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D1400.1: Report on market obstacles and strategies

Summary

What are the market obstacles which slow down the development of hybrid technologies on public transport vehicles?
Based on the experience of a group of users gathered in a "hybrid user forum" (HUF), the differences between users' expectations and reality of hybrid buses have been analysed and the obstacles pointed out.
Because of their positive contribution to ecological aspects like fuel consumption and emissions, hybrid buses gain a lot of interest from local authorities. Next to that, they also have a positive contribution to the ecological image of the operator. However, these good aspects come with a cost. If users understand this over-cost and could accept it, they are waiting for compensations by fuel savings and funding if needed in addition. Despite ecological interest and the good image of hybrid vehicles, some aspects do not help the development of this type of vehicles: hybrid offers are complex to understand, there is uncertainty regarding the after-sales period, etc. But insufficient fuel savings compared to too heavy over-cost remains the main obstacle.

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Introduction

What are the market obstacles which slow down the development of hybrid technologies on public transport vehicles?
Based on the experience of a group of users gathered in a "hybrid user forum" (HUF), the differences between users' expectations and reality of hybrid buses are analysed and the obstacles are pointed out.
The analysis starts reminding the fundamental operators' needs, presents their interests and motivations regarding alternative energy, focuses on performances and of course deals with the economic issue for this technology.

Short reminder about hybridization

Generally speaking, hybridization means the mix of 2 different kinds of energy storage or power generation: most of the time the first one is an internal combustion engine "ICE" (thermal generation) and the second one can be "hydraulic" (high pressure hydraulic storage and conversion by hydraulic motor-pump), "mechanic" (inertia wheel storage and conversion by electric motor) or "electric" (batteries/supercapacitors storage and conversion by electric motor).
In the field of public transport vehicles, the majority of hybridization is Thermal/Electric (ICE/Electric motor). As the current market offers mainly vehicles based on that technology, the HUF focused only on these vehicles.
Thermal/electric hybridization can be subdivided in different architectures based on 2 concepts: serial hybrid / parallel hybrid. Some architectures can mix these 2 concepts.
Several functions could be implemented: stop&start, energy recovery, boost, full electric driving. The "level" of hybridization results from the functions implemented.
According to the vehicle model, architecture and level of hybridization could be different.
Use condtions, energy management and hybrid lay-out/architecture have to be an optimal combination.The objective of vehicles hybridization is the reduction of fossil fuel consumption and polluting emissions.

Users' needs

Cities need buses for their operations

Let's remind the fundamental needs for a city: in terms of public transport, a city has to provide a public service in transport to serve its area as good as possible. To reach this objective, the cities rely, among other things, on a bus network to move people from one place to another. Depending on the passenger flow, different types of vehicles exist providing various capacities and different characteristics and size:

- Mini buses (2 axles, up to ~7m)
- Midi buses (2 axles, up to ~10m)

- Solo buses (2 axles, up to ~12m and 3 axles, up to ~15m)
- Articulated buses (3 axles, single articulated, up to ~18 m and 4 axles, double articulated, up to ~24m)
- Double decker (midi or solo, 2 or 3 axles)

For example, based on the 28 answers of the representatives of the user forum, the global distribution of the fleet (total of 26.808 vehicles at the date of May 2011) is as follows:

