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HYCHAIN: Assessment of the Development and Deployment of Several Fleets of Small Hydrogen Powered Hybrid Vehicles

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The HYCHAIN MINI-TRANS project is one of the three leading EU demonstration projects for hydrogen as an alternative fuel (2006-2011). HYCHAIN MINI-TRANS is an integrated project of 24 partners that received 17 M Euro funding under the EU FP6 and is coordinated by Air Liquide S.A.

The project focuses on the development and the deployment of several fleets of small hybrid vehicles (50) powered by hydrogen fuel cells. It includes fuel cell tricycles, utility vehicles, buses, wheelchairs and scooters. These vehicles are deployed with the accompanying hydrogen refuelling infrastructure in four regions of Europe: Grenoble/ Rhone-Alpes (F); Modena/ ER (I); Soria/C&L (S); Emscher Lippe/NRW (D).

Important lessons have been and will be learned on the experience of deploying fifty fuel cell vehicles, thus providing a precious feedback to position hydrogen as an alternative energy carrier for the transport market. The objective of this paper is to address the challenges which have arisen during the development phase and at the beginning of the operational experience.

We have limited the discussion to the main lessons drawn from the experience in five critical areas: technology; commercial feed back; homologation process; public acceptance and the management approach of a large scale complex project, such as HYCHAIN.

1 Technology and Industrial Approach

Developing and deploying several fleets of innovative hydrogen small size vehicles in five years became quickly very challenging. Many tasks had to be done in parallel and, in many instances, these tasks were interrelated. The risk analyses, the homologation approach, the desired level of industrialization, had an impact on the technological definition of the products. Many loops of design reviews were necessary and, inevitably, this delayed the development of the products, thus their launch on the market.

A key challenge was to have a light weight, high pressure, hydrogen cartridge with a quick connection in order to allow for an easy and safe even exchange of the H2 tanks. It became rapidly an ambitious objective as this meant developing jointly a 700bar composite Type IV cylinder and the associated high pressure connection. Many tasks had to be achieved in parallel, revealing their own difficulties. Currently the project is in the process of resolving the last reliability issues by doing field tests with a demonstration vehicle at 500bars. This is the

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pressure for which the highest reliability ratio was obtained. We are currently monitoring the last two important parameters for high pressure systems: tightness solutions and high precision mechanisms. The difficulties to elaborate such a cartridge were probably underestimated but we did managed to acquire valuable knowledge on high pressure design, manufacturing, and testing that will be used to develop the next generation of quick connect high pressure valves and high pressure composite cylinders.

To deploy the Hychain vehicles, Air Liquide defined and validated hydrogen cartridges using conventional 300bar components. All the vehicles, except the Midibus which uses fixed tanks, are built around homogeneous systems, using standard components and generating some industrial savings. Yet, the limited quantity of vehicles, the limited numbers of suppliers, and the absence of common standards – at that time – kept the costs at a high level compared to the project targets and obviously, there cannot be any comparison with the automotive industry. This had an impact on the commercial side.

2 Homologation – Certification

At the start of the Hychain project, no standard or directive was in place to support the homologation process for hydrogen vehicles. Some drafts directives existed and were used by the local authorities to assess the vehicles. So for Hychain, the homologation became vehicle specific, then country specific, and sometimes, contact specific. This generated a multiplicity of contacts, requirements, tasks, tests and reviews. The homologation of the utility vehicle, for instance, lasted significantly longer than planned, delaying furthermore the commercial phase and the start of the deployment.

Despite these difficulties, HYCHAIN was successful to obtain homologation for all vehicles in most countries: Certification for the wheelchair and the Cargobike; Homologation for the utility vehicle and the Midibus.

The Midibus was already homologated in Germany and Spain using a vehicle single type approval approach.

