

*EVS30 Symposium
Stuttgart, Germany, October 9 - 11, 2017*

Hydrogen Mobility France – De-risking the rollout of hydrogen vehicles and infrastructure in France

A. Stewart, F. Ferrari, V. Bouillon-Delporte

¹*Alex Stewart, Element Energy, Terrington House, 13-15 Hills Road, Cambridge CB2 1NL, UK,
alex.stewart@element-energy.co.uk*

²*AFHYPAC*

³*AFHYPAC*

Summary

The Hydrogen Mobility France coalition brings together vehicle manufacturers, refuelling station manufacturers and operators, and major energy companies. The coalition has developed a low cost, low risk strategy for vehicle and station deployment, using a unique combination of captive fleets, low cost stations and multiple vehicle types (from cars and vans to trucks and buses). The strategy includes a clear transition to full hydrogen mobility for passenger cars in the medium term, while reducing the investments required and associated risks in the early years of the rollout. Elements of this strategy have now been adopted in other leading hydrogen markets.

Keywords: hydrogen mobility, transport, fuel cell electric vehicles (FCEVs), hydrogen refuelling stations (HRS), range-extender

1 Project overview

The Hydrogen Mobility France coalition was created in 2012, and brings together vehicle manufacturers, refuelling station equipment suppliers and operators, major energy companies and regional development groups. The group carried out a one-year analytical phase to develop an aligned strategy for the early deployment of vehicles and stations, taking advantage of France-specific factors such as the presence of low cost range-extended fuel cell vehicles and relatively low cost, low carbon electricity available for use in water electrolyzers for hydrogen production. A key element of the strategy was to reduce the initial investment needs for refuelling stations and the associated demand risk, by ensuring a minimum hydrogen throughput from nearby captive fleets. This approach yields profitable refuelling stations earlier than an approach based solely on privately-owned passenger cars, while allowing a transition to full national mobility that is fully compatible with neighbouring markets such as Germany and Benelux.

Since the completion of the French hydrogen strategy, the group has remained highly active in deploying the first 20 stations and hundreds of fuel cell vehicles in France, collaborating in funded projects at a national and European level, while continuing to test new business models and prepare for the arrival of new vehicles from major manufacturers before and after 2020. The work has been highly successful in

stimulating capital investments in French equipment manufacturers, raising political awareness of hydrogen in local and national governments, and positioning France as a leading international market for fuel cell vehicles alongside Germany, the UK and Scandinavia. The Hydrogen Mobility France coalition (along with the three other leading initiatives on hydrogen mobility) participates in the FCH JU funded H2ME project, working to remove market barriers in order to create a truly pan-European hydrogen network and a united deployment strategy across Europe.

2 Description of the deployment strategy

2.1 Study methodology

The first phase of the coalition’s work developed a strategy for deploying vehicles and refuelling stations in France [1]. The strategy integrated the following elements:

- Detailed data collection on the costs and performance of fuel cell vehicles and refuelling stations from the present day to 2030
- A Geographical Information Systems-based analysis of the French road network and population centres to define the optimal placement of early stations
- A hydrogen production strategy, balancing conventional and green hydrogen production from water electrolysis, and ensuring very low well-to-wheels emissions from fuel cell vehicles
- A financing strategy, based on maximising throughput at early stations, and focusing on captive fleets in major cities before connecting these clusters and the wider population
- A detailed transition strategy, which defines ‘triggers’ such as cost-effective second generation passenger cars that would begin the shift to a national refuelling station network

