Rivers and roads – hydrogen mobility infrastructure in Germany

By Stephen B. Harrison on Jun 22, 2020 | Translate NEWS

Ludwig Bölkow was one of the brains behind Airbus. Around 30 years ago, his office was in Ottobrunn, close to Munich. A blast-proof door kept Bölkow safe from the 'Red Army Faction' terrorist threat. Today, his office is the conference room used by an associate organisation of the Ludwig Bölkow Foundation: LBST.

It was in Bölkow's old office where H2 View met with Ulrich Bünger, one of LBST's Senior Scientists, to talk about hydrogen mobility on Germany's rivers and roads.

Uli, so much has changed since Ludwig Bölkow used this room. What do you think he would say about your work with hydrogen today?

The foundation that bears his name is dedicated to working on sustainability in agriculture, energy and mobility. So, I am certain that he would be happy that LBST has recently been engaged in studies that have investigated and supported the realisation of the hydrogen mobility infrastructure in Germany.

Can you tell us more about some of those projects?

Let's talk about rivers and roads. One study that we undertook compared the feasibility of implementing various alternative fuels for inland barge operations on German rivers.

Millions of tonnes of cargo are transported by barges up and down the Rhine, Elbe, Neckar and Danube Rivers each year. Lots of commercial cruisers also use these waterways – floating hotels or restaurants which allow thousands of people to engage with these beautiful waterways.

The question that the German Ministry of Transport asked us to investigate was 'which fuels might replace diesel for this inland shipping application' in future fuel cell-operated ships. The cruisers, barges and bunkering would all need to be adapted. Together with our project partners, we analysed the potential feasibility and costs of various options, including the bunkering infrastructure.

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What kinds of fuels did you consider for that inland waterways study?

Clean burning fuels was our brief. The barges travel through the centre of major cities such as Berlin, Cologne, Frankfurt, Hamburg and Mannheim, so the idea would be to reduce noise and eliminate emissions of toxic air pollutant gases.

We looked at hydrogen gas at 350 or 700 bar and liquid hydrogen. We also considered hydrocarbon e-fuels such as synthetic diesel, LNG and methanol, all of which can be synthesised using renewable electricity.

And what parameters did you build into the cost modelling?

We assessed the impact of adapting the existing bunkering terminals and potentially building out the infrastructure to enable storage of the new fuels. Also, the costs of converting the barges to store the alternative fuels were estimated.

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So, are you able to share the conclusions with us?

Yes, we can. The final report has been published but not yet been formally 'launched' due to delays resulting from Covid-19, but we are permitted to share some insights.

Hydrogen gas seems like a viable option if the infrastructure and on-board storage is at 700 bar. Liquid hydrogen also came out as a feasible option.

The liquid hydrocarbon e-fuels could be used with an on-board catalytic converter to generate hydrogen to operate the fuel cell drive system. That's like a miniature steam methane reformer. Liquid hydrocarbons have the benefit of high energy density and low-cost storage, but that must be offset by the additional capital cost and energy losses of the on-board conversion to generate hydrogen.

Alternatively, some liquid hydrocarbon fuels can be fed directly to a high temperature solid oxide electrolysis fuel cell to produce power directly. We concluded that the liquid hydrocarbon e-fuels we studied could also be viable options.

Do you know how the German Ministry of Transport will use your findings?

Any of the changes that we investigated would cost more than the incumbent option to use fossil-fuel diesel in the short- to medium-term. In the long-term however, the cost trajectories would finally merge.

This finding is important for the Ministry to understand because this is a very cost-conscious sector and these operations run at thin margins. A change in the fuel type will not be self-financing in the transition period and it will therefore require regulatory incentives and perhaps financial subsidies to drive it through. That's the kind of thing that policy makers find it useful to know.

Another important point is the question of 'stranded-assets'. I don't mean that the barges will be stranded on a sand-bank next time the Rhine water level is low. I mean that we need to think ahead to solutions which will be relevant beyond 2050 in a net-zero carbon dioxide emission world.

