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Monarch Fuel Cell Bicycle

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Abstract

Fuel cell vehicles are aimed to be a new way of environmentally friendly transport. But they face significant problems in terms of costs and infrastructure. Only with demonstration projects and government or company subsidies fuel cell vehicles are so far possible. But there is a market for private fuel cell vehicles for personal transport which is viable even without subsidies based on latest current fuel cell technology. It is the niche market of high end fuel cell electric bicycles. Based on latest cost reduction of fuel cell systems and the strong growing market of the high end electric bicycles in Europe, USA and Japan, there is a market for fuel cell electric bicycles coming up. This presentation discusses the development of hydrogen fuel cell electric bicycles as a form a personal mobility.

Keywords: bicycle, fuel cell, hydrogen, infrastructure, market

1 Objective

The objective of this presentation is to discuss the development of electric bicycles as a form a personal mobility. The feasibility of adopting Hydrogen fuel cell in electric bicycles is discussed. And for the first time, the development of Monarch fuel cell bicycle, the first consumer fuel cell bicycle is introduced.

2 Background

As part of the effort to reduce Green House Gases (GHGs) emission, electric mobility has been widely promoted. However, many concerns were shown on the low energy density of current closed loop chemical battery system and the impact of wide adoption of fast charging system has on the electrical grid. Fuel cell vehicles are considered as an alternative way to provide clean transportation.

For more than a decade, much discussion had been taken place among the big automotive manufacturers and governments around the world on the future of clean mobility by using Hydrogen as a fuel. However, the biggest issues faced by this new form of environmentally friendly transport are cost and availability of refueling infrastructure.

With the high development cost and possible production cost of fuel cells for vehicles as well as the high cost associated with building sufficient Hydrogen refueling infrastructure, only a few demonstration projects were carried out.
Most of the demonstration projects so far are either heavily government subsidized or funded by big automotive companies as part of R&D. There is very limited effort seen in commercialization of such technology in full size vehicle any time foreseeable. Generally speaking, there isn't much focus on electric or even fuel cell personal mobility in the past.

3 Current Status

Although the pathway to commercialization of electric/hydrogen mobility is seen to be far and challenging, we saw very different scene when it comes to light electric mobility, especially electric bicycles [1]. More than 20 million e-bikes are added in the vehicle population every year for the past few years, although most of these bikes were sold in China for a price less than 500USD. In Europe, there is also a growing interest in electric personal mobility. In the past year, more than 750,000 electric bicycles were sold in Europe with most of them cost above 1,000Euro.

There is a potential market for personal fuel cell mobility based on current fuel cell technology even without government subsidies. The penetration to the mass market starts from the niche market of high-end fuel cell electric bicycles. With reduction in the cost of small fuel cells and the strong growing interest in high-end electric bicycles in Europe, USA and Japan, the market for a price competitive, performance superior fuel cell bicycle already exists.

4 Proposed solution

More and more people start to choose electric bicycle in Europe for a healthy and more enjoyable way of personal transport as compared to fully motorized vehicle or manual bicycle. It makes cycling more accessible for a wider range of population.

The market for high-end electric bicycles in the industrialized countries is not primary cost driven. The customers in this market segment typically made this as a life-style choice. With the maximum speed of up to 45km/h, customers are paying from 4,000Euro to 10,000Euro for these sportive electric bicycles.

It is worth to note that power consumption for such high-speed electric bicycle is significant. With high discharge during fast acceleration, the batteries can typically last for only an hour of continuous operation. With the right design of Hydrogen power pack, it has twice the amount of energy in the Lithium battery of the same weight. Based on proven technology [2, 3] in the fuel cell electric bicycle prototype with 250km range and a total weight of 26kg developed in 2010 as shown in Figure 1, the high-end Monarch hydrogen fuel cell electric bicycle is proposed. There are three main parts in this development. The Pios Power Pack, the Monarch bicycle and the Hydrogen refueling station.

