One of the principle goals of the Alliance is to ensure that by the end of 2015 hydrogen buses can compete with diesel competitors in commercial fleet operations. This is believed plausible, based on initial discussions with

suppliers and publicly announced targets, such as the US DoE targets, the European Hydrogen and Fuel Cell Technology Platform Implementation Plan, the US National Fuel Cell Bus Program and supplier targets. The Alliance wishes to drive this process in its role as market leader, through leverage of international programs (e.g. the EC's JTI) and by providing a forward commitment to procurement of hydrogen buses.

Early bus trials have demonstrated the technical feasibility of hydrogen buses for public transit. However, there are a number of technical and commercial requirements for hydrogen buses and associated refuelling infrastructure which must be met before the partners can make a major commitment to the technology in the 2010 to 2015 period.

Without robust answers to how hydrogen bus technology will evolve to meet these requirements, the partners will not be able to provide the substantial investment required to support hydrogen buses through this critical phase of their development.

This document sets out these requirements (which will be well known to their respective industries) and invites a dialogue with the hydrogen bus and refuelling infrastructure industries. The Alliance hopes that the various industries involved will be prepared to engage with us in defining how these requirements can be met and assist us in defining and then implementing a coherent strategy for the Alliance, leading to commercialisation in the 2010-2015 period. The reciprocal commitment from the Alliance is to publish the 2010-15 plans to those industry partners who provide assistance and to then begin work on implementing the plan.

Specific benefits to the hydrogen bus industry of engaging with the Alliance are:

- **Shaping the city and regional plans on hydrogen vehicles and refuelling to 2015 and beyond** – through input into the strategic plan for 2010-2015, to ensure plans are consistent with those of the hydrogen bus and refuelling industries.
- **Creating a market for hydrogen buses and refuelling** – by aiding the cities and regions in developing joint plans towards a continuous market for hydrogen buses, their associated components and refuelling infrastructure. Supplier input here provides the confidence necessary for politicians and budget makers to commit to firm plans for future hydrogen bus deployment.
- **Learning (both commercial and technical)** – through participation in the process and sharing market and technical information with the Alliance.
- **Standardising specifications** – the Alliance wishes to work towards as common a set of specifications as is feasible, to assist with cost reduction and volume manufacture
- **Developing future opportunities for hydrogen bus sales** – the cities and regions involved in the Alliance are committed to expanding the scope of the Alliance (and hence the hydrogen bus market) by assisting new cities and transit agencies in developing their own plans for hydrogen bus technology. Supplier input is critical to creating confidence here.

Format for the dialogue

The aim of the dialogue is for suppliers to provide a formal (and confidential) input into our planning process for the 2010 to 2015 period. The input from suppliers is expected to provide us with answers to the requirements outlined below for hydrogen bus commercialisation. We propose that this is best achieved with the following process:

1. 'Industry Dialogue' launched at the Canadian High Commission Grove Reception 24th September 2007 (18.30 Canada House) and subsequently promoted at the Grove fuel cell conference on 25 – 27th September 2007.

2. Industry Dialogue presented at a number of international bus exhibitions and conferences in the US and Europe during October 2007 to December 2007.

3. Responses from industry will be collated between October 2007 and January 2008. Responses and engagement in the dialogue exercise will take two forms. Suppliers are requested either:

- to submit a paper responding to the questions set out below
- to request a telephone or face to face meeting with representatives of the Alliance

The Alliance may also contact suppliers personally to request their engagement with the dialogue process.

4. Preparation of a draft action plan for the Alliance for the 2010-2015 period will be completed by March/April 2008. The document will reflect the aspirations of the hydrogen bus and refuelling industries, as well as the political and budgetary realities within the Bus Alliance cities and regions.

5. Consultation with industry on the draft proposal will take place May to June 2008 – a seminar will be held to which industry representatives will be invited. Representatives will also be invited to submit comments on the draft action plan.

6. Action plan to be finalised and approved by key political and administrative stakeholders in the Bus Alliance cities by July/August 2008. Once approved, the final Bus Alliance document will be shared with industry participants

7. Work to commence implementation of the action plan will start from August 2008.

Note that during the same timescales as the 'Industry Dialogue', we will be pursuing a workplan involving outreach to assist other cities and regions considering purchasing hydrogen buses and also promotion of the Alliance and its aims to policymakers and international funding bodies.

