D7.3: Policy support options for hydrogen buses in public transport

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Disclaimer

This document is the result of a 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. The producer of this document is the sole responsible for its content and recommendations.

Summary

This study aims to inform about policies that can be deployed to accelerate the roll-out of hydrogen buses. Hydrogen buses offer environmental benefits in terms of global warming, air quality and noise reduction. The study is targeted at the time window up to 2025, with cumulative bus numbers in European cities increasing to about 2000. In this phase, in which hydrogen buses will still be more expensive than conventional buses, policy support is crucial to reach the stage of mass production and the associated lower external costs to society.

The policy support measures presented are expected to be relevant for the Fuel Cell Hydrogen Joint Undertaking (FCH JU), as well as for governments on the local, national and EU level.

The study points out that support for hydrogen buses requires the direct contribution of public funds to alleviate investment cost – in contrast to the passenger car segment where a part of the additional cost can be also absorbed by car drivers. Consequently, local and national policymakers should be prepared for public financial support for hydrogen buses in the early market phase, that continues till about 2025. For the industry a switch to hydrogen would require a clear perspective of large future demand for hydrogen buses.

The policy support options presented here focus on the middle two phases of the roll-out plan for hydrogen buses, as defined in Workpackage 3 of the NextHyLights project:

- o Demonstration phase (2010-2013) to prove the technical and operational feasibility of hydrogen buses.
- ⇒ One-off order phase (2010-2015), with cost reductions via economies of scale, based on a joint tender of a few leading cities.
- ⇒ Continues expansion phase (2015-2020/2025), with a growing number of cities deploying hydrogen buses up to a cumulative fleet of about 2 thousand around 2025.
- o Competitive phase (after 2020/2025) when hydrogen buses are expected to be cost competitive with conventional buses.

⇒ *Up to 2015: one-off order*

In the early roll-out phase till 2015 a number of cities is expected to pool demand in a joint tender for a one-off order of a few hundreds of buses. This approach of pooling demand enables larger production volumes and associated economies of scale, resulting in lower bus cost. Measures could still take place on EU level as this is still considered support of the innovation phase of hydrogen technology. In this phase policy support measures can be divided in three forms, that ideally should be deployed all:

(1) Coordination of the pooling of demand and resources in various cities.

(2) Reduction of investment risks. Governments can share in the risk of purchasing hydrogen buses, e.g. in the form of loan guarantees, allowing bus operators to acquire low interest loans and thus reduction of costs.

(3) Investment subsidies to cover (part of) the capital expenditure will be crucial. Subsidies could involve coordinated resources at the local, national and EU level.

⇒ *2015-2025: continuous expansion*

In the subsequent phase of continuous fleet expansion, till a few thousand hydrogen buses around 2025, direct public financial support will remain essential to cover the (narrowing) cost gap with conventional vehicles. EU support will be unavailable as production volumes increase and market introduction support is outside the scope of EU R&D policy. That means that policy support needs to be initiated at the member state level.

This vision was confirmed by an analysis of the relationships between bus operators and their stakeholders, as well as by questionnaires send out to 5 European cities deploying hydrogen buses (Bolzano, Hamburg, Oslo, Amsterdam, Barcelona). The current (conventional) bus system in all cities cannot be completely funded by the ticket fares, with the local government making up the difference. Consequently additional public support - on top of the current subsidies - is the only way to bridge the financial gap between the hydrogen bus and the conventional alternative. Part of the financial support could be shifted from the local to the national level, where the relative impact will be smaller, for example by tax exemptions for vehicle purchasing and fuel. Policymakers may consider to finance the support of hydrogen buses by using revenues from the taxation of other vehicle segments (e.g. through a congestion charge).

Furthermore governments could support hydrogen buses by providing a consistent long term market perspective for ultralow emission technologies, reflected in low taxations in line with their lower external costs to society. However, it takes time for legislation to pass through political instances. Therefore, member states should be already aware of the situation. Measures to implement the required support schemes should start already now.

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1 Introduction

This report is part of the NextHyLights project, that aims to support the next phase of large-scale demonstration projects in hydrogen transport. The project has 12 partners from industry and academia and is financed by the Fuel Cells and Hydrogen Joint Undertaking (FCH JU), with equal contributions from the European Commission and industry partners from Europe.

Hydrogen buses have the potential to provide public transport that is characterised by: (1) ultra-low CO_2 emissions; (2) absence of local air pollution, including PM_{10} and NO_x; and (3) low noise (Rivera et al, 2010). These environmental benefits imply a reduction of external costs for society, compared to the diesel bus alternative. In the long run, the environmental performance of hydrogen buses is expected to be much better than can be achieved by the incremental improvement of current technologies (i.e. diesel and diesel-hybrid buses, see NextHyLights Environmental Assessment Report 6.2.).

Although these are attractive benefits, hydrogen buses are currently not yet cost competitive compared to conventional diesel buses. Further cost reduction would require additional R&D, learning-by-doing in demonstration projects, and the economies of scale achieved in mass production. However, from an industry perspective, improving conventional technology with the associated shorter term economic benefits, may be more attractive than investing in hydrogen technology unless they would have a clear perspective of large future demand for hydrogen buses. Consequently, the roll-out trajectory of hydrogen buses will inevitably require governmental support, in the form of: (1) financial support in early market phases towards economic competitiveness; and (2) consistent long term market perspective for ultralow emission technologies, reflected in low taxations in line with their lower external costs to society.

