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G. Fornol, J. Korevaar, G. Lugtigheid, T. Nauta

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Making Hydrogen Work – Sustainable, Emission-free-Energy Carrier for Local Power Generation on Demand

Gregor Fornol, Jaap Korevaar, Gerard Lugtigheid, Tjitte Nauta, H2Fuel, Systems bv, The Netherlands

1 Introduction

We have a unique inexhaustible and environmentally friendly energy carrier which can be produced worldwide and which can easily be stored, transported and refueled (H2FUEL). This H2FUEL enables the on-demand and emission-free production of electric energy and/or heat both at static and mobile locations. To that effect we have developed a unique compact and scalable generator (H2FUEL energy system). The released energy can in principle be used for any application and the spent H2FUEL can be completely recycled.

Our H2FUEL energy concept may play a crucial role in the future of our energy supply, not just for providing vehicles, vessels and airplanes with emission-free energy but also as an emission-free energy concept for households, companies and institutions. Furthermore, the mobile application of our H2FUEL energy concept amply meets the targets which have been formulated by the US Department of Energy (DOE) en her European counterpart StorHy.

Just to give you an impression: if we compare the lithium-ion battery pack in a Tesla Roadster to an equal volume H2FUEL energy system, then our system is 45% lighter and provides 5 times more electrical energy, resulting in a 5 times longer driving range.

Table 1

Volume equivalent	Li-ion	H2FUEL	Delta
• Volume	180 L	180 L	n/a
• Weight	450 kg	250 kg	- 45%
• System energy	53 kWh	260 kWh	+ 500%
• System mass per kWh output	8.5 kg/kWh	1.0 kg/kWh	- 90%
• System volume per kWh output	3.4 L/kWh	0.7 L/kWh	- 80%
• Range (EPA highway)	322+ km	1610+ km	+ 500%

In case of an equal mass H2FUEL system, our system indeed is 1,5 times larger yet provides 12,5 times more energy. Obviously, the driving range in that case is 12,5 times longer. An H2FUEL powered electric car has the benefit that the ratio of useable space to driving range can be drastically revised.

Table 2

Weight equivalent	Li-ion	H2FUEL	Delta
• Volume	180 L	280 L	+155%
• Weight	450 kg	450 kg	n/a
• System energy	53 kWh	663 kWh	+1250%
• System mass per kWh output	8.5 kg/kWh	0.7 kg/kWh	- 92%
• System volume per kWh output	3.4 L/kWh	0.4 L/kWh	- 88%
• Range (EPA highway)	322+ km	4025+ km	+1250%

Several prominent strategic parties have an interest to further develop and apply the H2FUEL energy concept in cooperation with us. Since this requires a substantial financial injection, not just from the strategic parties but also from us, we are approaching different organizations

The strategic partners we are deeply engaged with in setting up the joint development projects include amongst others the research organization TNO (Defense and Safety, Industry and Technology), the German national research centre for aeronautics and space (DLR), an important airplane manufacturer and a German industrial supplier for emergency electrical power for aviation and other industrial applications.

2 Background

Electrically powered vehicles, vessels and airplanes play a prominent role in the growing global need for emission-free mobility. Major challenge is to bring electrical energy on board. At first sight the battery seems to be a suitable solution. However, batteries are harmful to the environment and furthermore the recoverable raw material reserves are insufficient. These reserves will de depleted quicker than oil wells and thus we exchange dependence from one sources to the other. Batteries make electrically powered vehicles expensive to buy and maintain, and the massive application of batteries provides enormous logistic problems, for which the power grid is not designed. The relatively low energy density furthermore limits the driving range and the required charging time does not match the current driving experience.

It is very clear that the solution lies in an inexhaustible and environmentally friendly energy carrier which can easily be stored, transported and refueled, and from which electrical energy can be generated on board while driving and on demand, such that the driver of a conventional fossil fuel vehicle becomes motivated to change over to an electric vehicle.

