Comparison of Batteries and Fuel Cells for Electric Mobility

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Comparison of Batteries and Fuel Cells for Electric Mobility

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Summary

Electric mobility is more than just battery electric vehicles. The wide range of vehicle classes and application areas require different electric vehicle technologies (hybrid, battery electric and fuel cell vehicles). The development proceeds from the micro and mild hybrids, full- and plug-in-hybrids to battery electric and fuel cell vehicles. As each technology has its strengths and weaknesses we will find a wide range of solutions for sustainable mobility in the near future. In order to introduce sustainable mobility the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT) supports the development and market introduction of alternative propulsion systems and fuels by a wide spectrum of funding programs and instruments. Funding has been increased up to 60 Mio. € in 2009 and 2010. In addition to the financial support the BMVIT founded the Austrian Agency for Alternative Propulsion Systems and Fuels (A3PS) as a strategic cooperation platform with the industry and research institutions.

1 Introduction

Tightening emission standards for pollutants, greenhouse gases and noise favour the market introduction of alternative propulsion systems. The EU has set the goal to reduce greenhouse gases by at least 20% until 2020 as of 1990. Therefore it is necessary to increase energy efficiency and to push renewable energy sources not only but particularly in the transport sector. To do so, ecological vehicles have to be developed and introduced to the markets in large quantities. Ecological vehicles are characterized by a low environmental impact throughout the whole life cycle. They have low air pollutant and noise emissions and run on low-carbon energy sources. Considering the whole life cycle ecological vehicles finally must be easy to recycle. Among the wide range of different drive train solutions Battery Electric Vehicles (BEV) and Fuel Cell Vehicles (FCV) fit best with these requirements. In the following this two technologies are compared concerning emissions, costs, range, system simplicity and infrastructure.

2 Comparison of Battery and Fuel Cell Electric Vehicles

In **Figure 1** different drive trains are classified starting with the conventional drive train on the left with increasing electrification going rightwards. A maximum of electrification is reached in the middle of the x-axes where the pure BEV is located. On the contrary in the left side the ICE is mechanically coupled to the drive train. In the right there is no mechanical connection of the ICE in the case it is used. The lower part of the graph shows the division of energy converters and on the upper part the corresponding energy carriers and storages respectively.

The electrification starts with hybridisation of the conventional drive train. Depending on the implemented electric performance different hybrid concepts such as micro-, mild- or full- are realised. In the middle of the sketch the pure BEV is located. Regarding the system complexity, like the conventional drive train the BEV combines only one energy carrier/storage with one energy converter. As it lacks a gearbox the BEV is even simpler. To extend the range of the pure BEV, the drive train is again supplemented with an ICE or a fuel cell. Because the ICE is mechanically decoupled from the drive train it is directly coupled to an electric generator, which converts the mechanical power output of the ICE into electrical power. On the very right of the sketch, the ICE/generator unit or the fuel cell has about the same maximum performance than the electric motor. The battery is then only needed as a buffer.