Workpackage 3 of NextHyLights has analyzed the potential cost reductions and developed a commercialisation roll-out plan for hydrogen buses that provides the basic input for this report. The commercialisation of hydrogen buses is likely to be characterised by a number of phases. First, the technical and operational feasibility of the hydrogen buses needs to be proved in the demonstration phase (phase Ia). Then, a few leading cities will need to implement the buses in their routine operations in the phase of a one-off order of a few hundred buses (phase Ib). The efforts and experiences of these leading cities will induce cost reductions and proof of feasibility, motivating other cities to also implement hydrogen buses in the phase of “continuous support” (phase II). Eventually, hydrogen buses will then reach the phase of being competitive with conventional technologies (phase III).

This report outlines how the commercialisation of hydrogen buses could be supported by means of policy support to alleviate cost. The focus is on the required support in phases “one-off order” (Ib) and “continuous expansion” (II), because these will be most challenging and crucial to the success of the commercialisation strategy. The mix of policy instruments deployed should provide optimal support in each of these phases.

Report structure:

Chapter 2 presents an overview of the policy support options that that can be deployed in phase of the one-off order of the commercialisation strategy (phase Ib). This information is interesting for European, national, and local policymakers.

Chapter 3 provides more details on the policy measures that are proposed for the phase of continuous support (phase II). It explains why these policy measures are proposed and what they could look like. This chapter also addresses country-specific differences for policy support based on the five example cities.

Chapter 4 provides more details on the commercialization strategy for hydrogen buses. It is based on deliverable D3.2 of NextHyLights. This chapter is interesting for readers who would like more details on the commercialisation strategy.

The appendix provides more information on the questionnaire that has been used to collect input on country-specific situations.

2 Policy support for a one-off order

This chapter provides an overview of policy measures that can be employed to support the phase of the “one-off order” (Ib) of the rollout of hydrogen buses. The objective of this phase is to induce cost reductions by increasing the demand for buses, enabling significant production volumes and associated economies of scale. Policy support measures should be directed at pooling demand to create the required demand volume.

A major hurdle in this phase are the large capital expenditures that are associated with a large order of hydrogen buses in this phase. It is estimated that total expenditures of approximately € 200-300m [1] are required. Policy should therefore support bus operators in coping with these expenditures. It is estimated that approximately € 150-180m should come from public support (Zaetta & Madden, 2010).

2.1 Suggested policy support measures

Policy support for hydrogen buses can be divided into three forms (Figure 1). The first form is coordination of the pooling of demand and resources in various cities. The second form comprises measures that can be employed to reduce costs, mainly by reducing investment risk. The third form is to supply funding to cover (part of) the capital expenditures. Please note that ideally all three forms of policy support must be deployed to successfully stimulate the one-off order.

[1] Undiscounted, includes infrastructure investments.

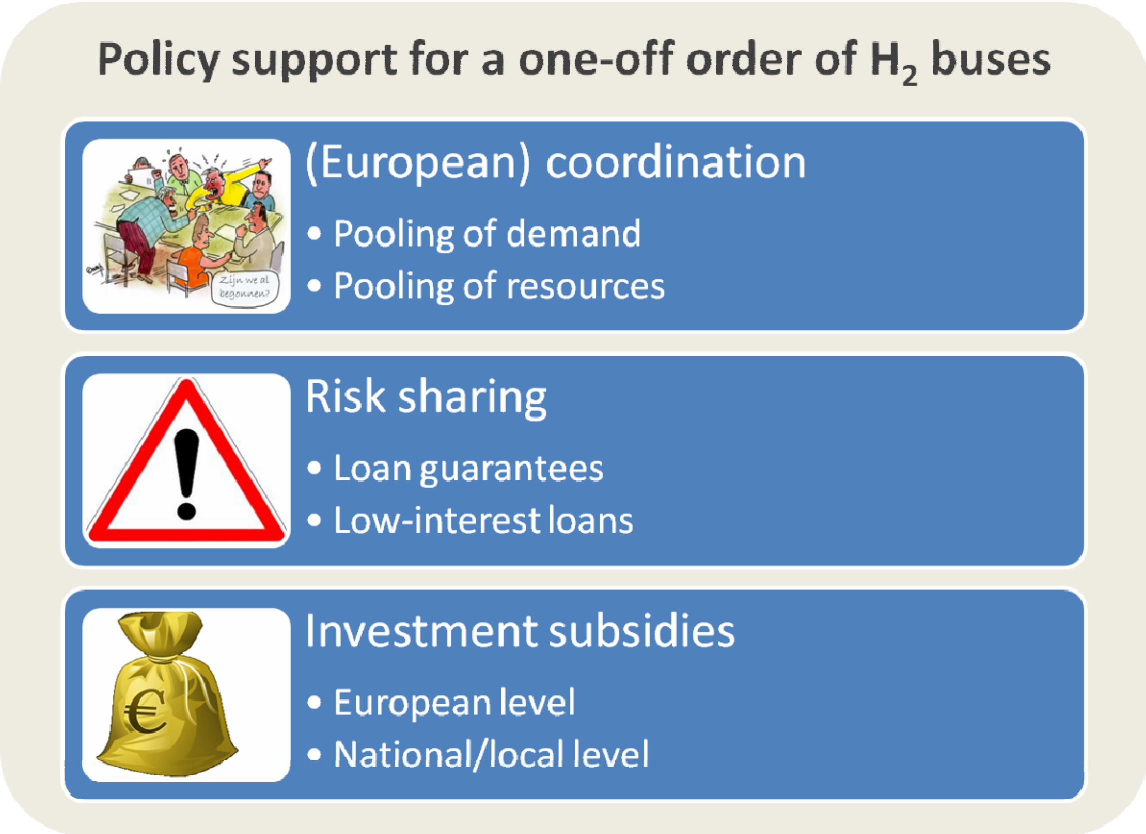

Figure 1 Overview of policy support measures for a one-off order of hydrogen buses

(European) coordination

There are two reasons for pooling demand of a number of cities. First, the volumes required to achieve significant economies of scale can only be achieved by adding the demand of multiple cities. Second, pooling demand offers bus manufacturers a better perspective, compared to separate smaller orders, that justifies investing in dedicated production facilities.