For a long time the clean energy carrier hydrogen appeared to be the most promising solution. Electrical energy can be generated instantaneously from pure hydrogen and ambient air using a fuel cell. Application of pure hydrogen appears not to be economically viable, particularly due to the precautions required to safely and efficiently store, transport

and refuel pure hydrogen. In addition, the present day industry does not succeed in increasing the energy density, as a result of which the targets formulated by the US Department of Energy (DOE) and her European counterpart StorHy cannot be met by a long run.

Initially our project objective was to develop a renewable energy carrier as an alternative for pure hydrogen, and a plug & play energy system able to release energy from this carrier on board a vehicle and emission-free. Our desire was to develop a mobile energy concept that meets the targets formulated by the US Department of Energy (DOE) and her European counterpart StorHy, such that electric driving better matches the present day driving experience. In the mean time we realize that our H2FUEL energy concept has a much broader applicability.

3 A Unique and Promising Energy Concept: H2FUEL

The H2FUEL energy concept can play a crucial role in the future of our energy supply, not just for providing emission-free energy to vehicles, vessels and airplanes but also as emission-free energy concept for households, companies and institutions.

An H2FUEL energy system instantaneously releases pure hydrogen from H2FUEL, subsequently the released hydrogen reacts with oxygen in stacked fuel cells to form water, while an electric current is created in an efficient way. If desired, the same energy system may for certain applications be limited to an instantaneous, emission-free hydrogen production on demand.

H2FUEL is better to handle and therefore its application is more economically viable than compressed pure hydrogen. H2FUEL is a liquid by itself and can be stored under slightly adapted conditions, without serious degradation of storage materials. The risk profile of H2FUEL is more or less equal to that of gasoline and in addition, pure hydrogen is not released prior to any demand. Furthermore, the energy density of H2FUEL per liter energy system is larger than that of compressed pure hydrogen. All this results in an energy carrier having a large driving range and a short refueling time at a large number of potential refueling locations, and an energy system having a long life expectancy.

The instantaneous release of pure hydrogen from H2FUEL causes no harmful emissions. Furthermore, combustion of pure hydrogen in an internal combustion engine or the use thereof in a fuel cell to produce an electrical current does not result in harmful emissions. In both cases the released hydrogen reacts with oxygen to produce energy, while the only exhaust gases released comprise water vapor.

H2FUEL has enormous potential as a renewable, emission-free energy carrier. The major component of this energy carrier, viz. a modified type of chemically bound hydrogen, can be produced from virtually all primary energy sources including renewable sources such as solar energy, wind energy, hydropower, biomass and geothermal energy. As energy carrier H2FUEL will never be depleted.

4 Status

Obviously, we have applied for patents both for the energy system and the energy carrier. The basic design of the H2FUEL energy system has been positively assessed by several renowned scientific institutes and the manufacture thereof is considered to be feasible. Furthermore the H2FUEL proposed by us (including its application in the H2FUEL energy system) has been positively assessed.

Although H2FUEL is not commercially available, the basic processes for its manufacture are known. Research organization TNO (Defense and Safety) claims that for performing prototype tests, TNO can produce H2FUEL according to our specifications. The particular expertise of TNO is producing and applying the major component of H2FUEL: a modified type of chemically bound hydrogen. Currently the basis thereof is used in ammunition, as rocket fuel and as emergency ignition fuel for military aircrafts.

The moment our strategic partner(s) and us have made a fist H2FUEL energy system and an amount of H2FUEL, we can prove not just in theory but also in practice that the energy capacity of the H2FUEL concept, both in terms of system volume and system mass, by far outclasses other innovative and environmentally friendly energy concepts allowing the on demand generation of electrical energy and/or heat on location. In fact, this enables us to prove in practice that the ultimate targets formulated by the US Department of Energy (DOE) and her European counterpart StorHy for hydrogen based energy systems (to be used in vehicles), are actually achievable with our H2FUEL concept; and we herewith close a time gap of more than a decade.

TNO Industry and Technology, business unit Automotive, has made us an offer to provide and electrical vehicle with the H2FUEL energy concept, with support from the Dutch Government. In addition, TNO Defense and Safety has offered to produce H2FUEL for prototypes and to develop a scalable and economically viable manufacturing model for the longer term, also with support from the Dutch Government. A contribution from us is required. This contribution obviously increases as the development risks decrease.