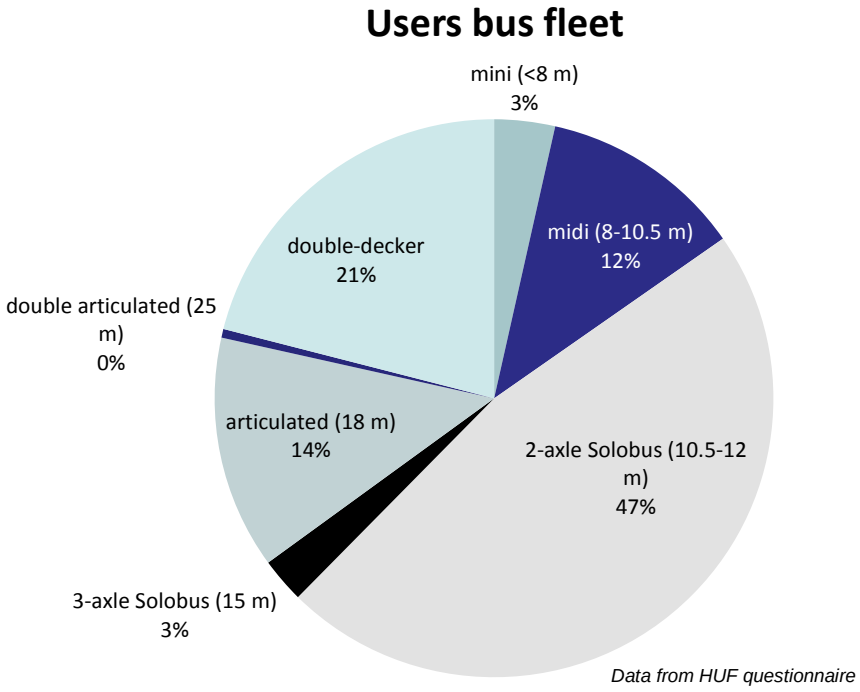


Figure 1: Bus distribution in the HUF bus fleet

This distribution shows that solo buses represent a huge part of the fleet, completed with midi and articulated buses. In the case of the HUF, the double-decker buses represent also a significant part of the fleet.

As the service of transport is always related to an area, some other constraints exist for cities and operators. Figure 2 shows important criteria for bus operations:

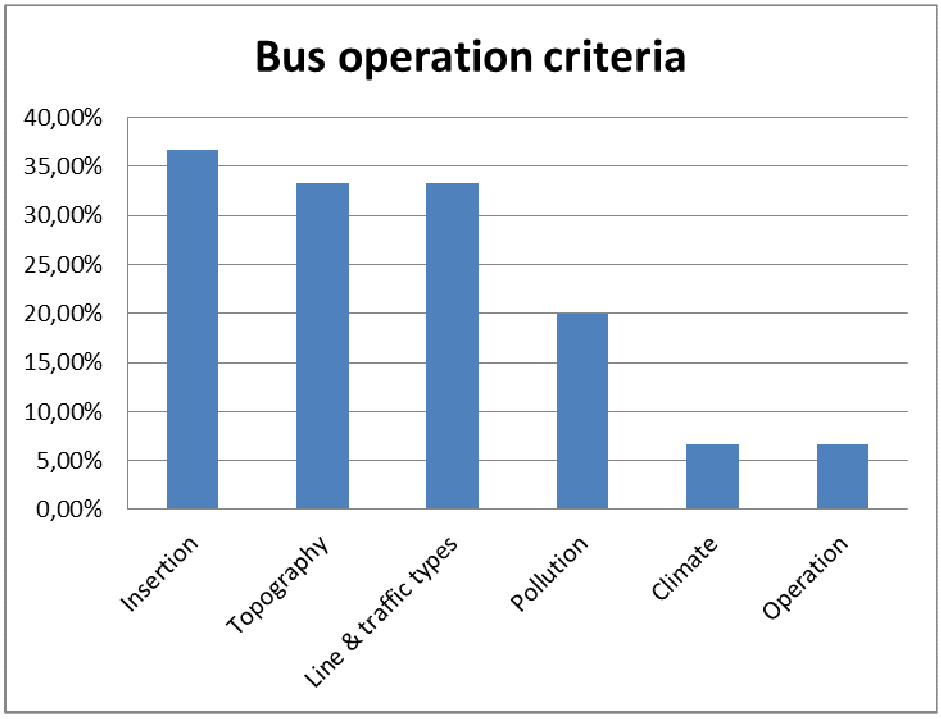


Figure 2: Bus operation criteria for HUF group

Based on the feedback of the hybrid user forum, insertion performances (narrow streets, historic city center for example), topography and type of line (urban, suburban…) are the major criteria for bus operation. Insertion, as 1st criterion for bus operation, reflects the necessity of different type of buses which explains the huge range of buses shown by the Figure 1. .

The fundamental user needs have to be kept in mind prior to discussing the technology of a vehicle. So when a new technology is emerging, such as hybrid propulsion, it is important that it is not restricted only to a limited part of the bus market. To have a chance to be chosen in the frame of a new tender, the technology has to be present on various types of vehicles (midi, solo, articulated buses and also double-decker in this case) and to be adapted to various conditions: flat or hilly routes, soft or strong traffic conditions, high or low operational speed.

It is of course the case for diesel buses for which the offer is large thanks to the combination of lot of models (mini to double articulated), engine power and driveline configurations. Is it the same for the hybrid buses offer?