In this long-term scenario, there are attractions to the use of hydrogen in favour of the liquid fuels because the barges have a very long life and barges which are built in the next decade will possibly be operating beyond 2050.

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And the roads project, what was your brief there?

The ADAC foundation was partly behind this study. They were founded to promote 'green mobility'. They teamed up with the Ludwig Bölkow foundation to sponsor this work. With a focus on cars, the goal was to compare the full cost implications of hydrogen vs battery electric mobility: to look at the long-term full-system cost implications of BEVs vs FCEVs.

There is a lot of debate about the merits of BEVs compared to FCEVs but people often talk about the cars. For example, it is commonly said that the BEV is twice as energy efficient as the FCEV. Drawing a neat box around the car, we do not dispute that. However, the macro issues go beyond the vehicle propulsion system and include the energy storage, distribution and refuelling or charging infrastructure which would be required.

The issue also plays into the wider context of electricity transmission and gas distribution infrastructures. Ultimately, we see advantages of BEVs and FCEVs co-existing for individual mobility.

And what was the crux of your study?

One of the issues that we face in Germany is that our power distribution infrastructure is heavily loaded and there are bottlenecks in several places. In the future, a large share of electric power will be generated in the north from wind energy to be distributed to the south.

With the transition from coal-fired stations to wind and other renewables, the electricity grid will need to change shape, and it will still be heavily utilised.

Electrical power is also expensive to store. In future when fluctuating renewables play a larger role the daily and seasonal cyclicality of hydro, wind and solar power generation will mean that energy storage at small and large scale becomes even more of an issue at both centralised and decentralised levels.

On the other hand, hydrogen gas could potentially be distributed in the extensive existing pipeline grid at comparatively low transport costs and we will be able to convert parts of the natural gas grid to move this energy around. Hydrogen is also easy to store both locally and centrally. It means that a combination of molecule and electrical power movement could be an attractive solution.

Taking a deep look into these infrastructure considerations was at the heart of our brief study.

Tell us about some of your main findings Uli.

Yes, here's an interesting one. In an extreme case that we modelled, if lots of us are driving BEVs in the future we might put an additional 20% of load onto the power grid. In many rural areas, more than in urban areas, the electricity grid would struggle to serve this load. Especially if we all come home at the same time in the evening after work and plug in our BEVs to recharge.

Another point that we came to realise is that the costs of the BEV infrastructure investment would be incremental over a long period as more and more people convert to BEVs. They are also distributed to the consumer because the car-owner will often pay for a charging station in their home. It is not about a few 'big ticket' items – it is very diffuse.

And what about hydrogen? How did that shape up?

Very well. Investment in a hydrogen filling station network to replicate the current number of petrol stations (or probably with slightly fewer stations) would be a highly visible cost that would need 'up-front' investment.

It looks like a lot of pain, but when you compare the BEV and FCEV options over the long-term, there comes a point when the slow incremental rise in the cost of the BEV infrastructure significantly increases above the cost of the hydrogen-powered FCEV infrastructure. That was a very important conclusion which surprised a lot of people.

Another benefit of hydrogen is that both the refuelling stations and each vehicle has built-in energy storage in the form of a high-pressure hydrogen gas fuel tank. Each tank is small, but if half of us are driving around in FCEVs that would add up to a big energy storage buffer. Clearly the battery in a BEV also has power storage capacity, but it stores less energy than a decent sized high-pressure hydrogen cylinder.

That sounds like a very complex project Uli. It must have taken a lot of effort.

For sure it was. I think it was about 18 months from start to finish. In our team, we had four people working on it and the Fraunhofer Institute AST had another three. Fraunhofer supported with the electrical grid modelling cases.

But we debunked a lot of myths, our clients appreciated our work and we managed to keep within the agreed 6-digit figure budget. So, at LBST we call that a job well done.