NATIONALER WASSERSTOFFRAT

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Research and development requirements: Storing, transporting and refuelling hydrogen in the road vehicle and rail sector

PRELIMINARY REMARKS

This paper considers the areas of storage, transport and refuelling of hydrogen as a fuel that are essential for ground-based mobility, as well as the associated infrastructure aspects. The area of rail technology is also covered. The extensive topic of drive technology is not discussed here.

1 HYDROGEN STORAGE AND TRANSPORT

1.1 TANKS FOR COMPRESSED H_2: CH_2

Status: Currently, hydrogen is mostly stored and distributed in pressure tanks (compressed H_2, CH_2). It is typically stored in tanks that already have a high degree of technical maturity. There are standards for individual tanks in all areas of application, and these standards are continuously adapted to the state of the art. Currently, however, these tanks are only produced in small batches. The cylinder shape used at present (which is also effectively the only shape that can be used for the time being) restricts optimisation to the limited space available in road and rail vehicles.

Recommended courses of action: Research and development requirements: The existing tank systems should be scaled up and their production processes optimised. The current tank service life of 15 to 20 years should be increased, and recycling/second-life options should be developed. In addition, space-optimised flat storage tanks with a smaller diameter but the same usable area should be researched and developed, as should tanks made of sustainable, carbon-neutral plastics. Another possible area to develop is enhancing the monitoring of tank condition by implementing improved sensor technology. To this end, the monitoring of potential impurities in the hydrogen gas should also be taken into account. These potential impurities should be prevented from interacting with the inner coating of the tank, and it should also not be possible for impurities to accumulate, so as to prevent damage to the tank and the downstream fuel cell system. Generally speaking, all tanks should require globally standardised certification.

1.2 TANKS FOR (COMPRESSED) LIQUID HYDROGEN (LH_2, CCH_2)

Status: An alternative to gaseous hydrogen is liquid hydrogen (LH_2) and compressed liquid hydrogen (CcH_2). They have both a significantly higher energy density and a higher hydrogen purity, and the tanks used to transport them require less installation space. The latter is particularly advantageous for HGV transportation. However, hydrogen must be cooled down to low temperatures (LH_2: <-253°C; CcH_2: -220°C) during liquefaction. The technology required for this is derived from LNG technology, but must generate temperatures that are approximately 100 K lower. The energy required for the cooling process is partially recovered when the liquid hydrogen is expanded to H_2 gas. Transporting liquids places higher demands on the entire chain – from production to distribution and storage – than transporting gas does.

Recommended courses of action: Research and development requirements: All the individual components involved in transporting hydrogen in liquid form (such as compressors, turbines, fittings, pumps, tankers, charging systems) must be scaled and optimised in production. As part of this, hydrogen liquefaction plants with a higher capacity than the ones available today should be developed, as they are more efficient. At the same time, combined hydrogen production and liquefaction plants that are directly coupled to solar or wind farms (especially offshore) should be developed. Finally, plants that produce liquid hydrogen dynamically and directly at sea should be developed. Larger liquefied gas tanks need to be developed to aid transportation. Regulations regarding tonnage limits for transport and approval criteria for large spherical tanks need to be clarified.

2 REFUELLING

2.1 TANK SYSTEMS

Status: Both rail and road vehicles are now almost exclusively refuelled with gaseous compressed hydrogen (passenger cars: 70 MPa; trains, buses and HGVs: 35 MPa). The refuelling system, connection and communication with the fuel pump are largely standardised for passenger cars.

Recommended courses of action: Research and development requirements: An agreement should also be put in place regarding a hydrogen standard for HGVs (and regarding a pressure level in the case of pressure refuelling). Materials research on vehicle tanks should increase the technically permissible hydrogen temperature in the tank, so as to minimise the amount of energy consumed for cooling. The technical communication between the refuelling station and the vehicle should be standardised. Vehicle parameters such as tank size, vehicle type and pressure in the vehicle should be securely transmitted to optimise the refuelling process to the greatest extent possible. In addition, internationally standardised refuelling protocols for HGVs should be developed and implemented.

2.2 REFUELLING STATIONS

Status: Currently, Germany has the best developed network in Europe with around 100 refuelling stations for cars, about 20 for HGVs and buses and two for rail transport. However, it is likely that this network will need to be significantly expanded to accommodate the build-up of HGV transport – with mobile refuelling stations providing a useful bridge. Hydrogen refuelling stations are usually supplied via trailers at the moment. The cheapest alternative is a direct connection to a hydrogen pipeline (the infrastructure for this is still not in place). Another option is to produce the hydrogen at the refuelling station.

Recommended courses of action: Research and development requirements: Types of key modules or even entire refuelling station concepts should be standardised in order to make the expansion of the refuelling station network fast and cost-efficient. In addition, licensing requirements for refuelling stations should at least be harmonised across Europe so that they are suitable for all modes of transport. Approval procedures for refuelling stations should be standardised and simplified. Hydrogen hubs that are used by several transport modes (at least rail and HGV transport, ideally also shipping) and, if necessary, industrial consumers should be initiated in order to bundle hydrogen supply and demand. Bus fleets, rail infrastructure, car parks and refuelling stations should be planned together for this purpose. This manner of bundling would make supplying hydrogen via pipelines worthwhile. Hydrogen hubs should primarily be established in locations where either hydrogen can be produced in large quantities (such as in metropolitan areas in northern Germany) or there is strong evidence that it will be consumed in large quantities (such as in the Ruhr region).

3 RAIL

Status: Vehicle systems from some European manufacturers, which are based on proven commuter train platforms, are already in use in rail transport today. These rail vehicles are undergoing final testing, and some are already in use. They are considered the ideal replacement for today's diesel vehicles on long, non-electrified routes. Locomotives with higher capacities for other purposes are being planned. The fact that rail vehicles are highly predictable, consume large quantities of fuel, are tied to one location (in relative terms) and have high longevity of 30 years or more make them an ideal ramp-up application for hydrogen.

Recommended courses of action: Research and development requirements: Currently, there are few cooperation interfaces between HGV transport and rail in terms of on-board technology and refuelling infrastructure. These areas should start working in closer cooperation and sharing knowledge owing to their similar requirements. In addition, refuelling trains with liquid hydrogen and LOHC should be further developed and tested. Existing pressure tank systems should be improved to allow for higher capacities. Similarly, operational concepts in which trains are refuelled more frequently than once a week (which is the current cycle) should be tested. This could address the capacity limitations of the tanks. In order to quickly build up the infrastructure, mobile refuelling station concepts, connections to hydrogen hubs (see 2.2) and on-site hydrogen production from overhead lines should also be tested.

If you are interested in finding out more or have any questions, please contact:
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THE GERMAN NATIONAL HYDROGEN COUNCIL

On 10 June 2020, the German Federal Government adopted the National Hydrogen Strategy and appointed the German National Hydrogen Council. The Council consists of 26 high-ranking experts in the fields of economy, science and civil society. These experts are not part of public administration. The members of the National Hydrogen Council are experts in the fields of production, research and innovation, industrial decarbonisation, transportation and buildings/heating, infrastructure, international partnerships as well as climate and sustainability. The National Hydrogen Council is chaired by former Parliamentary State Secretary Katherina Reiche.

The task of the National Hydrogen Council is to advise and support the State Secretary's Committee for Hydrogen with proposals and recommendations for action in the implementation and further development of Germany's National Hydrogen Strategy.

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