Hybrid buses: a complex offer

Analysing the current offer of hybrid busses, we can see that:

- There is only a small number of models offered with hybrid technology: manufacturers offer all type of busses in diesel version, this is not the case for hybrid versions ;

- If an hybrid version exists, there are lots of hybrid architectures: serial, parallel, mixed ;
- In addition, all the models do not present the same functionalities : Stop&Start, regenerative breaking, boost, full electric driving ;
- Nor the same technologies for energy storage (Lithium-ion batteries, NiMH batteries, supercapacitors…) and auxiliaries ;

All these characteristics have of course an influence on the performances of the bus regarding the area where it is driven. These performances are difficult to evaluate and the comparison between models is not easy.

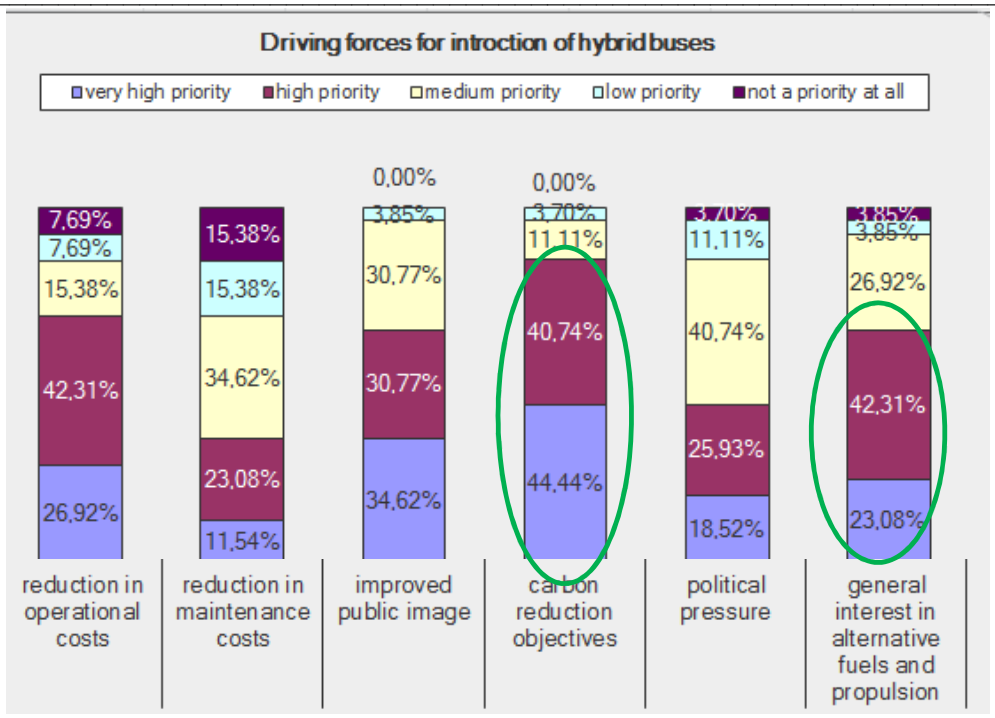
Figure 3: Example of hybrid buses, midi, solo and articulated

The current market does not present the same offer in hybrid buses as in diesel ones and the offer is not easily "readable". For this reason, it could be difficult for a city or an operator to keep a hybrid model in the final shortlist of a tender.

Environmental, political and economic interests & motivations

Now that the fundamentals are reminded, let's analyse the interests and motivations for a city or an operator regarding propulsion, and especially diesel-electric hybrid technology.

In the frame of the HUF, the way to do that has been to directly ask the users about the driving forces which could push them to introduce hybrid buses.
Figure 4 shows that the main priority is the carbon reduction. This objective is a very high or a high priority for more than 85% of them.
The general interest for alternative fuels or propulsion appears also as a driving force for about 65% of the users.



Data from HUF questionnaire

Figure 4: Ecological motivation for introduction of hybrid buses

Looking at these first two results, we can say that the "Ecological motivation" would be the main driving force for users to choose hybrid technology.
But this is not the only one.

