EARPA Position Paper

Green Hydrogen in Automotive Road Transport

About EARPA

Founded in 2002, EARPA is the association of automotive R&D organisations. It brings together the most prominent independent R&D providers in the automotive sector throughout Europe. At present its membership numbers 52, ranging from large and small commercial organisations to national institutes and universities.

Context

https://ec.europa.eu/energy/topics/energy-system-integration/hydrogen_en

Hydrogen

The European Hydrogen strategy was published in 2020 and the Fit-for-55 package in 2021 and both open a strong strategy for the build up of a European clean Hydrogen market. Also the use of Hydrogen in transport is underlined in several legislative revisions of the package, as well as the proposal to build up a refueling infrastructure for Hydrogen with at least one fueling station along the Ten-T network every 150km. Under these boundary conditions EARPA sees essential research needs for road transport highlighted in this paper.

SCOPE and OBJECTIVES

Since the definition of a dedicated strategy on Hydrogen in Europe on the 8th of July 2020 (European Commission, 2020), stating the Hydrogen strategy for a climate-neutral Europe, the adoption of a Roadmap on Hydrogen strategy deployment is a must for all the stakeholders of transport sector. This position paper aims at giving a brief factsheet on the main topics and challenges from the viewpoint of EARPA for the use of Hydrogen in future sustainable propulsion systems for different vehicles.

Background:

- **EU Hydrogen strategy:** Hydrogen can be used as a feedstock, a fuel or an energy carrier and energy storage, and has many possible applications.This veristilty makes Hydrogen a crucial component in reducing greenhouse gas emissions across industry, transport, power and building sectors. The Commission's economic recovery plan 'Next Generation EU' highlights Hydrogen as an investment priority to boost economic growth and resilience, create local jobs and consolidate the EU's global leadership. From 2020 to 2024, the installation of a capacity of at least 6 GW electrolysers for the production of renewable Hydrogen in the EU will be supported. From 2025 to 2030 Hydrogen will become an intrinsic part of the integrated energy system, with at least 40GW electrolyser capacity (European Commission, 2020). From 2030 onwards, renewable Hydrogen shall be deployed at a large scale across all sectors to be decarbonised, in particular, the transport system (European Commission, 2021).
- **Hydrogen generation in Europe:** The published Hydrogen strategy brings different strands of policy action together, covering the entire value chain, as well as the industrial, market and infrastructure angles. Together with the research and innovation perspective and the international dimension, an enabling environment to scale up Hydrogen supply and

demand for a climate-neutral economy shall be established. (Publications Office of the European Union)

- **Hydrogen promotion in Europe:** The production of green Hydrogen will be increased by creating a sustainable industrial value chain and the demand must feed the industrial and mobility applications. Clean Hydrogen will benefit from a supportive framework, well-functioning markets and clear rules, as well as dedicated infrastructure and a logistical network – These are challenges that have to be tackled and this will imply cooperation and trade opportunities with neighboring countries and regions of the EU.

Hydrogen for the propulsion system in vehicular transport

The current CO_2 standards for cars and commercial vehicles should set technology neutral targets to reduce emissions by 2030 and by 2035. Hydrogen and its derivatives must be part of the solution, in particular for heavy-duty, commercial vehicles and finally passenger cars. Solutions should include the whole energy chain in contrast to todays usual tank-to-wheel approach. Future CO_2 standards should enable a "net zero" approach to broaden the pathways to climate neutrality and to help de-fossilizing the extisting fleet., Renewable and green Hydrogen and Hydrogen based fuels using strictly circular CO_2 as a feedstock would then show a pathway to long term necessity.

The electric drivetrain offers high efficiency and zero tail-pipe emission in local operation but also has its limitations, for instance, in range. **Full electric vehicles** can be equipped with fuel cells as one option to mitigate limited electrical driving range, however for battery electric vehicles (BEVs) as well as for fuel cell electric vehicles the following main challenges have to be tackled:

- the total amount of electricity needed for transport (regional potential on renewable energy and associated electricity costs) for BEVs and for green hydrogen,
- necessary charging and re-fueling infrastructure and
- environmental impact, especially in terms of Life Cycle Analysis (LCA) and possible bottlenecks of certain raw materials.