A joint tender is an appropriate instrument for the first, one-off order for hydrogen buses. In this tender, coordination[2] is required with respect to the following four aspects:

- *Accumulating demand*. Demand in the order of a few hundred buses is required to induce the envisioned cost reductions between 2010 and 2015. This demand should ideally come from a small number of cities, with a relatively large demand for hydrogen buses each (order of dozens), to keep costs down through economy of scale benefits[3] (Zaetta & Madden, 2010).

[2] Coordinating body still to be identified, depending on eventually involved parties in this phase (which will in turn depend on who's willing to pay).

[3] Reducing the number of cities will increase the costs for infrastructure (which needs to be installed in more cities) and for bus customisation (as the buses need to be customised to the requirements of more cities).

- *Requirements and specifications.* These need to be separated into a part that applies to all cities and a part that is specific for the participating cities. To fulfil the specific requirements, of the cities the uniform buses of the one-off order batch needs to allow for some level of customization per city, regarding the arrangement of seats etc.
- *Criteria for determining the winning bid.* The capital expenditures for buses play a large role, but also operational costs (e.g. maintenance) and proven reliability should be taken into consideration.

Pooling of financial resources. A funding scheme needs to be devised to combine the various sources of funding. Such schemes may vary from the coverage of the costs of each bus operator by their respective local/national funds to the complete pooling of resources. The consortium that issues the tender should include participants from the following three groups:

- *FCH JU*, in case the Joint Undertaking is able and willing to supply funding for the tender.
- *Bus operators*, to define requirements, specifications, and to determine the number of buses that is to be ordered. Existing alliances and projects (e.g. Hydrogen Bus Alliance, CHIC[4]) may provide a platform for this work.
- *National and local suppliers of funds*, to determine how the funding of the buses will be arranged.

Cost reduction

The major source for policy-induced cost reductions in the phase of the one-off order (phase Ib) is the mitigation of risk, allowing to acquire low interest loans.

Figure 2.2 shows a cost breakdown for hydrogen fuel cell buses, including expected cost developments up to 2020. Major cost reductions are expected in the various components (specifically the fuel cell system), triggered by technological development and increases in bus volumes, as well as by the ongoing development in other transport sectors deploying fuel cells.

However, the only component that policy can directly influence is the risk premium. (Private) suppliers of funding will command a risk premium because they are dealing with unfamiliar technology.

4 Clean Hydrogen for European Cities, http://chic-project.eu/

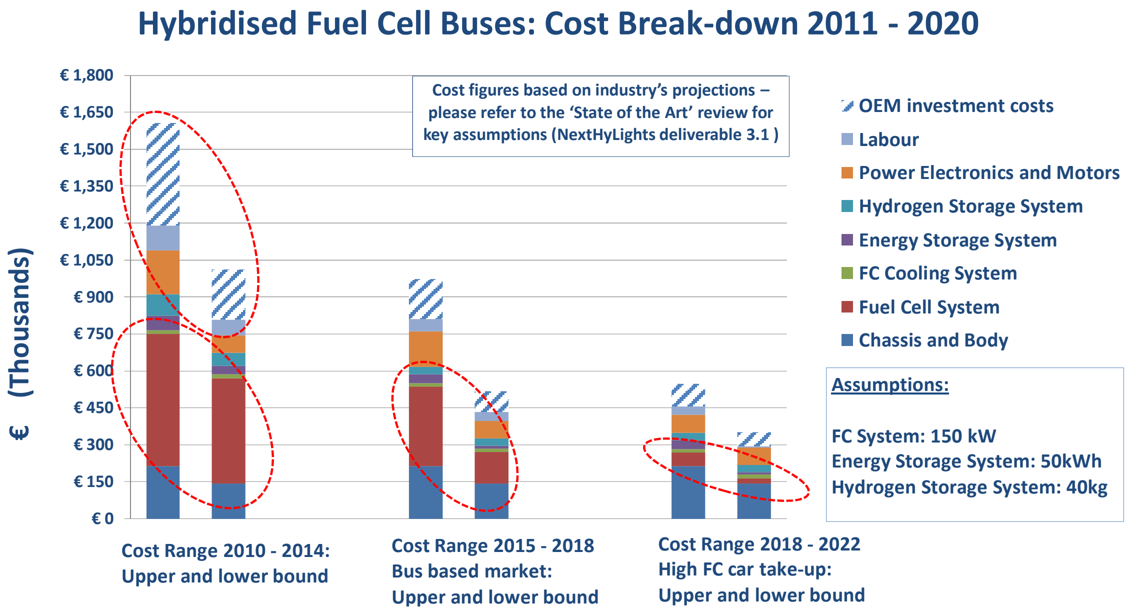

Figure 2 Cost breakdown of hydrogen fuel cell buses. Source: NextHyLights' deliverable 3.1, 'Hydrogen Fuel Cell Bus Technology State of the Art Review'

Two policy measures can be deployed to reduce this risk and thus lower investment cost: (1) risk sharing, and (2) low-interest loans. In the former case, governments (usually through an investment bank) guarantee the loan(s) that the consortium takes out. This reduces the risk for (private) financiers, implying that they are able to offer lower interest rates.

In the latter case, the government supplies a low (or zero) interest loan. Implicitly, this represents a subsidy to the consortium, covering the investment risk and – if the agreed interest rate is below the market rate for risk-free investments – other interest costs.