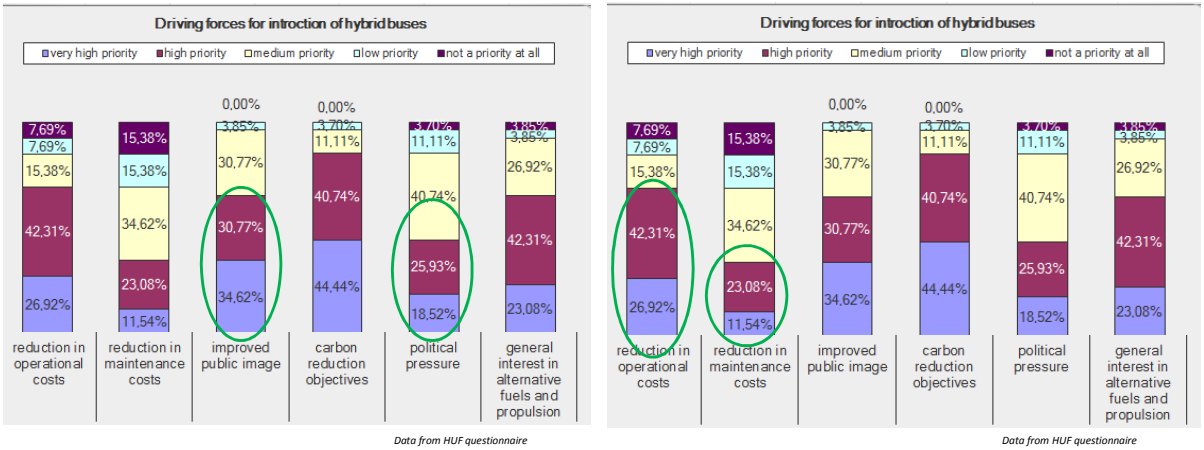


Figure 5: Political and economic motivations for introduction of hybrid buses

In a middle ground we can see that the "political motivation" is also strong since the public image is a priority for 65% of users and the political pressure remains important (41%) or priority (44%) for a large part of the decision makers.

Lastly, after these two motivations, we can see that reduction in operational and maintenance costs is important for the users and could take part in the choice for hybrid technologies.

Emission and consumption performances… not sufficient

Figures above have shown that ecological motivation and economic motivation are two driving forces for introducing hybrid buses.
In the first case, the main current indicator is the CO2 reduction and in the second case the main indicator is the cost reduction, mainly during driving operations. So hybrid buses have to demonstrate their emission and consumption performances in order to prove the benefits they can create.

Regarding consumption, it has been asked to the members of the hybrid user forum to give their expectations in term of reduction. The figure below shows their answers:

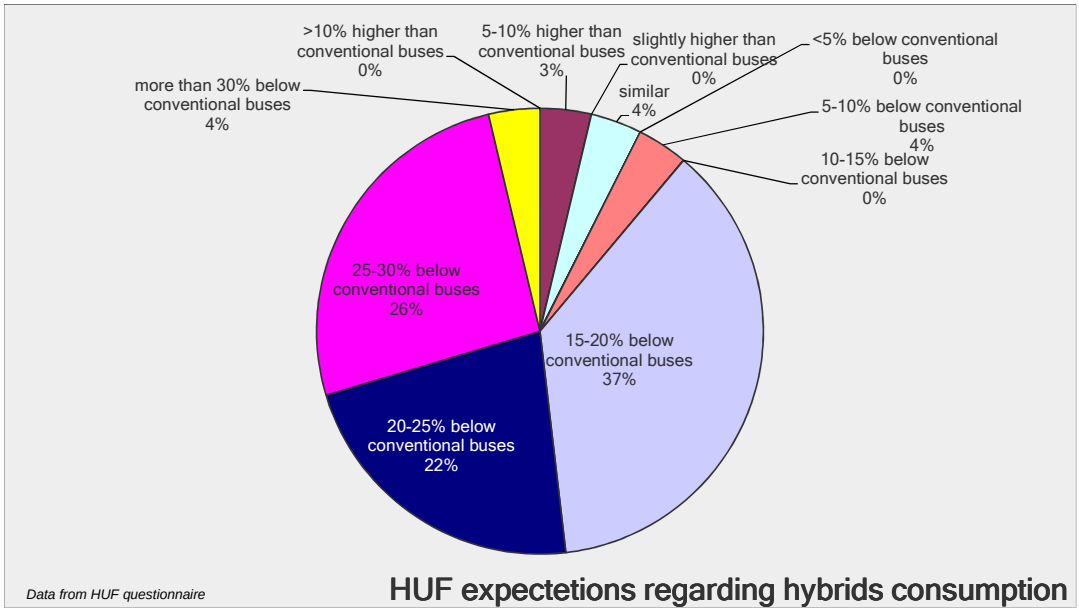


Figure 6: HUF expectations regarding hybrid buses consumption

We can see that more than 85% of the users expect a reduction of fuel consumption more than 15% on their network. It signifies that whatever the type of line, whatever the topography and whatever the traffic conditions, since each city has its own specificities and constraints which could be different from others cities, a diesel-hybrid bus driven on the network should consumes at least 15% less than a diesel reference bus.