Fuel Cell technology has been validated in numerous European funded projects in the past. Their operational reliability allows them to be deployed in series production for limited series, in the order of thousands of units. Heavy duty applications show a wide potential for fuel cell technology with a possible steep increase in truck sales share from 0.2% in 2023 to 16.8% in 2030[1]. The challenge however, is to reduce the cost through combination of increased production volume as well as technology development to improve production and automate techniques, reduce material costs per unit and improve designs at stack and system level.

Hydrogen fuelled ICEs (internal combustion engines) are a feasible type of powertrain that will come under closer scrutiny regarding overall impacton sustainable targets as well as social and labour effects of the massive adoption of BEVs for the existing energy and conventional propulsion industry. Hydrogen powered ICEs can match power outputs and efficiencies of typical modern fossil fuelled ICE counterparts, whilst eliminating tail-pipe carbon-based emissions and enabling ultra-low NOx emissions. In addition, the use of Hydrogen in modern ICEs offers a fast and cost-effective route to de-fossilization.
However, the utilization of Hydrogen as fuel in ICEs is more challenging than using conventional fuels requiring the needed activities to ensure a commercial success. At the component level, one of the significant challenges is the availability of durable and low-cost Hydrogen high-pressure injection systems, being exposed to the fuel featuring low lubricity and viscosity. In addition, Hydrogen also chemically interacts with metals of pipes and engine.
Research needs are engineering limits in terms of engine efficiency and emissions, ensuring reliable, safe and low-cost operation and certainly holistic engine development and optimization.

To meet a CO_2 reduction of the transport sector by 55%, a full electrification of the powertrain alone can mathematically not reach this goal with the given fleet renewal rates. Therefore **synthetic**

[1] IHS market forecast, Roland Berger

fuels, obtained by green Hydrogen and re-captured CO_2, in view of the CO_2 neutrality goal, is a feasible option for the near future, since internal combustion engines do not need to be severely modified.

Research needs for Hydrogen application on European vehicles:

- **Fuel Cell**: Improvements should be done for all of the fuel cell vehicle components, specifically: volumetric and gravimetric power density, increased reliability, affordability and extended lifetime at single cell and short stack level, increase the efficiency by design and materials to reduce thermal losses and hence minimize cooling effort .
- **Hydrogen ICE:** Modifications of existing systems or new development focussed on Hydrogen are needed for: Fuel system (pre-conditioning, direct - indirect injection), combustion system (mixture preparation, charge motion and turbulence, low energy activation and short ignition delay), Exhaust gas aftertreatment (lean deNOx using carbon-neutral reduction agents, soot emissions from oil combustion), control, sensors and OBD functions and Onboard Monitoring (OBM).
- **Tank:** Aging, material and price are still to be optimized. Hydrogen compression is still a bottleneck in the refuelling infrastructure for Hydrogen-mobility. Development of new materials for high pressure tanks enhancing the properties of the liner and optimizing the shape to be properly integrated, use of low cost concepts and improving manufacturability is also needed.
- **Methodology and Simulation:**
  Hydrogen technologies are now in a process of accelerated development. Simulation and development methodologies are proven to significantly support the research and development needs and lead to optimized systems with respect to efficiency, cost reduction and durability. Therefore research needs are seen in (i) models representing physical processes as well as simplified representative models for system design as well as for embedded implementation in the target applications, (ii) Simulation technologies including the quantification of uncertainty (iii) simulation of all effects in the product lifecycle including ageing, (iv) measurement and testing methodology for development and series applications.

For further information, please contact our contact persons of the Foresight Group:

Energy, Powertrains and Electrification

Contact

FG EPE Speaker

Bernhard Brandstätter

E: bernhard.brandstaetter@v2c2.at

FG EPE Secretary

Marco Mammetti

E: marco.mammetti@idiada.com

Drafting:

Marco Mammetti, Alois Danninger, Christof Schernus, Thorsten Schnorbus

More information at our website: www.earpa.eu

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