Supply of funding

Despite expected cost reductions, in phase Ib (one-off order), hydrogen buses are likely to be significantly more expensive than their conventional counterparts. Therefore - in addition to risk reduction - direct financial support to the proposed tender will be required in the form of investment subsidies.

At the European level, part of the FCH JU budget could be used for this purpose, provided that the tender takes place in 2013 ultimately (Zaetta & Madden, 2010)[5]. The remainder of the subsidies would have to be covered on the local and national level.

[5] This assumes that phase Ib (one-off order) can still be considered precompetitive.

3 Policy support for the gradual replacement of conventional buses

This chapter provides an overview of policy measures that can be considered to support the phase of continuous support for incremental improvement towards competitiveness (phase II, 2015-2020/2025; see Chapter 4 for details). In the previous phase costs reductions are expected from pooling of demand into a one-off order. However, it is not expected that costs will have decreased already to a competitive level. To get and keep the hydrogen buses on the road, policy measures are thus still required to cover the additional expenditures compared to the diesel bus alternative. Although the cumulative number of hydrogen buses being purchased will increase (a few thousand), the capital expenditures for purchasing buses will also be spread over an increasing number cities and countries.

Research approach

In order to identify the options for support from all angles, and including all relevant stakeholders, we took into account the local situation in 5 European cities. To his end – in cooperation with Element Energy - a questionnaire was compiled and sent to 5 cities that deploy hydrogen buses: Bolzano, Hamburg, Oslo, Amsterdam and Barcelona (See Appendix A for additional information and the full questionnaire). In this way we tried to identify relevant circumstances and potential opportunities for policy support of hydrogen buses.

3.1 Scope for policy measures

Generally, all bus operators have technical costs for fuel, infrastructure, maintenance, and buses itself. These expenses are covered by two sources, first revenues from fares and second by subsidies from the (local) government (Figure 3). Policy support for hydrogen buses should either be aimed at reducing the (additional) costs of hydrogen buses or increasing revenues.

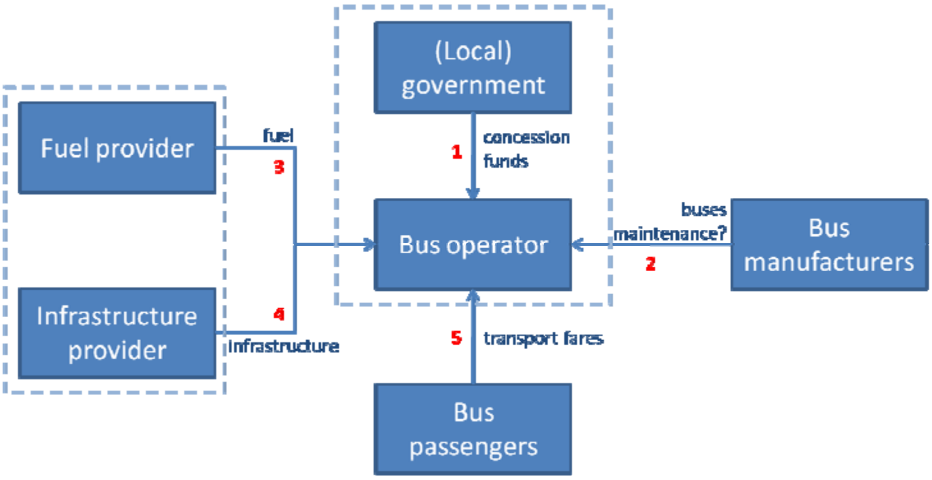

Figure 3 Relationships of bus operators to their stakeholders

Potential for cost reductions

The scope to (directly) reduce costs through policy interventions is limited in this phase. One option is to reduce taxation on vehicles and hydrogen, if in place. Section 3.3 discusses this option in more detail.

Potential for increasing revenues

The results from all five questionnaires that were administered clearly indicate that bus operators are not in the position to raise fare prices to increase income. Likely, the impossibility to raise bus fares is related to two factors: (1) low bus fares are needed keep bus transport competitive; and (2) public transport needs to be affordable for the majority of citizens, including those in the lower income classes.

The low fares imply that the current diesel bus system is subsidized already. Therefore, additional public support to the bus operators, on top of the normal subsidies, is the only way to bridge the financial gap between the hydrogen bus and the conventional alternative.

Note that the situation in the public transport segment thus differs markedly from the situation in the passenger car segment. In the latter segment, the government can adjust the tax system in such a way that the cost reductions offered to hydrogen cars will be covered by additional taxes on conventional cars. On balance, the drivers rather than the government will pay for the cost gap of the hydrogen vehicle. In addition, in the passenger car segment the hydrogen vehicle may be supported by “early adapters”, willing to pay a higher price to drive a car powered by a new technology.

For each city, it is advisable to evaluate the most effective way of increasing the revenues for the local bus operators, taking the local circumstances into account. The next section presents a brief evaluation of how this could be done for the five cities to which the questionnaire was administered.

3.2 City case studies

The questionnaire allowed to obtain a picture of the way bus transport is organised in 5 European cities. The organisational structure per city is briefly explained in the sections below, with the main aim to address how the financing of hydrogen buses can be integrated in the current system. All 5 case studies clearly show that in the current situation cost recovery by ticket fares is less then 100%, implying that all local governments already subsidize their bus systems. Consequently, in the case of implementation of more hydrogen buses, this subsidy need inevitably increase.

Bolzano

The city of Bolzano directly commissions its own our public owned bus company. The funding is based on a km calculation characterized by fixed costs per km of public transport for covering current operation costs including maintenance. Buses are owned by the bus company and investments are financed directly by the city. The ticket prices are fixed by Province Government (gross cost system).