Is it really the case?

Consecutively to that question, it has been asked to the members of the HUF to report their own experience with hybrid buses on their network. Results are shown in the figure below:

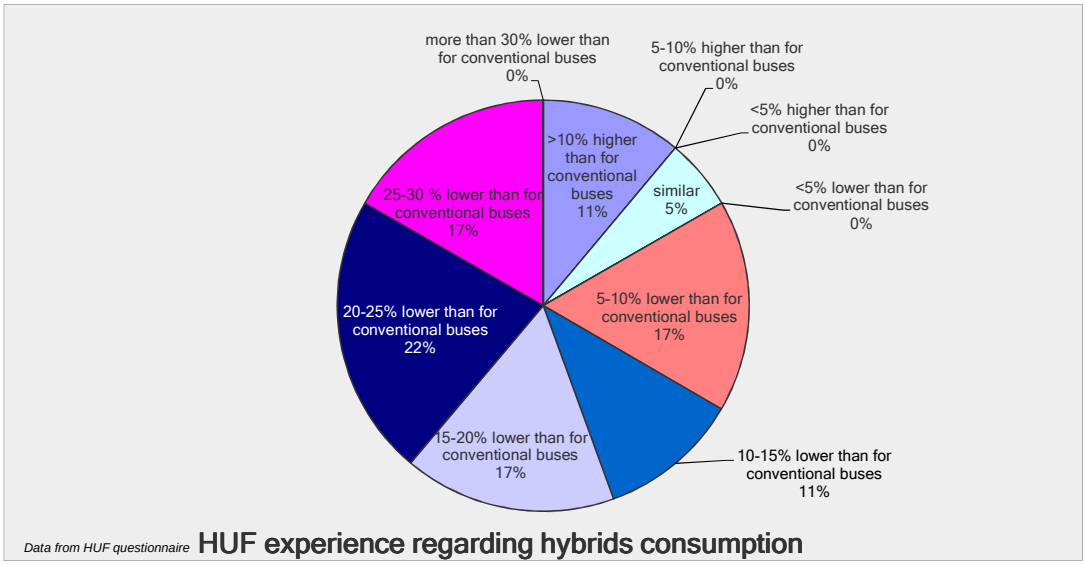


Figure 7: HUF experiences regarding hybrid buses consumption

We can see from this figure that only 56% have noticed more than 15% fuel consumption reduction. There is a big gap between the expectation and the reality, and about 15% of the users have been disappointed since the hybrid bus had a similar or higher consumption than the reference diesel bus.
Of course these results depend a lot on the diesel reference bus used to compare the data and the conditions of comparison.

Regarding the conditions of comparison:

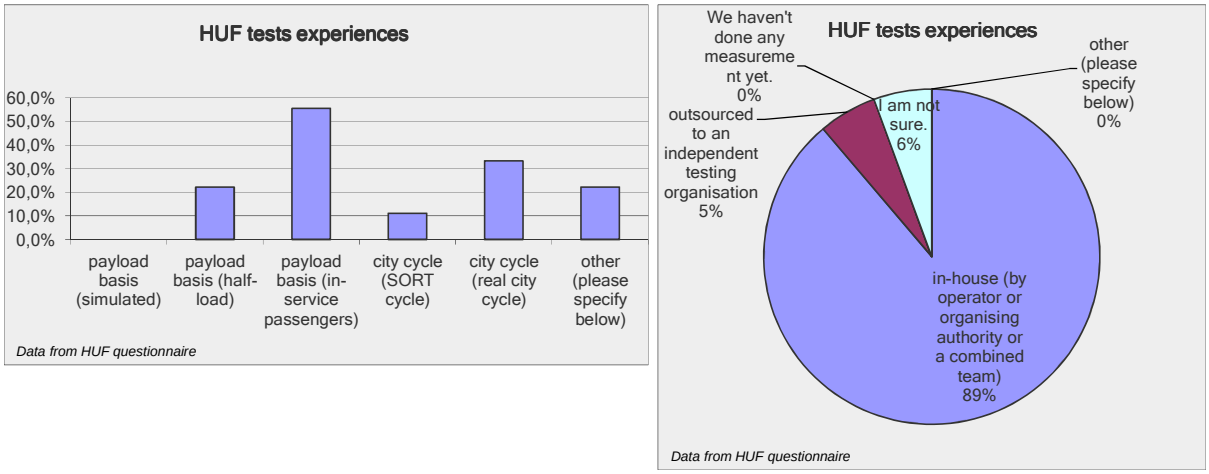


Figure 8: Test conditions for Hybrid-Diesel bus comparisons in HUF group

The figure above shows the test conditions which led to the results mentioned in figure 7.
A big majority of the tests, the so called "in-house tests", has been made by the operators themselves, or the public transport authority (or a combined team). Of course in this case each user has its own protocol.

An interesting thing is that the majority of tests has been conducted in real city-cycles with an in-service passengers payload basis which is more representative for a specific user of the reality of its network than a test conducted following standardised cycle (like SORT cycle) with simulated payload.
At the end, despite the "test" conditions used to do the comparison, these results are the only basis for the users to help them choosing, except the "promises" of the manufacturer. So this kind of results is important.

Data referring to the diesel reference buses used for the comparison do not allow any analysis. The only thing possible to say thank to the general knowledge is that, comparing to an Euro 3 diesel bus, the consumption performances of a hybrid bus will be very good but will it be the case if the comparisons were made with a last diesel generation bus equipped with EEV engine and new generation of gearbox?. Of course the future choice for users should be made with that comparison, and in the near future, with euro 6 engines.

Economic issue

If users expect better performances in term of emission and consumption thanks to alternative fuels and hybrid technologies, they know that it will be probably not for the same purchasing cost, and they could accept that. The figure below, based on the HUF opinion, illustrates that.

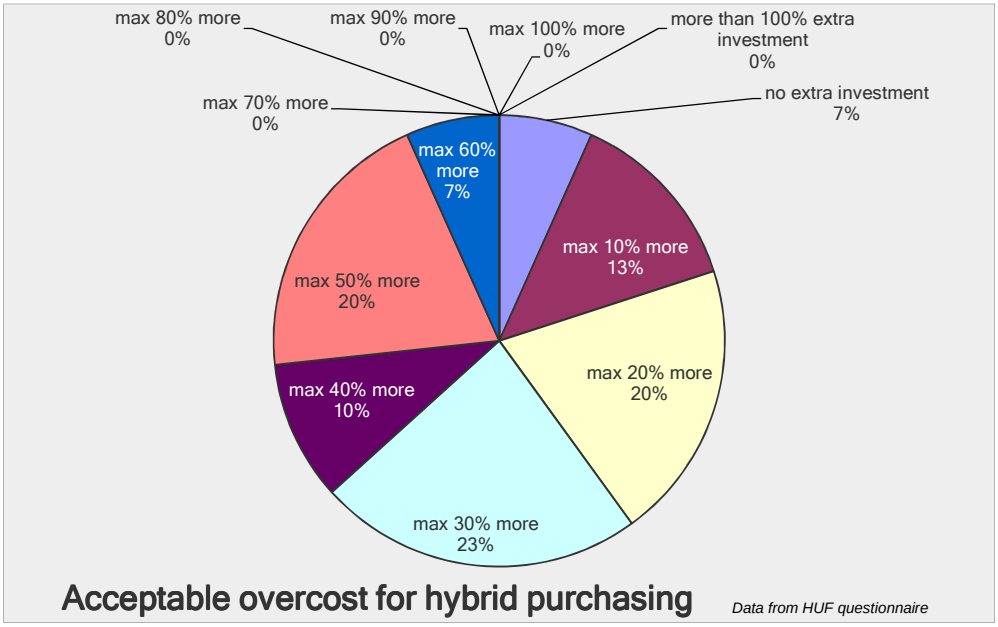


Figure 9: HUF acceptable purchasing overcost for hybrid buses

More than half of the users would be willing to pay up to 30% more than an "equivalent" diesel bus.