Wheelchair:

The HYCHAIN wheelchair, as Class 2 medical device, was auto certified by the manufacturer. The standards applicable to electrical wheelchairs were the starting point for the certification. The hydrogen aspects were treated with a certified laboratory (TUV-Sud) which tested the wheelchair according to the standard for electrical wheelchairs and analyzed the H2 system according to HYCHAIN's risk analysis and the installation's requirements described in the draft EIHP. The ISO 7176-21:2003 conformity certificate for the HYCHAIN wheelchair was obtained in June 2009.

Cargobike

The Cargobike was also auto-certified. The existing European directive, exempts from model authorization for the two-wheeled or three-wheeled vehicles. The vehicle integrator declared conformity according to the draft standard for electrical bikes (prEN 15194). Regarding the H2 system, the approach was based on the risk analysis performed by the HYCHAIN partners during the project.

Utility vehicle

The process for the UV has been long and demanding. The path chosen by the vehicle integrator was to homologate the utility vehicle country by country through a small series, light homologation request. It was a single vehicle type approval, not a global approach. This resulted in multiple exchanges with the authorities and in many cases additional tests on the base vehicle had to be performed at each request. In our case, most of the discussions were focused around the base vehicle and not around the Hydrogen system or the fuel cell systems. This is an important lesson: the choice of the vehicle base can impact the homologation strategy.

It is clear that the coming European directive on fuel cell vehicles will make the homologation process global as it will be accepted as a reference to work with by all the European countries and all manufacturers (vehicles and components).

Scooter

At this point of time, the scooter is starting its homologation process using a single vehicle type approval approach for an operation in Spain. Its development took much more time than foreseen due to the required high integration level. Building a fuel cell scooter is not only very challenging from a design perspective but it is also difficult for safety reasons. The fuel cell integration issues and the late availability of the high pressure Hydrogen cartridge (required to provide an adequate driving range) caused a major delay. In the end, the deployment of the scooter was not possible since it was not homologated at the start of the deployment. However it was decided to complete the homologation and to capitalize on the experience from this process.

Authorities

With the exception of Germany, the local authorities lacked experience regarding the hydrogen and the fuel cell homologation aspects. They showed a serious interest in the HYCHAIN vehicles and the hydrogen fuel cell technology. All the representatives involved were enthusiastic and supportive to define the requirements. In some cases, the authorities relied on the expertise of a third party, such as certified laboratory. We can safely say today that thanks to this process, homologation of hydrogen and fuel cell vehicles has moved a step forward in all the four HYCHAIN countries since the local authorities have considerably increased their knowledge.

Today all the deployed vehicles are certified or homologated (with the exception of the utility vehicle for France). This achievement was a key project milestone as it allowed for the deployment of the HYCHAIN vehicles, their operation and the associated demonstration tasks (training, data gathering, support, dissemination)

3 Commercial Challenges

The commercial experience of HYCHAIN provides a valuable feedback to position hydrogen as an energy carrier in new market segments for sustainable development and to test the commercial acceptance of this technology. The HYCHAIN vehicles were mainly targeted – for infrastructure reasons - to the customers with the capacity to deploy captive fleets (municipalities or private company). There are many advantages: maintenance is local;

technical support and training are offered to identified users and the hydrogen supply chain is centralized and controlled.

Several business models were studied and tested with the targeted customers. Most of the discussions with the customers were focused on the price of the vehicles in comparison with a standard combustion engine version (CAPEX) and the associated energy cost (OPEX), leveraged with the ecological image and the HYCHAIN communication package.

The HYCHAIN offer had many positive aspects.

- Most of the products fit well the targeted customer needs: a medium size passenger transportation vehicle (Midibus), a light duty vehicle (utility vehicle) and a small size duty vehicle (Cargobike) for “last mile” type of urban transport.
- Environmental benefit of using an electrical vehicle powered by a hydrogen fuel cell
- Technological benefits (increased driving range and reduced recharge time) compared to standard battery electrical vehicle.
- Wide exposure for the customers through HYCHAIN, around a demonstration project of high visibility and around an innovative technology.

