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This document appeared in

Detlef Stolten, Thomas Grube (Eds.):

18th World Hydrogen Energy Conference 2010 - WHEC 2010

Parallel Sessions Book 6: Stationary Applications / Transportation Applications

Proceedings of the WHEC, May 16.-21. 2010, Essen

Schriften des Forschungszentrums Jülich / Energy & Environment, Vol. 78-6

Institute of Energy Research - Fuel Cells (IEF-3)

Forschungszentrum Jülich GmbH, Zentralbibliothek, Verlag, 2010

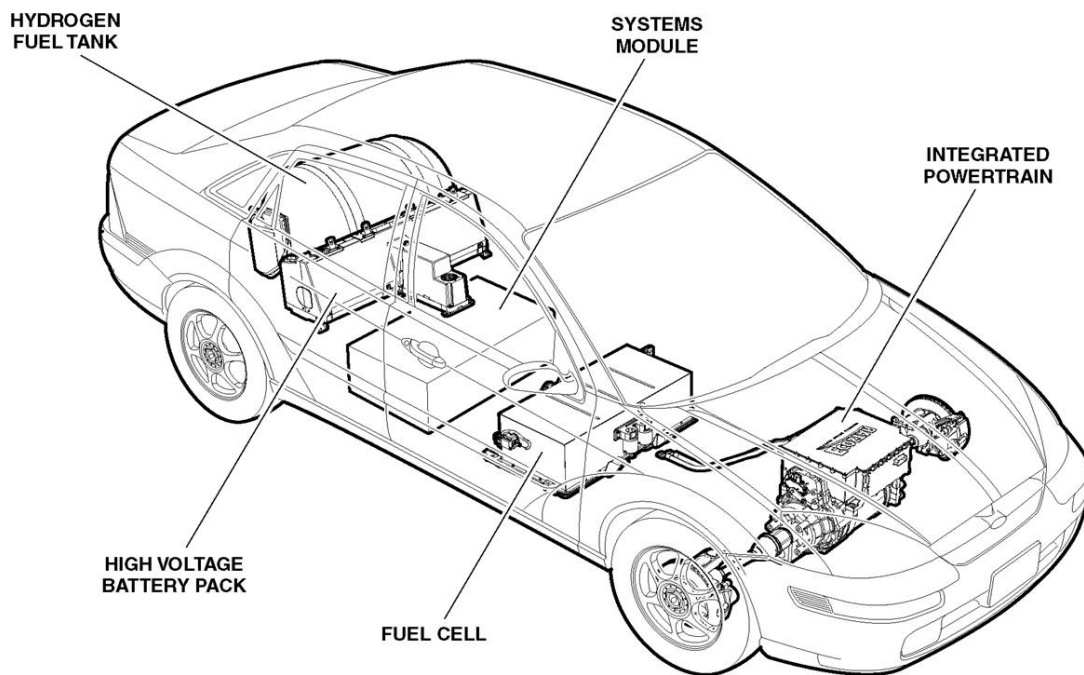
ISBN: 978-3-89336-656-9

5 Years of Experience with Ford Fuel Cell Vehicle Fleet Operations

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1 Introduction

Looking back the long road of electrification of vehicle (beginning with the first battery powered vehicles back in the days that outnumbered the ICE vehicles) the challenge remained unchanged: the energy to propel the vehicle has to be carried on board. We are still looking to find high density, light weight, affordable, safe forms of energy to place them in our vehicles. Since it surfaced to our minds that crude oil is not as abundant as we had thought, we are looking to find other sources of energy that we can use without emptying our stocks. Also, with the density of traffic specifically in the big cities augmenting, the need to reduce pollution from this badly needed form of transportation gained a bigger momentum and lead for example to the Californian Clean Air Act that demands a certain percentage of zero emission vehicles.



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Figure 1: Main Module of the Ford Focus Fuel Cell.

Hydrogen in combination with a fuel cell onboard a vehicle was one possible way that promised to catch up on our conventional cars in terms of performance pretty soon. Ford has decided to team up with Daimler in 1998 to form an alliance and develop fuel cell and hydrogen powered vehicles that should not bear the taste of golf cart battery driven vehicles but regular, every customer standard cars. With hydrogen being well known, but not

available at the pump, the OEMs had to join projects with energy supplying companies to solve the problem with providing fuel to the fleet. Fleet being here the entity of all H2-driven vehicles no matter which OEM labels the hood.

Thus, we are part of world wide vehicle demo projects (USA, Canada, Germany, and Iceland) nestled around the hydrogen infrastructure. We, the Ford Research Center Aachen, represent and operate the Ford Fuel Cell Vehicle (FCV) fleet in Germany. As partner in the Clean Energy Partnership in Berlin that was founded in 2002 we deployed 3 vehicles in customer hands in Berlin. In fall 2004 we celebrated the inauguration of the first public H2 fueling station, which operated through 2008. In spring 2005 the vehicles were handed over to our customers.

Since that time we gained a tremendous amount of customer insight, technical data, public events and feedback from technical and non-technical over business related and emotional statements. The most important findings could be characterized in the following.