Regarding maintenance costs, figure 5 has shown that a reduction in this matter could be a driving force to introduce hybrid technology. However, it seems that the majority of them thinks that, for the moment, maintenance will be more expensive for hybrid buses. And they could also accept that.

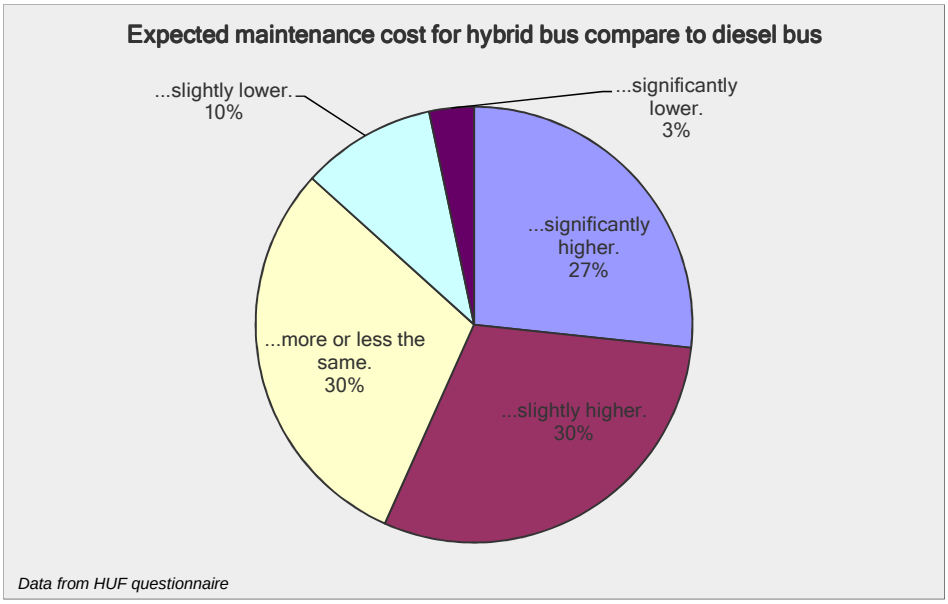


Figure 10: HUF expectations in term of maintenance overcost for hybrid buses

But if users could accept to pay more to purchase and maintain their bus, they have to have good reasons. The figure below shows that the main reason given for this is the funding. Of course funding allows buying buses more expensive since the over-cost is directly covered by the money of someone else.
The second reason would be relative to consumption performances: some directly give this reason (~12%) and others declare it through the "fuel price" (~40%), expecting that the increase of fuel price will be balanced by fuel savings. The economical motivations described above are confirmed.

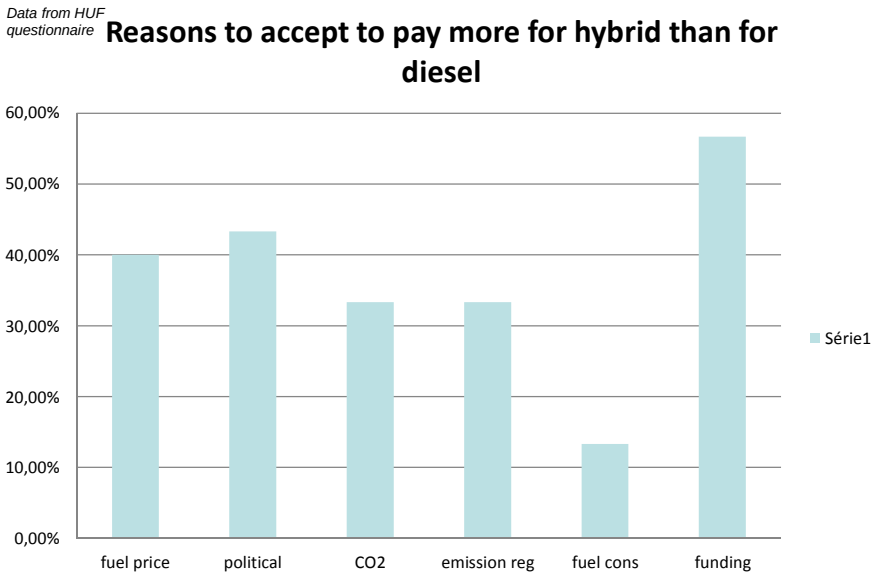


Figure 11: HUF acceptable reasons to pay more

Of course ecological and political motivations are also confirmed with "political" and "CO2" figures and one new reason appears: the evolution in emission regulation. This kind of obligation would be a reason to accept to pay more for a hybrid than for a diesel bus.