Yet, the commercial objectives turned out to be very challenging; only 50 vehicles were sold compared to the initial target of 158. There are several reasons to this situation, some are structural, and others are HYCHAIN specific.

The main blocking factor was the cost of buying and operating the vehicles. The customers have all the figures in hand to compare with standard combustion vehicles of their own fleet. In some business cases, the calculated cost of ownership reached three times the standard ownership level of a diesel powered vehicle.

Another interesting point was related to the hydrogen local storage. In some cases, the premises were not suited to receive hydrogen or to maintain fuel cell vehicles, and the necessary investments (ventilation, H2 detectors, separate compounds…) were viewed as too costly by the customer.

Finally, the commercial challenge for the HYCHAIN partners was inherent to the delay in the development and the homologation of some vehicles. In most cases, the vehicles were not available for a test by the customer. Selling innovative vehicles via a presentation helps generate interest in the mind of the prospective customer. But it is not sufficient to finalize the sale when the discussion falls down to the price review. Being able to show the vehicle in its operational environment would have certainly improved the sales figures. The main lesson that we learned is that the market is not ready to pay substantial premium for new “green” technology. The need for state aids remains very strong.

4 Public Acceptance and Products

The public acceptance and the targeted groups’ acceptance were always very good. There is a real interest in an innovative environmental alternative fuel. With the first deployed vehicles (24), we are already starting to get operational feedback. The HYCHAIN partners set up many tools to monitor the performance and to assess the acceptance of the hydrogen fuel cell technology. However at the start of deployment phase, the utilization ratio was not ramping up as quickly as we expected. There is a first lesson to be drawn from this

observation. Some vehicles, mainly the wheelchair and secondly the Cargobike, were not well positioned and lacked end users willing to operate them. This highlighted the importance to have products which are well adapted to the end users. Products which target a large base of users and can be operated in all kind of circumstances.

We also learned that the users need extensive and close accompaniment by the HYCHAIN partners to overcome reliability issues that are normally encountered and expected in a demonstration project of this kind in order to build trust in the technology. Accompaniment turned out to be essential as the customer's expectations can be very high. They expect to be able to use the vehicle as a normal vehicle with equivalent performance. This was the case in Soria, for instance. In Germany, the expectations were more in line with the reality of the products. This is probably due to the fact that German customers are already participating in H2 developments (e.g. Herten).

5 Managing a Long and Complex Project with 24 Partners

The management of HYCHAIN is clearly a success story thanks to the structure that was adopted. The management is centralized in an executive board of four people where each of the members represents one of the four involved regions. The local and centralized management has contributed to steer without conflict and overcome successfully the difficulties encountered during the project execution with the agreement of all the partners. The collaborative relationship between the local regional representative, the HYCHAIN partners and the political organizations contributed efficiently to the successful implementation of the project in each region.

6 Conclusion

HYCHAIN MINI TRANS has already achieved one of its most significant objectives. From its first feedback, we are able to draw many valuable lessons for the implementation of hydrogen and fuel cell technology. It shall continue to do so, as more vehicles are used for longer time. HYCHAIN is paving the way for future projects.

With the precious inputs, it gives sound economical models related to the Hydrogen fuel cell technologies and their implementation in the transportation domain. The HYCHAIN experience has clearly proven to be one of the cornerstones to launch this new technology.

HYCHAIN MINI TRANS has involved more than 200 staff who will be able to capitalize on their experience. Definitely, there is room for improvement of the products and there are many opportunities to reduce the cost structure for Hydrogen and fuel cells. However, it is obvious that larger volumes of vehicles are needed to achieve the critical mass and allow standardization and cost reduction

Project partners

Hychain partners are Air Liquide SA, AXANE, BESEL, WIN, Air Liquide Italia, CEA, INERIS, INPG, PAXITECH, ASCOPARG, Air Liquide España, CIEMAT, DERBI, RUCKER, CEU, DOMENECH, IBERDROLA, WI, HYDROGENICS, MASTERFLEX, FAST, VEM, DEMOCENTER, Air Liquide Deutschland