Please submit your response or request for an interview/meeting to:

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All responses to the Dialogue will be treated in utmost confidence.

Please note:

Any plans developed by the Alliance will be aimed at creating a genuine market for hydrogen buses. It is not our intention to support a single supplier or a particular technology, instead, the aim is to support the development of the industry.

Requirements for hydrogen bus manufacturers and component suppliers

Cost is clearly the major barrier for hydrogen bus suppliers to bring their product to the market. For hydrogen buses to offer a useful alternative to diesel by 2015, **they must compete with diesel vehicles on a whole life cost basis over at least a 12 year operational life** (some of the transit agencies e.g. BC Transit have a 20 year life requirement). This has implications for cost of components (particularly fuel cells, fuel storage and any hybrid drive systems), durability of components and fuel economy.

In addition, for the cities and regions involved in the Alliance to commit to major bus deployment programmes in the 2010 to 2015 period, it is imperative that the cost of the technology to the end user is reduced during that period. It is highly unlikely that politicians will be able to support any significant (100+ vehicles) deployment if the average whole-life additional cost of operating hydrogen buses in the period remains at the high levels seen today.

There are a number of other issues which will influence the feasibility of hydrogen vehicle deployment in 2015, such as the ability to fast fill the on-board tanks, ability to maintain vehicles in a manner comparable to today's diesel vehicles, compatibility of fuel purity requirements with those that can be easily delivered and monitored by the refuelling industry, vehicle range (which is customer specific) and the ability to use hydrogen on double-deck buses.

The Alliance would like to discuss the following questions with industry:

1. What are the routes to commercialisation envisaged by hydrogen bus manufacturers, in terms of key technical steps, requirements for deployment of pre-commercial vehicles and the points when commitment to high volume manufacturing would need to occur? Is 2015 a reasonable target date for commercially available FC buses, perhaps earlier for H_2ICE? What technological and economic circumstances would be required for commercial FC and H_2ICE bus production lines to be operating commercially by 2015?

2. What are the likely developments in the lifetime and associated warranties of the key components within hydrogen fuelled buses? The Alliance will require warranties in excess of 20,000 hours (for all major or high cost components) for commercial operation. An alternative would be a low cost component replacement regime which meets the Alliance lifetime aspirations.

3. What level of confidence can industry provide that these commercial and technical targets will be met?

4. How is the fuel consumption of the vehicles likely to develop over time? What is the likely fuel consumption of an H_2ICE or fuel cell bus in 2015, with and without hybridisation? The Alliance would expect performance well in excess of diesel vehicles for FC vehicles and comparable for H_2ICE.

5. What developments in on-board storage are envisaged? For example will hydrogen be stored at 700 bar, or any other pressure?

6. What is the short term (i.e. by approx. 2010) potential for cost reduction of hydrogen buses (and associated maintenance) based on a single order of 50-100 vehicles?

7. What is the industry's projection of the **actual price for hydrogen buses (including warranties)** under various assumptions on global sales volumes? We are interested in detailed costs between 2010 and 2015 and in views beyond 2015. The Alliance will require a significant reduction in the cost to the consumer for pre-commercial hydrogen buses to allow any significant 100+ vehicle roll-out programme. This could be achieved through genuine cost reduction, a commercial investment by the manufacturing industries or through investment by an international funding agency (e.g. the EC or a US programme).

8. What mechanisms would industry suggest for grouping bus demand from members of the Alliance? Demand must be grouped in a way which allows manufacturers to scale up production etc. Options could include common procurement of vehicles (not favoured due to different national requirements), common procurement of components (e.g. fuel cell stacks), a common set of vehicle specifications or simply forward quantified commitments to individual procurement programmes by each member of the Alliance.

9. Have manufacturers considered or produced designs for a double-deck hydrogen vehicle? If so, when might it become available?

10. Is the development of affordable hydrogen fuel cell buses dependent on the development of mass market fuel cell applications in the automotive sector (passenger cars) or can these be decoupled by working in partnership with suppliers and relying on the volumes available in bus markets? What needs to be done to allow commercial hydrogen buses without commercial hydrogen passenger cars?