2 Vehicle Technology

The initial phase of the demo project was planned for three years. All design and engineering was done to prove a three year life cycle of the Focus FCV. The uptime of the fleet was targeted at 85% but exceeded the expectations and averaged at about 92% of vehicle availability. The vehicles robustness showed to be better than anticipated leading to an extension of the fleet in customer hands though end of 2010 for the Berlin CEP. Other programs extended the vehicle use as well (Canada) or even stocked up like Iceland that actually received ten additional vehicles in January 2010 due to the fact that the DoE project in USA was terminated according to schedule. The US Department of Energy did decide not to extend the program due to the financial situation.

Ford wouldn't have opted for this proceeding without being sure to not create a financial burden to the stretched out budgets in nowadays. The cost for maintaining the fleet has been proved to be lower than anticipated.

3 Hydrogen Infrastructure

Given the fact that no hydrogen refueling infrastructure was available and that there was no fall back – standard refueling procedure, it became obvious even early in the project that one OEM by itself could not handle this approach. Pretty fast agreements on standards such as fueling receptacle and safety proceedings or fuel quality could be installed. Most of the hardware for example was modified from the technology that was used for natural gas (CNG) powered vehicles that also are the result of search for alternative fuels. This puts us in the position that even at the beginning of demo rallies around 2002 world wide the vast majority of all existing hydrogen powered vehicles could be flawlessly refueled on any given hydrogen station. The SAE standard J2600 was issued as early as October 2002 to cover this piece.

So now we can focus on making the refueling process even faster and more robust instead of making sure that a vehicle could be fueled at all.



Figure 2

4 Customers

We like to address the users of our vehicles as customers but also as development partners. Knowing that we placed an all new technology from the labs into real world, we tried to link our customers to their new vehicles technically and emotionally. Ford chose the approach to have down to earth vehicles, that means other than the decals the car looks, feels and handles just like an ordinary MJ 2004 US Focus. We at one part decided to do so to underline our commitment to deliver solid, affordable vehicles to the everyday customer without exaggerated technological display externally. If the technology was that different from the known, at least the vehicle should look familiar. It turned out that this was taken differently by the users of the vehicles: No one could tell that this was not an ordinary vehicle but an elaborate piece of the engineering department. After all, even if you are running an environmentally friendly vehicle, one should see what your ride is all about. At the beginning of the program we took larger efforts to make the technology – not only the vehicle handling – known and understood for our customers. Mostly our drivers have developed a relationship to "their" vehicle. We received positive feedback from the usage and customers that acted as multipliers in spreading the word about Ford's sustainable activities. It must be kept in mind that the majority of people have only driven one FCV by one supplier and cannot compare with the technology of other suppliers. The only reference to compare with is the regular internal combustion engine allowing for comparing with a vehicle technology that is in extensive usage since over 100 years. We will not forget the complaints we got during this project. Amongst fuel cell specific and non-fuel cell related topics, we learned that the customers were suffering from the very few H₂ refueling stations that forced them to cross downtown Berlin from East to West during rush hour. We all can imagine how this affects mood – no matter what vehicle you are driving.

5 Public Education

One important part of the fleet operations was and is still to make the public and opinion leaders aware of the capabilities of the fuel cell technology. We participated in public events (60th Anniversary of North Rhine Westphalia, Open House at the Federal Ministry of Transport, Building and Urban Affairs (BMVBS), Night of Science Berlin etc.) or supported small events like projects on schools with show and tell of our vehicles. Another part was road demonstration with rallies, like the 2009 from Oslo to Stavanger for the opening of the Norwegian Hydrogen Highway. Being out and about with the FCVs it was not easy to spread the essence of the technology and why it is so important to look for an alternative to conventional cars. The public has quite some misconceptions when it comes to hydrogen (the Hindenburg, the Challenger, the Apollo program etc). The German translation of fuel cell is rather misleading and the bridge to a technical device that is generating electricity is not easily built. Only since a couple of years the subject of environmentally friendly technologies and alternative propulsion systems finds its way to the curriculum in our schools. Over the past 5 years we had more requests to go into middle schools and explain our vehicles as well as the job description of modern engineers.

6 Lessons Learned

So, what have we learned from all this? Why all the effort when now it seems that everyone is voluntarily jumping back to pure battery powered vehicles?

The answer might be as simple as Fuel Cell Vehicles are driven by an electric motor without having the fall back of an internal combustion engine. All components and accessory drives are electrical. Hybridization takes place between the usage of the fuel cell and the HV battery. Electrical safety has to be considered since we are dealing with voltages above 60 V DC.

Engineers are required to be thinking out of their well known box.

Energy providers see those vehicles not as a mono-directional sink for what they provide but rather as a bi-directional usage that they want to look into to be more efficient in the usage of our precious resources.

As for the fueling infrastructure where nothing substantial was available we used the existing work from CNG technology and modified it to suit the needs for the H2 infrastructure. Since nothing was pre-set there, achieving common standards (see SAE J2600) was relatively easy and lead to a common understanding of the hardware equipment of a fueling station. Surprisingly, all OEMs agreed on one solution pretty soon. For the recharging infrastructure for battery electric vehicles we have some more work to do.

We also discovered that besides the challenges to bring flawlessly operating BEV to the market, the public embraces this technology a lot more than they did with FCVs. Maybe this comes from the fact that everyone changed batteries at least once in their lifes on the flashlight – hardly anyone who handled hydrogen at all.

Ford still believes that the long term solution will be supported by hydrogen/fuel cells and that BEV will be around as well. We found a lot of synergies in both fields and engineers that worked on fuel cells bring a great knowledge to work on battery vehicle technologies as well.