Figure 1. The first author with fuel cell electric bicycle prototype with 250km range and a total weight of 26kg in Hannover Messe 2010

4.1 Pios Power Pack

The fuel cell power pack is designed with following features.

- 220W PEMFC
- 350Bar Hydrogen storage
- TN-1 automotive standard connector
- 12VDC, 5VDC power output for charging of electronic gadgets
- Fuel Cell and battery hybrid system for better dynamic load handling

The removable design as a standalone unit allows users to enjoy excess power for other electronic appliances, away from grid power. Figure 2 shows the Pios Power Pack separate and integrated in the bicycle.

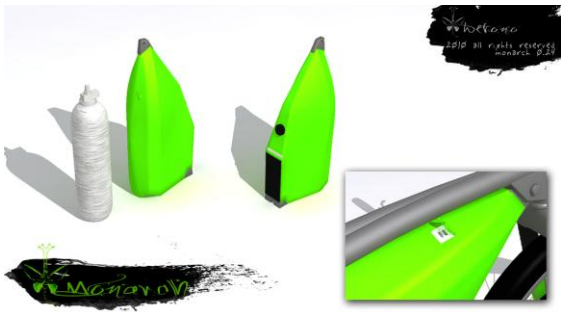

Figure 2 Pios Power Pack

4.2 Monarch Bicycle

The bicycle is designed with following features as shown in Fig. 2.

- Pedal assisted electric powered
- More than 250km electric range
- Up to 45km/h speed

The Pios power pack with hydrogen fuel cell is located between two wheels in green colour as shown in Figure 3. For economic reasons peak power up to 1kW is provided by hybrid battery.

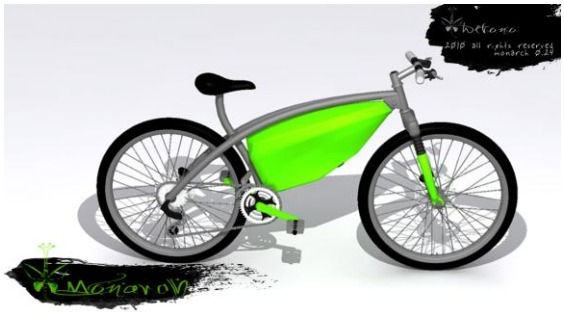

Figure 3 Monarch fuel cell bicycle

4.3 Hydrogen refuelling station

The Hydrogen refuelling station is designed with the following features as shown in Figure 4.

- Optimized low cost system with no compressor needed
- Supports up to 45 refills a day
- Self-sustaining off-grid system to minimize excavation work.

A new approach of hydrogen refuelling with several fuel tanks is proposed for the refuelling station.

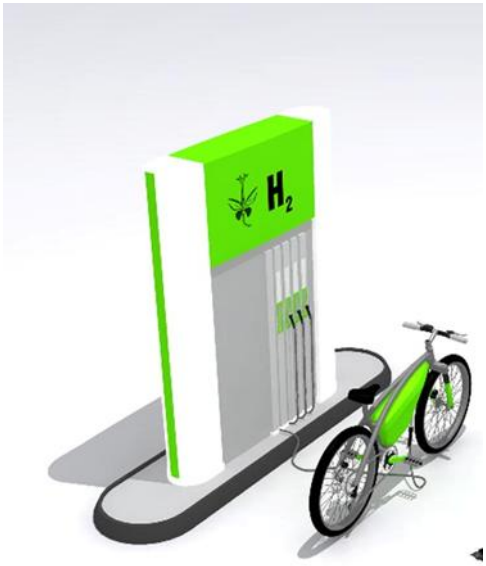

Figure 4. Monarch Bicycle equipped with integrated fuel cell power pack at hydrogen refueling station

5 Conclusion

The study shows the latest development of fuel cell electric bicycles based on one decade of experience with fuel cell electric bicycles. The latest generation shows how with the current technology a fuel cell electric bike and micro hydrogen infrastructure is practically possible.

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