Hamburg

The city of Hamburg (via their representative agencies) grants concessions for a period of 8 years to a bus company (Hamburger Hochbahn), that is fully owned by the city. Buses are owned by the bus company. Although city owned, the bus operator is run according to private-sector guidelines. In principle, the German federal states are in charge of public transport systems and bound to secure sufficient public transport services. On average, the cost recovery in the German public transport systems amounts to around 65%, with ticket prices set by the state parliament/city senate. The Hamburg bus system, however, has a cost recovery of almost 90%. The remaining uncovered costs are subject to a transfer of losses to the City of Hamburg.

Oslo

In Norway the local counties are responsible for local public transport. Most of the (larger) counties award bus contracts via their executive offices. In Oslo usually Gross Cost Contracts are awarded following a tender procedure with prequalification. Selection is based on the economic most valuable bid, which includes criteria on price, quality and environment. In the end the counties finance the bus services, although most of the finance comes from ticket revenues. The bus operators own the buses. Ticket prices are set by the executive offices of the counties.

Amsterdam

In the Netherlands there are 16 Public Transport Authorities with Amsterdam being one of them. In general contracts to operate buses are awarded by public tendering. In contrast, in Amsterdam (and some of the other main cities in the Netherlands) contracts are awarded after negotiations with the municipal (public) bus company. Requirements to fulfill include: quality of services and equipment, safety of the organization, punctuality, and price. The buses are owned and maintained by the bus operator. In the end the Amsterdam transport authority sets the ticket price and subsidizes the additional costs to cover total expenditures of the bus system.

Barcelona

In Spain major cities have public owned transport companies, without following tender procedures. For Madrid and Barcelona, the public funding is shared by local the city council, the regional government, and the Spanish administration. Smaller cities have only local and regional funding. Buses are owned by the bus operator; in the case of Barcelona under the formula of financial leasing for the last years. The Barcelona bus company carries out maintenance by itself. Ticket prices are defined every year by the Governmental Transport Authority, because the fare is integrated for the complete Metropolitan Region. In conclusion, both the national and local government provide the additional funding for the bus services that is not recovered by ticket fares.

3.3 Additional options policy support

The evaluation of the questionnaire showed that in general the organisation of the bus system in the 5 cities, located in 5 different countries, has a lot in common, suggesting that the case studies examined will also be relevant for other European cities.

Nevertheless, differences were identified on several aspects that may be important for policy support of hydrogen buses. The questionnaire reveals that there is not a silver bullet available to close the cost gap between the hydrogen bus and the diesel alternative: the cost difference can only be bridged by public resources. Depending on the local circumstances, there are several mechanisms allowing to shift part of the financial support from the local to the national level.

Time limits of current subsidy schemes

Most of the local parties involved in operating buses, indicate the need of (large) funds to finance hydrogen buses. In addition current subsidy systems are mostly characterised by the too short timescales allowed for the procurement of clean vehicles, that do not take into account the intrinsically longer times related to purchasing hydrogen buses. (Coordinated) adaptation of the time lines of subsidy systems is advised.

Tendering

None of the cities is characterised by a fully open tendering system. From the 5 cities participating in the questionnaire, Oslo has the most market competitive tendering system to select a bus operator. Extending the tendering system towards a more market competitive system may result in lower costs for hydrogen buses by enhanced competition between tenderers, and associated maximising of cost reductions.

Fuel tax exemption

The questionnaire reveals that buses in most cities pay the regular fuel tax for all motorists on the diesel for the conventional buses. By offering a tax exemption for hydrogen, the FC-buses will have a substantial advantage, that does not involve local governmental funding. Given the limited numbers of buses, compared to the national scale, initially this burden will be easy to bear on the national level. Moreover, as the number of hydrogen buses increases, and costs of tax exemptions for the national government becomes larger, the competitiveness of hydrogen buses will increase at the same time, eventually lowering the need for tax exemptions.

All bus operators questioned indicated that they pay normal fuel tax levels, except for Hamburg were only “petroleum tax” is being paid, thereby limiting the potential benefit for hydrogen tax exemptions there.

Vehicle tax exemption

Purchase taxation for conventional vehicles offers a support mechanism to decrease the cost gap for hydrogen buses, by exempting them from purchase tax. Again in this case the local government does not have to pay the price, whereas the cost for the national government will be manageable, given the limited number of local hydrogen buses compared to the national scale. Moreover in the roll-out phase considered the price of a hydrogen bus is still higher than the diesel bus that is substituted. Consequently, in the case of purchase tax exemption for hydrogen buses, the local elevation of the tax exemption for a hydrogen bus will be larger than the “loss” for the national government, that only involves not receiving the lower purchase tax of the cheaper diesel bus, that was substituted by the hydrogen alternative.

The answers to the questionnaire indicates some regional differences. In Oslo and Barcelona also diesel buses do not involve purchase tax. The situation in Amsterdam is not yet clear. In Hamburg purchase tax of current diesel buses is CO_2 dependent, implying that hydrogen buses could benefit here from purchase tax exemptions if already regarded as zero emission vehicle[6]. In Bolzano diesel bus taxation is 20%, offering a substantial scope for support for hydrogen buses by tax exemption.

Cost recovering by congestion charging / road pricing

Cities with a congestion charging system, could consider to recover (part of) the additional costs for hydrogen buses through congestion charging scheme, by offering hydrogen buses a higher or complete exemption, compared to the diesel alternative. In this way all paying vehicles in the congestion charging zone would indirectly make up for the exemption offered to the hydrogen bus. The answers to the questionnaire indicate that it could be worthwhile to further investigate the options related to the Oslo congestion charge system.

