Executive Summary of the Results of the Work Package on Hydrogen Buses

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Disclaimer

This document is the result of collaborative work between NextHyLights Industry and Institute partners. The results of the research were subsequently elaborated and presented in a coherent manner, which involved extensive stakeholder consultation in locations around the world as well as feedback from the NextHyLights Industry Partners.

The ideas presented in this document were reviewed by certain NextHyLights project partners to ensure broad general agreement with its principal findings and perspectives. However, while a commendable level of consensus has been achieved, this does not mean that every consulted stakeholder or NextHyLights Industry Partner necessarily endorses or agrees with every finding in the document.

Introduction

Hydrogen buses have the potential to provide ultra-low carbon public transport, with no harmful local emissions. The technology is, however, not fully commercially mature and will require further support in the coming years if it is to gain commercial traction within the sector.

This document summarises the three core deliverables of the Work Package 3 of the NextHyLights project which are aimed at mapping out a pathway to achieving commercialisation within the hydrogen bus sector:

- The "*Hydrogen Fuel Cell Bus Technology State of the Art Review*" – which explores the state of hydrogen buses today and the technical and economic prospects into the future
- The '*Commercialisation Strategy for Hybrid Fuel Cell Buses during and beyond the JTI'* (deliverable 3.3), aimed at understanding the pathway to achieving commercial maturity within the sector
- The '*Technical Work Plan for Hybrid Fuel Cell Bus Demonstrations during the JTI*' (deliverable 3.2), aimed at delivering a coherent set of recommendations to the JTI' Fuel Cell and Hydrogen Joint Undertaking on the make-up of the next calls for hydrogen buses from 2011-2013

Key conclusions of Work Package 3 on Hydrogen Buses

Hybrid fuel cell[1] bus technology provides one of the two viable zero emission bus options for the urban transit market (the other is an all-electric drivetrain, in e.g. Trolley buses).

The analysis of performance data indicated that fuel cell bus performance is improving significantly over time. The table below provides a snapshot of the key metrics:

Hybrid FC buses (12m platform, low floor)	Current Values	Next Generation	Diesel buses (12m platform, low floor)
Fuel Economy*	**8 – 15 kg/100km** (up to 30% improvement over an *equivalent* diesel route at parity of calorific content)	**7 – 12 kg/100km** (from 20% to 40% improvement over an *equivalent* diesel route at parity of calorific content)	**35 – 50 litre/100km** (approx. 11 – 15kg-H2/100km at parity of calorific content)
Range	**250 – 450 km**	**250 – 450 km**	**>> 400km**
Availability**	**55% - 80%**	**≥ 90%**	**≥ 90%**
Refueling Time***	**7 – 10 minutes/bus**	≤ **7minutes/bus?** (It may depend on tank size)	**<< 5minutes/bus**

* Fuel economy depends on drive cycles. It is worth noting that there is no standard drive cycle for buses and hence these figures are indicative of best of class urban drive conditions only.
** Availability is defined as the percentage of days of actual service compared to the number of day of scheduled service (over the year).
*** Best of class performance range

The technology is expected to provide a more flexible and cost effective solution (on a total cost of ownership basis) compared to trolley buses on new routes in the period between 2015 and 2020. Further cost reduction is expected to lead to parity with diesel bus total ownership costs beyond 2025. At this point the economics will be dictated by the relative price of diesel versus hydrogen fuel for bus operators.

[1] Hybridised fuel cell buses combine hydrogen-fuelled fuel cells with energy storage devices such as batteries, super-capacitors or a combination of both.

The key challenge facing the technology is to create sufficient demand in the short term while the buses are more expensive than alternatives, in order to justify the technology developments required to achieve the 2025 goal.