11. What are manufacturers' views on the synergies between H2 buses and the development of diesel hybrid drivetrains for urban buses? To what extent does the roll-out of diesel hybrid vehicles obviate the need for mass pre-commercial roll-out of hydrogen buses?

Requirements for hydrogen bus refuelling infrastructure providers

It is clear from both the early hydrogen bus trials (especially CUTE) that there are major technical challenges for refuelling hydrogen buses in conjunction with daily bus operation. The requirements for hydrogen refuelling providers are focussed on the ability to provide affordable low carbon hydrogen for a complete bus depot. Bus depots can support up to 250 buses.

Technical requirements include:

- Refuelling must be provided at or very close to bus depots
- Refuelling of all buses in the depot (up to 250) currently occurs in a short overnight window (the window can be as short as 6 hours). Bus operators would expect a similar refuelling regime when using hydrogen. This could be achieved using either a fast fill or slow-fill solution, though fast fill is used in the vast majority of diesel bus depots. We recognise that there may be a major cost benefit to altering bus operator refuelling patterns (e.g. to spread refuelling throughout the day). If this is the case, this benefit needs to be well quantified by the refuelling providers and discussed with bus operator logistics managers.
- For fast fill operation, refuelling times must be under 10 minutes per bus (longer times cause unacceptable delays for operators).
- Sufficient redundancy/backup in the system to achieve availability comparable with diesel fuelling.
- Provide the above requirements in a footprint no larger than existing diesel refuelling facilities and with safety restrictions in place which do not compromise operation of the bus depot more than existing diesel dispensing areas.
- Provide flexible refuelling facilities capable of responding to wide fluctuations in daily hydrogen demand (up to 50%).

The above systems must deliver hydrogen at an affordable price. The DoE target of $3/kg is a reasonable target. We recognise that this may require long term contractual commitment and substantial hydrogen throughput. For illustration, a typical depot may have 100 buses (at least 2,000 kg/day) and could commit to a refuelling contract for 10-15 years, provided the cost was close to the DoE target. The assumption is that 350 bar refuelling will dominate hydrogen buses for the short to medium term.

There is little point in deploying hydrogen buses if they do not eventually lead to ultra-low CO_2 public transit. Whilst it is recognised that ultra low CO_2 hydrogen may not be available on a large scale by 2015, it is important that CO_2 drives the technical solutions to the above requirements. Ultimately CO_2 emissions per km are the key driver and hence hydrogen bus efficiency plays a role in the CO_2 argument. In the longer term, it is important to demonstrate that ultra low CO_2 solutions are available and compatible with the cost and technical requirements above.

In our dialogue with refuelling providers, we would expect to discuss:

1. The affordable options available for the refuelling of hydrogen buses at bus depots at prices competitive with diesel, i.e. <$3/kg hydrogen. Which technologies can deliver these costs by 2015? What scale is required? What contract lengths are required? At what point can these options deliver ultra low CO_2 hydrogen?

2. What is the implication on cost of progressively ramping up hydrogen demand at a given depot, over converting to a complete hydrogen bus depot immediately? Are there any production volumes where the capital cost per kg dramatically reduces?

3. Will standard refuelling operations in bus depots need to change in order to ensure hydrogen can be delivered at a reduced cost? Can <10 minute fill time be achieved at reasonable cost? Can all buses be refuelled in a short time window (current practice is to refuel all buses in as little as 4 hours)? Alternatively, will slow fill or altered bus refuelling patterns be the only option for large volumes of demand?

4. Can space requirements be reduced in urban bus depots - to be equivalent with diesel refuelling facilities? Will off-site production be the only feasible option to reduce space requirements with large hydrogen demands? What are the trade offs between daily H_2 consumption, distance from production facility etc where off site production becomes viable?

5. Do designs exist for systems which are suitable for a complete hydrogen bus depot, refuelling up to 250 buses each day? If not, what steps are required to develop appropriate designs and in what timeframe are these designs likely to be available?

6. To what extent does the high purity requirement of FC buses increase the cost of hydrogen refuelling? What steps are required to achieve an optimisation of the purity requirement with FC and ICE manufacturers?