[6] Regarding hydrogen buses as zero emission vehicles would be in line with the current vision of the EC, that assumes hydrogen vehicles – at least till 2015 – as zero emission vehicles, according to the Renewable Energy Directive (2009/28/EC) article 3.4, sub c.

4 Commercialisation strategy for hydrogen buses

This chapter provides information on:

- The phases in the commercialisation strategy of hydrogen buses.
- Policy measures that may be applied to stimulate hydrogen buses in each of these phases.

4.1 Phases in the commercialisation of hydrogen buses

As part of the NextHyLights project, a commercialisation strategy for hydrogen buses has been developed (Zaetta & Madden, 2010). This strategy is based on the state of the art of hydrogen buses and has been developed by integrating the results of a number of detailed case studies.

Three phases are distinguished in the commercialisation strategy. The first of these phases incorporates two types of dynamics, each requiring a different form of policy support. For the purpose of this report, this phase is therefore separated into two distinct phases. A set of four phases is thus created, as illustrated in Figure 4.

The remainder of this section will briefly discuss each of the phases. Note that this report only gives detailed recommendations on the phase of a 'one-off order; Ib'(Chapter 2) and phase II 'continuous support' (Chapter 3).

Phase Ia is the *demonstration* phase. A prime objective of this phase is to improve the technical performance of the buses. In particular, it is important to demonstrate bus availability levels equivalent to diesel buses (>90%), in order to allow transit agencies to operate fuel cell and conventional diesel buses on equal operational basis. Demonstration projects will involve deployment in the order of tens of buses[7].

Phase Ib is a *one-off order*. The objective of this phase is to induce cost reductions via economies of scale. A one-off, rather large order (a few hundred buses) enables such cost reductions. Creating a sufficiently large volume requires pooling demand in various cities. Keeping the number of cities involved low will reduce the total expenditures required. Expenditures are expected to be in the order of € 200 - 300m (assuming a rollout of approx. 300 buses by 2015/6). The major barrier in this phase is the large capital expenditures that are associated with hydrogen buses in this phase.

Phase II is characterised by *continuous support* for hydrogen buses. The previous phase has resulted in a significant reduction of the capital expenditures required for introducing hydrogen buses, but the buses are still not competitive with conventional

[7] It is worth noting that bus trials currently planned or underway in Amsterdam, Cologne, Hamburg and in the CHIC project are already expected to demonstrate high availability for fuel cell buses.

buses. Yet, there is still potential for further cost reductions through R&D and learning-by-doing. Continuous policy support is therefore required, notably for the additional operational costs. It is expected that expenditures of approximately € 850m are required in this phase (assuming a rollout of approx. 2,000 buses).

In phase III, hydrogen buses will be *competitive* with conventional buses. In this phase, market forces ensure that the conventional part of the bus fleet is replaced by hydrogen buses.

It is uncertain whether competitiveness for hydrogen buses will be achieved eventually. Policy interventions may be required if this is not the case.

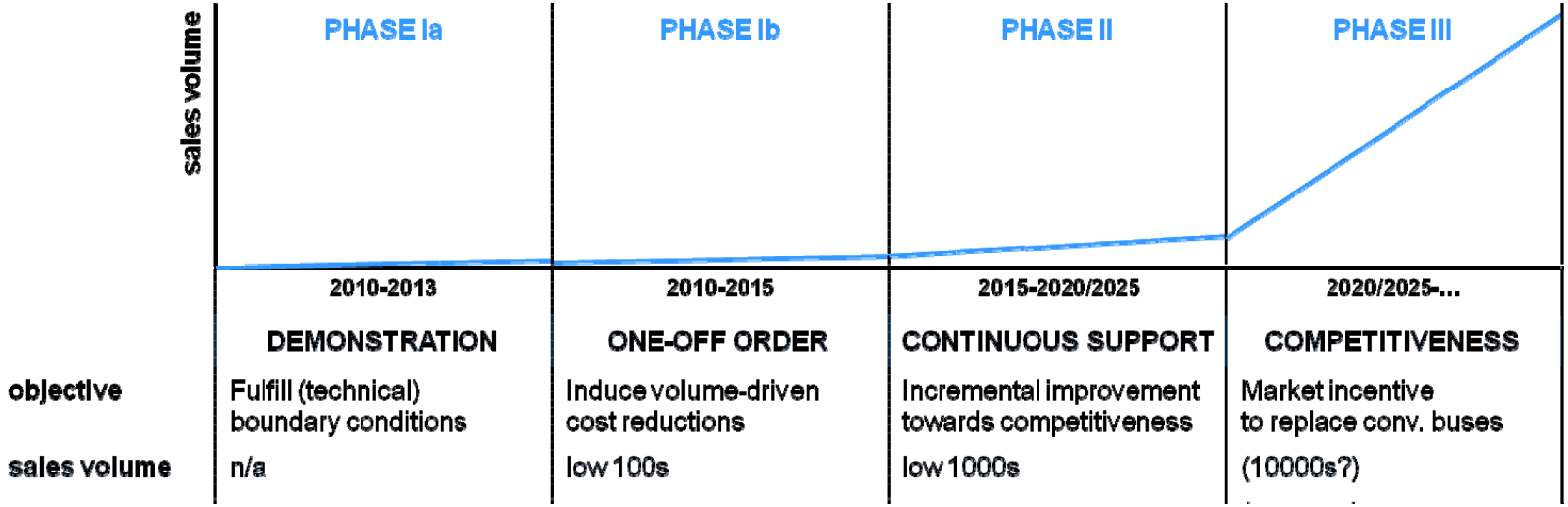

Figure 4 Phases in the commercialisation strategy of hydrogen buses. Based on (Zaetta & Madden, 2010). In the original publications, three phases have been distinguished. For the purpose of this report, phase I is separated into phases Ia and Ib.

