

Executive Summary

Fuel cell bus For mining route

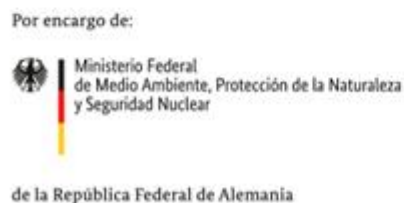
Analysis about the current market offer for fuel cell coach buses and simulation of the technology operation for a Chilean mining route with some extreme conditions high altitude and gradient, among other).

August 2021



Analysis of the technical capacity of fuel cell buses for route between different geographical heights

30 JUL 2021



Executive Summary

As in many parts of the world, also in Chile the use of green hydrogen is considered as a key element for the decarbonization of the country's energy supply.

As hydrogen is not yet implemented in Chile as an energy carrier but could play an important role to achieve the NDC targets intended to accomplish the Paris Agreement, stakeholders are searching for suitable early applications. These criteria need to be fulfilled:

- feasibility from a technology availability point of view,
- financial viability in the medium and long term and
- strong and committed actors to safeguard the transition from early non-self-sustaining pilot projects to real business cases.

This analysis provides the basis for the next steps towards the implementation of a pilot project on Chilean mining routes. In order to start the discussions, the 180 km bus route from Antofagasta to Minera Escondida had been chosen as a basis, but can be used as a blueprint for other routes with comparable conditions to be potentially serviced by FC buses. This route offered a good starting point for the discussions with the potential FC bus suppliers in order to overcome challenges such as route length, high altitudes, high gradients, slippery roads, extreme ambient conditions. But it also turned out in the course of the analysis that, due to

the limited market size for this specific application scenario, a better knowledge of the various mining routes, the required transport capacities and how they are influencing the vehicle specification is urgently needed in order to evaluate the development and production efforts in comparison to the expected market volume.

In order to proceed with the preparation of a pilot project, contacts have been established to five fuel cell bus manufacturers which all show high interest in getting involved in the further process. In total, 17 potential FC bus manufacturers had been approached but many declined from further involvement due to several reasons such as focus on other world regions or no activities in the requested field of FC buses. It became clear that none of the FC bus manufacturers has a suitable solution for operating the demanding route at hand.

It also turns out that receiving (general) specifications from those companies that already have FC (city) buses in their portfolio is not an issue, but discussing approaches or technical solutions without signing an NDA is understandably difficult as, of course, the manufacturers want to use their know-how only for their own benefit.

The replies of the potential FC bus manufacturers show that no real-world experience on operation of fuel cell buses at these high altitudes exists and therefore

it is still unclear and depending on demand if and when such FC buses will become commercially available. Accordingly, respective pilot projects would be supportive. For the time being and according to the manufacturer's feedback, provision of appropriate FC buses in the short term would be limited to a maximum operation altitude of about 2,500 m.a.s.l. Therefore, a simulation of the mining route operation has been performed.

Based on synthetic data a route simulation could be performed that already gives some insights in the power demand and the hydrogen consumptions on routes of this kind. The simulation results in an average hydrogen consumption of about **14.5 kg H₂/100 km for the uphill ride** traction.

Recommended next steps:

(1) Before entering in a pilot project, it is recommended to perform a dedicated market potential analysis as it is required for both the attraction of the fuel cell bus manufacturers and the definition of the fuel cell bus specification. A trade-off needs to be found between overengineered vehicles and too small a market.

(2) It is recommended to establish a consortium which comprises at least one mining company or one mining fleet bus operator as they have to be the main driving force creating the urgently needed pull effects. Most FC bus manufacturers are profiting from the currently high dynamics in the field of hydrogen and fuel cells and therefore this specific field of application is by no means developing by itself but needs real

commitment by the stakeholders. For the time being this specific niche seems to be most attractive to start-ups and to global players as they want to cover nearly all potential applications. The objectives of the consortium should not only comprise the smooth implementation of a pilot project, but should focus even more on the successful implementation of FC coach buses in Chile including the required hydrogen infrastructure taking also a fair risk sharing between the partners into account.

Finally, all ingredients required to proceed in this field of fuel cell buses for high altitudes are there – demand for the vehicles, interest of all required stakeholder groups (Lols submitted) – and the next steps are to be taken. Nevertheless, it is too early to immediately and directly enter into a pilot project as upfront a robust vehicle specification needs to be developed in order to call for reliable and comparable offers. Therefore, it is recommended to enter into a pilot project only after successful finalisation of step (1) and step (2) for this specific type of FC buses capable of servicing those demanding routes.

Nevertheless, in order to gather first real-world experiences especially with regard to hydrogen refuelling infrastructure it might be useful to initiate a pilot project with FC buses already available on the market to service less challenging routes and service conditions, but this was not in the focus of this analysis. This way, stakeholders would get acquainted to the various components of the value chain and ideally a first market for FC buses and the according hydrogen infrastructure could be established.

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