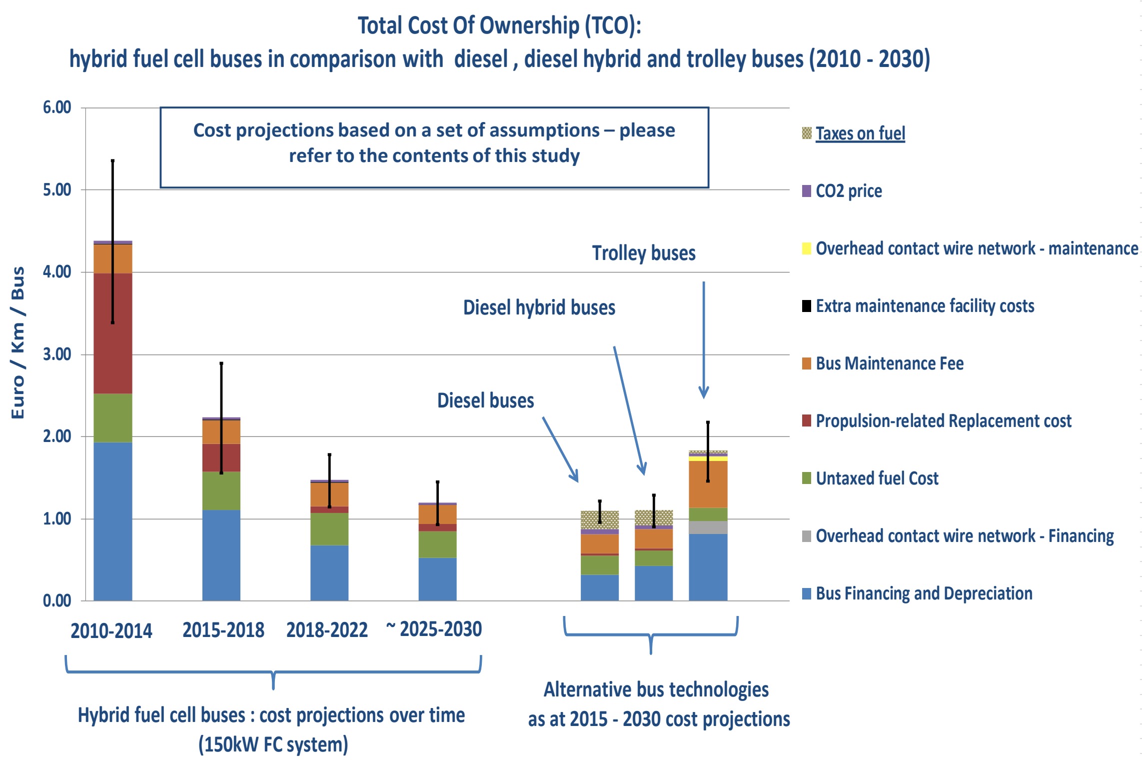

Figure 1 Total cost of ownership for different bus drivetrains today and into the future – assumes a 12m bus platform. Error bars represent upper and lower bound projections on ownership cost. **Cost figures are expresses in 2010 money value. Figures assume an untaxed diesel fuel price of €0.58/litre.**

When this is translated into a hydrogen bus deployment strategy for bus operators, it is possible to demonstrate a positive business case. This is only apparent when considering a) industry's more optimistic projections for bus cost and performance and b) favourable local circumstances (particularly the relative price of hydrogen and diesel fuel for bus operators).

This is a significant conclusion as it suggests it is possible to justify investment in the technology from today (when it is more costly than diesel alternatives) as the benefits of running hydrogen fuel cell buses from 2025 onwards can have a sufficient value to cover initial high costs.

Investing today in hybrid fuel cell buses, however, does represent a risk for transit agencies as the technology's market competitiveness is only expected around 2025. Before then any interested city/region will need to base their investment decisions on local conditions, such as the general desire to contribute to the development of the technology, a particular desire to be seen as environmental cities or the potential to stimulate local economic development.

In addition to investment of this type, buses' rollout over the period 2010 – 2020 will require support as in this phase the technology will be more costly to operate than diesel alternatives (on a total cost of ownership basis). The level of support is predicted to drastically reduce over time - from a Capital intensive regime between 2010 and 2015 to a lower cost regime between 2015 and 2020/5. This less expensive regime could be supported using ongoing opex based subsidies, such as differential tax rates, or a small subsidy per km travelled, rather than relying on cumbersome capital schemes. The need for subsidies is expected to be low by 2020 and disappear even for competition with diesel vehicles by 2025.

Optimal rollout strategies in the 2011 to 2020 period would favour a deployment of large fleets of buses in a very small number of cities in order to take full advantage from economy of scale benefits for both infrastructure and buses.

In practice, the actual capabilities of European cities/regions to fund large bus projects may require a less optimised approach. According to discussions with interested players, even leading European cities/regions will be ready to deploy only twenty to thirty buses each by 2015/6 and up to a maximum of 100 by 2020.

In order to achieve industry's volume requirements to achieve cost reduction targets, up to 6 cities will need to actively engage in large fleets of hydrogen buses by 2015 and some 15/20 by 2020.

From this perspective, the FCH-JU can play a key role in initiating the commercialisation process by supporting a first wave of large bus rollouts in the next calls. Beyond this early rollout support, the JU could also consider a facilitator role aimed at encouraging member states to consider hydrogen bus deployment programs from 2015, as these are likely to be best deployed on a member state level.

It is possible to make recommendations to the JTI's Fuel Cell and Hydrogen Joint Undertaking (FCH-JU) on the make-up of the next calls for hydrogen buses from 2011-2013.

The study established that outstanding bus operational availability is a precondition to benefiting from the very high fuel economy and other environmental benefits available from hydrogen buses. Availability equivalent to diesel buses is, furthermore, also a necessary condition for the bus operators before they commit to the technology in large fleets.

The main short-term target for the next generation of hybrid fuel cell buses is therefore to prove an operational availability equivalent to that of diesel buses. If acceptable bus availability is not achieved within the current wave of demonstrations, the FCH-JU should require it as a precondition to any future large scale bus deployment support.

This is a result expected from the current wave of bus demonstrations taking place in Amsterdam, Cologne, Hamburg, and the other European cities included in the EC's CHIC project.

Assuming that the technology demonstrates diesel level availability in the current demonstration projects, the next target is cost reduction. To this end, the FCH-JU should consider two new calls for bus projects:

- Call 1: Support large roll out of buses (60 – 120 buses in, say, two to six cities/regions, dependent on fund availability)

  Large bus deployment (50 buses or over) is the next logical step towards cost reduction for fuel cell bus technology. In this call the FCH JU should stimulate large proposals from cities/regions with experience in hydrogen bus projects and/or from cities/regions and bus operators with large fleets.

- Call 2: Support small bus deployments to encourage the entrance of novel hybrid fuel cell bus concepts into the market by commissioning new bus prototypes

  Only few European OEMs are currently active in the fuel cell bus sector. It is recognised that a wider range of competitors would accelerate the cost reduction process of the technology (through competition) and also promote new business opportunities on regional level. In this call the FCH-JU is therefore recommended to support the entrance into the market by a broader range of hybrid fuel cell bus options, by supporting prototype development.