4.2 Policy support options per commercialisation phase

Each of the phases requires different types of policy support. Table 1 provides an overview of policy measures that could theoretically be employed, categorised by the phases that they are most appropriately deployed in. This section will briefly discuss each of the measures. Suggestions on which measures to actually deploy can be found in Chapter 2 (for support of a one-off order, phase Ib) and Chapter 3 (for continuous support, phase II).

R&D support will typically come in the form of subsidies, to be distributed in R&D programmes. The programmes need not be focused on hydrogen buses only – outcomes of R&D may also be relevant for other sectors (e.g. passenger vehicles).

Public R&D is most relevant in precompetitive phases. In the competitiveness phase, the bulk of R&D will be private.

Demonstration project support usually takes the form of subsidies. These subsidies cover part or all of the costs of the project. Demonstration projects should have clear objectives and subsidies should be granted to the project consortia that are most capable to achieving these. Obviously, demonstration projects are only relevant in the demonstration phase.

In some cities/regions, *tenders* are used to grant concessions to bus operators. The criteria of these tenders can be designed to favour hydrogen buses. The clearer the tender criteria are, the more successful the tender is likely to be. Therefore, this instrument is suited for the continuous support phase and the competitiveness phase, when rather elaborate experience with hydrogen buses has been gained.

Note that these tenders differ from the tender procedure for a purchase alliance described in Chapter 2. A purchase alliance will issue a tender for bus manufacturers, whereas the tender referred to here is a tender for bus operators for a concession.

Voluntary agreements between the various actors (local funders of bus transport, bus operators, bus manufacturers, hydrogen suppliers) are a good way to create a common vision and a basis for further action. The agreements may be deployed in any phase beyond demonstration.

Exemption from *road pricing* is a way to save operational expenditures for bus operators. Of course, this is only possible if road pricing is levied for operators. The measure primarily applies for the continuous support phase, in which operational expenditures are the most relevant barrier.

Environmental standards may be employed to favour hydrogen buses. These are most effective when the cost gap between hydrogen buses and conventional buses has already closed significantly, which is towards the end of the continuous support phase. However, if hydrogen buses prove unable to become fully cost competitive with conventional buses, tight environmental standards can be used to provide the hydrogen buses with a decisive competitive advantage.

A *quota obligation* requires that a certain amount or percentage of the bus fleet consists of zero-emission (or more specifically: hydrogen) buses. Similar to standards, this instrument is most effectively deployed for continuous support or to ensure competitiveness.

Policy measures that relate to capital expenditures (CAPEX) are most effective in the one-off order phase, in which capital expenditures form a major barrier. How *investment subsidies*, *low-interest loans*, and *loan guarantees* can be deployed is explained in Chapter 2.

The reduction of *registration tax* has two effects. First, registration tax is typically a percentage of the list price of the vehicle. Registration tax will therefore exacerbate the additional costs of hydrogen vehicles. Reducing this tax to a level comparable to that of conventional buses is a measure that does not impact government budget – reducing taxation further would imply a subsidy.

Second, registration tax is typically collected by the national government. A reduction of this tax would therefore shift the burden from the budget of the local government to the budget of the national government.

Finally, measures related to operational expenditures are most suited in the continuous support phase, as operational expenditures are a major hurdle in this phase. As with vehicle registration tax, a reduction of *circulation tax* and *fuel tax* would imply a shift of the burden from the local government to the national government.

Table 1 Potential policy support measures for hydrogen buses categorised by phase in the commercialisation process

	Ia - Demonstration	**Ib - One-off order**	**II - Continuous support**	**III - Competitiveness**
		Generic measures		
R&D support				
Demonstration project support				
Tendering				
Voluntary agreements				
Road pricing				
Environmental standards/regulation				
Quota obligation				
		CAPEX-related		
Investment subsidy				
Low-interest loans				
Loan guarantee				
Vehicle taxation reduction (registration)				
		OPEX-related		
Vehicle taxation reduction (circulation)				
Fuel taxation reduction				

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Appendix A Questionnaire and interviewees

This study aimed to include the local conditions of bus operators in several European cities deploying hydrogen buses, in order to identify conditions that might be relevant for supporting hydrogen buses. To this end a questionnaire was compiled - in cooperation with R. Zaetta of Element Energy - and send out to 5 cities that deploy hydrogen buses: Bolzano, Hamburg, Oslo, Amsterdam and Barcelona.

All 5 cities contacted responded to the questionnaire. The section below gives an comparative overview table of the answers to the main questions (Table 2). Subsequently a copy of the questionnaire as sent out is included.

The authors like to acknowledge the following persons for their interest and time to respond of behalf of the bus companies:

- …. Bolzano.
- …. Hamburg.
- …. Oslo.
- …. Amsterdam.
- …. Barcelona.

Table 2 Comparative overview of the results of the questionnaire Consultation on Local Circumstances for Policy Support for the Introduction of Hydrogen Buses

	Bolzano	Hamburg	Oslo	Amsterdam	Barcelona
Commissioning by external party?	No	Yes (no tendering)	Yes	Yes (no tendering)	Yes (no tendering)
Funding operational costs	Per km	Public topping-up of losses	Gross cost	Subsidy	?
Funding investments	Direct				
Buses owned by operator?	Yes	Yes	Yes	Yes	Yes (financial lease)
Maintenace by operator?	Yes	Yes (fully owned subsidiary)	Mixed	Yes	Yes (some outsourcing)
Scope to change prices	Limited (cost-plus)	None	Rather large	None	None