So this data regarding economic aspects shows that an over-cost could be acceptable but have to be in balance with funding or/and fuel savings (compare to fuel price).

What about the current reality?
Regarding purchasing over-cost, of course it is not easy to know the reality because it is very depending on the purchasing conditions. But up to know, the over-cost range could be considered between 30% and 50%.
Regarding maintenance over-cost, the feedback of the HUF shows that the users were right when thinking that maintenance for hybrid would be more expensive. For 67% of them it has been the case.

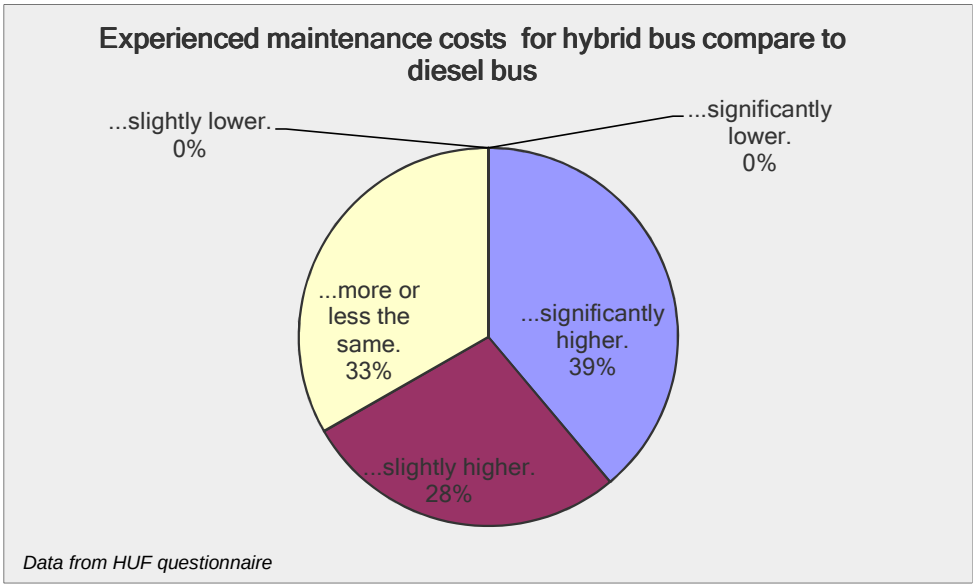


Figure 12: HUF experience regarding maintenance over-costs with hybrid buses

Regarding funding, there is no generality. It depends on the country and the local politics with regard to CO2 reduction. From the HUF no data exists about the funding, except that each time a fleet of hybrid buses has been bought there has been funding.

What else?

We have just pointed out the main obstacle for the development of hybrid buses in the field of public transport. But would there be other barriers if this obstacle was overcome?
Let's suppose that there is a convenient model for a given operation, that the environmental performances are acceptable regarding the CO2 reduction target and that the economic balance is acceptable thanks to fuel savings and funding. Is it sufficient for operators to buy the bus?

- What about reliability, availability and life time?
- What about after sales in my region regarding hybrid technology?
- What about spare parts in the time while technology has not been stabilized yet?
- What about obsolescence and resale?

All of these uncertainties are risks to evaluate before purchasing a new technology of bus.

Moreover, with the coming new Euro 6 standard, what would be the difference in terms of emissions, fuel savings and cost?
Or maybe would it be more relevant to wait for electric vehicles…

Conclusions

Conventional diesel engine buses are a strong reference for hybrid buses to compete with. This is caused by the high optimisation level of these vehicles due to very long feedback leading to a good performance and low cost.
Because of their positive contribution to ecological aspects like fuel consumption and emissions, hybrid buses gain a lot interest from local authorities. Next to that, they also have a positive contribution to the ecological image of the operator. However, these good aspects come with a cost: the cost of innovation and of new developments for ecological performances. Users understand this over-cost and could accept it, but only if balanced by funding and/or by fuel savings. This is not the case today and this is the main obstacle for the further development of hybrid buses.
Finally, the hybrid offer is complex to understand and the uncertainties regarding the after-sales period will also be questions to solve to allow the full development of hybrid vehicles.