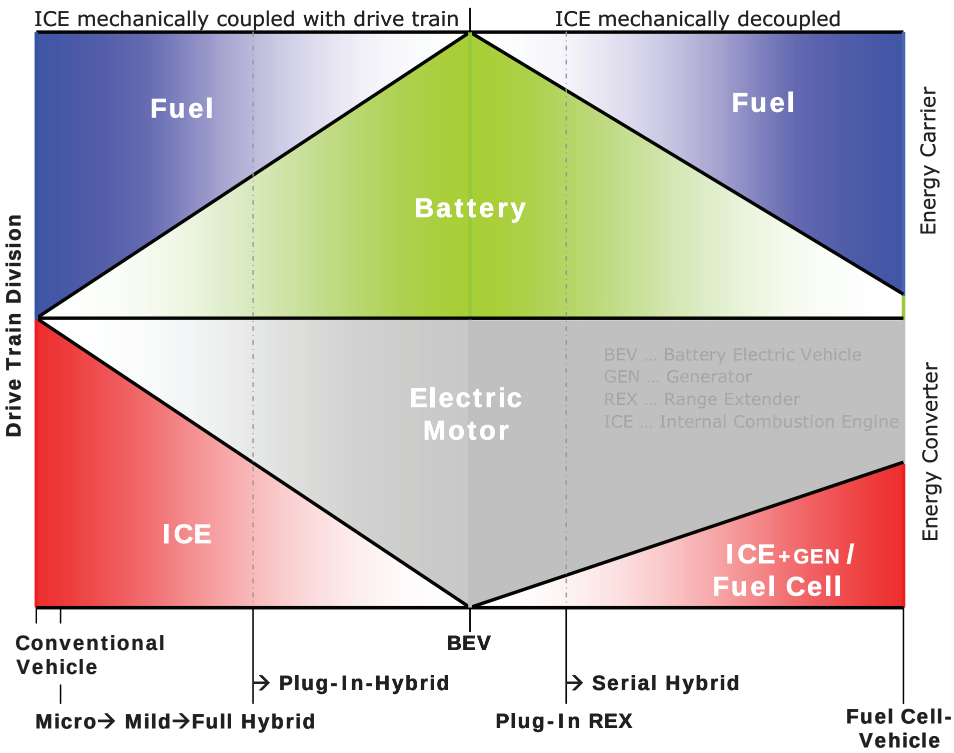

Figure 1: Drive train division from the conventional to the electric power train.

The wide range of vehicle classes and application areas require different technologies within and beyond electric vehicles (HEV, BEV, FCV). Especially in the case of long distance freight transport, other options like biofuels seem indispensable.

Hydrogen in fuel cells or internal combustion engines is an interesting option to increase vehicle range beyond battery vehicle limitations. Another asset of hydrogen is the broad choice of energy sources including renewable energies to generate hydrogen.

Limited driving range of BEV due to low energy density of batteries is sufficient in most cases of real driving behaviour. Figure 2 compares energy density of different battery technologies, hydrogen and conventional fuels. Hydrogen pressurized at 700 bar has a ten times higher energy density than a modern Li-Ion battery. Therefore a FCV reaches a significant higher range than a BEV, even though the efficiency of the battery electric drive train with 70 to 80 % is higher than the efficiency of the fuel cell drive train with 40 to 50 %.

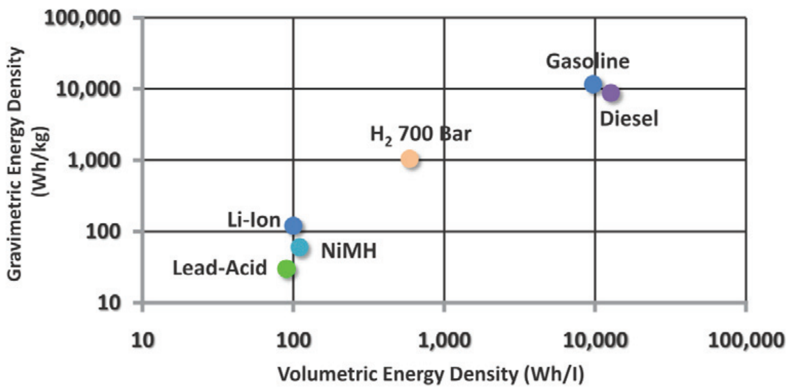

Figure 2: Energy density of different energy storages.

Figure 2 shows five critical factors for a successful market launch of both technologies. The clearest difference lies in the range. The fuel cell has there significant advantages in comparison to battery-electric drive trains because of the higher energy density of hydrogen. The present disadvantages of the FCV concerning higher overall system costs, a more complex system configuration as well as a higher effort to establish the hydrogen infrastructure must be reduced strongly during the next years to allow a necessary coexistence of both technologies. In the area of pollutant and noise emissions both technologies have equally high potential, as long as renewable energy is used for the production of hydrogen and the generation of electricity.

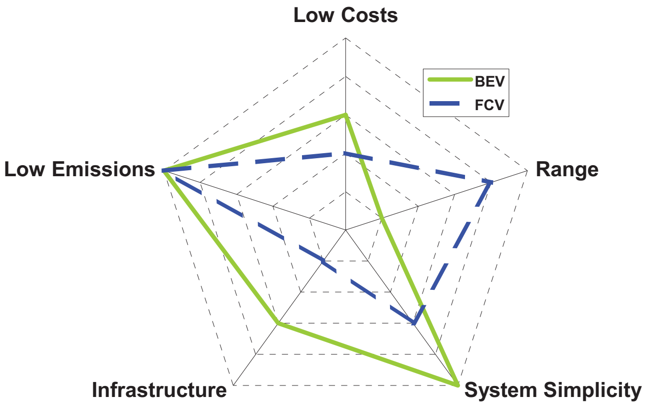

Figure 3: Key Factors of BEV and FCV.