Vehicle taxation	20%	CO2-differentiated	No	?	None
		Exemption for EVs			
		Energy Eff. and Emission Labeling (?)			
Emission standards	EURO-5		(in tender)	EURO-5	
Congestion charging	No		No	No	No
Road pricing	Highways	Yes (HDVs)	No	No	No
Diesel taxation	Standard	Only petroleum tax	Substantial	Standard	Standard
		Quota to blend biodiesel			
Hydrogen taxation	Not regulated		Water & electricity	None	None
Environmental zones	?	Yes	None		
Additional policy support?	No	Yes (Economic Stimulus Package & NOW)	Research funding	No	No
Scope for policy measures	No taxation of green hydrogen	General technology optimization		Additional subsidies	No policy is able to support
	No taxation of hydrogen buses	Bring down maintenance costs		Obligation	
	Purchase alliances	Purchase alliance			
	EC-funding	Promote market visibility and public awareness			
		Reduce H2 costs			
Trialling period	5 years	5 years	1-2 years	Depends on OEM	2 years
Vehicles to be deployed	5-10	20	5	Depends on experiences of others	5
First vehicle commitment	12	Constant replacement	(political question)	25-30	20
Different bus models?	Yes	Yes	Yes	Yes	Yes

Additional model testing?	No (but testing in other locations)	Yes (but shorter tests possible)	Yes	OEM guarantee	Yes
Other considerations than TCO	Sustainability, Environment	Existing infrastructure	Quality related to local conditions	City air quality	Fuel availability
	Future fuel availability	H2 pricing and availability	Number of seats		Diversified offer of models
	Refuelling at own depot	Fuel pricing	Footprint, efficiency, capacity HRS		
		Competition with other modes (EVs)			
		Marketing effects, customer retention, new customers			
Barriers	Price of hydrogen buses	Total volume of investments	Limited time window to spend requested funds	Lack of national vision	Costs
	Price of green hydrogen	Risks			
	Regulations for hydrogen	Lack of infrastructure standardization			
	Hydrogen vehicle approval	Non-competitive tendering, H2 costs not compensated for			
		First-mover disadvantages			

Project Description	NextHyLights is a project called for by the FCH JU, which will conduct feasibility studies into the next generation of hydrogen vehicle demonstration projects and, for the buses segment only, the subsequent steps to commercialisation of those vehicles. The project started on 1st January 2010 and will run for one year. We see NextHyLights as an opportunity to a) aggregate stakeholders' ideas on the next steps for hydrogen vehicles in Europe and b) present these ideas to FCH JU and to committed European regions which can jointly plan and prepare the next generation of large scale demos across Europe.

Purpose of this Document	The purpose of this document is to engage bus operators in an *open consultation* on local conditions, relevant to identify policy support measures for hydrogen buses. Initially, hydrogen buses will be more costly than their conventional counterparts. Consequently, policy instruments are needed to reduce the costs for bus operators deploying hydrogen buses, until costs have come down to a competitive level. This consultation aims to get an overview of local conditions for bus operators in several European cities, in order to: Identify generic policy measures that are expected to be effective in reducing the costs for hydrogen buses (OPEX and CAPEX). Identify policy measures that are expected to be effective locally. Identify additional barriers for the deployment of hydrogen buses; as well as potential solutions to lower these barriers. The selected policy instruments to support hydrogen buses will be communicated to the EU and local governments.
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Date	29th October 2010

Questions

Fuel cell buses have been extensively demonstrated in a number of trials worldwide, proving their sustainability to provide a valuable low-carbon alternative to diesel buses.

However, fuel cell buses will need to overcome barriers to become competitive with their conventional counterparts. Policy support can help to create conditions that make an introduction of hydrogen buses affordable

Local circumstances

We would like to understand your specific circumstances in order to help designing better European policy support schemes.

1: Who commissions public transport? Are you an integral part of that organisation? **COMMISSIONING**

<please provide your answer here>

2: What procedure is followed in awarding the contract? What criteria are involved?

<please provide your answer here>

3: How is the funding of public transport organised?

<please provide your answer here>

4: Do you own your buses yourself? If not, how is bus ownership organised? **BUSES**

<please provide your answer here>

5: Do you take care of maintenance yourself or has it been outsourced?

In case of outsourcing, what type of company does the maintenance?

<please provide your answer here>

6: What scope do you have to change fare (ticket) prices? **TICKET PRICING**

<please provide your answer here>

7: What policy measures apply (currently and – if known – in the future) to… **POLICY**

a: …vehicles (e.g. taxation, emission standards, congestion charging, road pricing)?

<please provide your answer here>

b: …fuel (diesel and hydrogen; e.g. how much taxation)?

<please provide your answer here>

8: Is any policy support (e.g. subsidies) for investing in clean bus technologies currently available to you?

<please provide your answer here>

9: What scope do you see for measures that improve the competitiveness of hydrogen buses at the expense of the competitiveness of diesel buses?

<please provide your answer here>

Investment perspective

We would also like to know what would be the conditions that would offer sufficient perspective to accept a substantial commitment to hydrogen buses.

10: For how long would you need to trial a bus before you had sufficient confidence in the technology to consider significantly expanding fleet size? **TECHNOLOGY**

<please provide your answer here>

11: How many vehicles would you need to deploy to gain this confidence?

<please provide your answer here>

12: How many vehicles would you be able to commit after this first trial?

<please provide your answer here>

13: Would you accept different bus models in your fleet? **FLEET**

<please provide your answer here>

14: Would you need to prove the operational viability of each hydrogen bus model separately before accepting it?

<please provide your answer here>

15: Apart from Total Cost of Ownership, what are considerations in decisions to invest in new equipment (buses, refuelling stations)? **INVESTMENT**

<please provide your answer here>

16: What barriers do you see in financing hydrogen buses and refuelling infrastructure compared to financing conventional buses?

<please provide your answer here>