3 Activities in the Field of Hydrogen in Austria

Graz, the capital of Styria, plays a particularly important role in the field of hydrogen research. HyCentA Research GmbH (Hydrogen Center Austria), which operates a hydrogen testing centre, the Institute for Internal Combustion Engines and Thermodynamics at the Graz University of Technology, the Joanneum Research Forschungsgesellschaft mbH and Magna Steyr Fahrzeugtechnik AG & Co KG form a hub for innovative hydrogen research and development.

Figure 4: Hydrogen Center Austria[1].

Located in northern Austria, Fronius International GmbH and Profactor GmbH are also actively involved in the field of hydrogen technology. The activities of OMV AG in Austria are supported by the company's participation through its subsidiaries in the German H_2 Mobility initiative.

4 Funding Programs and Instruments of the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT)

In order to secure the competitiveness of the Austrian automotive sector as well as to support it in the market introduction and implementation of cleaner technologies (especially in order to face the increasingly strict requirements regarding emissions and fuel economy set both by the EC and international agreements), the Austrian Ministry for Transport, Innovation and Technology (BMVIT) launched in the year 2002 the Program A3 (Advanced Austrian Automotive Technology). The complete portfolio of instruments of the BMVIT to support R&D activities and demonstration projects include:

- A3plus-Technology Program: cooperative R&D projects on alternative propulsion systems and fuels
- Program OptiDrive: ICE optimisation, light weight structures, electronics
- Lighthouse projects: demonstration for market introduction
- FFG basic program: bottom-up product optimisation
- Climate and Energy Fund: 500 Mio. € for climate protection
- Headquarter Program: supporting Austrian companies
- Infrastructure for research: e.g. HyCentA (Hydrogen Center Austria, conceived as an hydrogen test center and first hydrogen delivery station in Austria acts as a focal point and information platform for hydrogen-oriented research and development activities.
- Competence Centres (e.g. K2-Mobility for sustainable vehicle technologies)
- International Cooperation (7th EU-framework program, European Technology Platforms, ERA-NETs, IEA)
- Austrian Agency for Alternative Propulsion Systems (A3PS)

A3plus program and tender for lighthouse projects

In the A3plus program and its predecessor A3 hundred and fifty cooperative R&D projects for the development of alternative engines and fuels have been selected for funding in annual tenders for projects, on the basis of evaluation by international experts since 2002. Funds amounting to 43 Mio. € have been used for this purpose. Within the context of the "Technology Lighthouse Program for electric Mobility", which opened its first call in 2009, three project proposals with a requested funding volume of 22.5 Mio. € were submitted. In contrast to the A3plus projects, the lighthouse projects are demonstration projects devoted to optimize new technologies under real life conditions and to prepare the public for an impending technological shift. Several hydrogen projects from the A3plus technology program are described in the following sections.

5 Austrian Agency for Alternative Propulsion Systems and Fuels (A3PS)

Following the principles of modern technology policy, the BMVIT also provides non-financial support for Austrian industry and research institutions and has entered into a strategic public-private partnership within the Austrian Agency for Alternative Propulsion Systems (A3PS). A3PS was founded in 2006 and developed as a coordination platform and an international point of contact in the field of alternative engine systems and fuels. A3PS offers a broad range of services in support of its 26 member institutions in their joint efforts to develop alternative propulsion systems and to bring them on the market:

- Stimulating the cooperation among complementary partners, building up international research partnerships and interdisciplinary pilot and demonstration projects
- Providing, compiling and analyzing information (technology foresight and assessment, studies, lectures, workshops, conferences, travel reports,...).
- Supporting the creation of innovation friendly framework conditions (Regulatory- and fiscal policy, fuel taxation, endowment of research programs, 7. FP, codes and standards, emission limits, access to sensitive areas,...).
- International networking and marketing support for Austrian technological expertise and the engineering and product-know-how of its members through publications, presentations and the organization of conferences.

References

[1] HyCentA Research GmbH