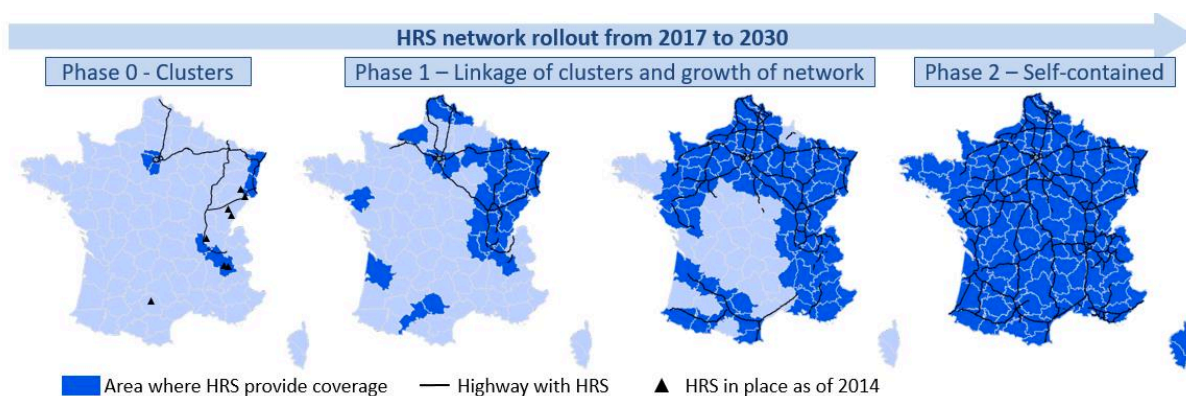


Figure 1: The geographical strategy for hydrogen stations in France

2.2 Deployment strategy for vehicles

The vehicle deployment strategy in France is based on a variety of vehicle types, ensuring that fleet operators can use fuel cell vehicles for as wide a range of missions and duty cycles as possible, in turn maximising demand for hydrogen in the early years of the rollout. Deployments to date have been split between range-extended fuel cell vans and ‘full power’ passenger cars deployed by established constructors. Range-extended vans are produced by SymbioFCCell in France, and are based on the Renault Kangoo ZE battery electric van. By integrating a small fuel cell and hydrogen tank into the vehicles, the ‘HyKangoo’ can drive over 300km between refueling events. This maximizes flexibility for operators with long daily distances, or operating in hilly or cold regions where battery electric vehicles’ range are

adversely affected. Approximately 150 HyKangoos have been deployed to date in a wide range of fleets including the French postal service, major utilities, logistics companies and the fire service. In each case, deployments are focused in ‘captive fleets’, where vehicles have predictable operating areas and return to the same place each day. This ensures that all operations can be completed, even with a single hydrogen refueling station in the area. The use of captive fleets has a further benefit of providing certainty to refueling station operators on likely hydrogen demand before a station is constructed, since operators and vehicle suppliers can provide evidence of their commitment to buy vehicles once the station location is finalized.

The other vehicle type deployed to date is fuel cell passenger cars from Hyundai and Toyota. These are primarily used in Paris by a zero emission taxi company. By operating the vehicles 24 hours per day with multiple drivers, the additional capital cost of the vehicles per kilometer is reduced, and the resulting high daily hydrogen consumption helps to improve the economics of HRS. Demonstrating the viability of zero emission, fast refueling taxis in large cities has an important secondary benefit, as it allows local governments to introduce ambitious air quality policies without negative impacts on taxi services and passengers.

Beyond vans and passenger cars, hydrogen can be used in heavy vehicles such as trucks and buses. The high daily hydrogen consumption of these vehicles is particularly helpful in improving the utilization of early refueling stations. Table 1 illustrates the daily consumption of different vehicle types and the number of vehicles required to provide 50kg of daily demand. Based on the current economics of hydrogen retailing, reaching this threshold allows acceptable annual revenues from the earliest operations, while justifying deployment of relatively large (100-200kg/day stations) that are highly profitable in the long term with further increases of demand. A single refuse truck consumes the same amount of hydrogen as 5 taxis or 20 passenger cars in private use, and a small fleet of 5 trucks is sufficient to provide 50kg/day of daily demand at an HRS. While truck and bus operators are likely to install refueling facilities in their depots in the medium to long term, in the short term there are likely to be opportunities to share refueling stations between vehicle types to minimize investment costs and maximize load factors. Even where heavy and light vehicles use separate refueling stations, this still creates economies of scale for hydrogen production and transport, and secondary services like maintenance which all contribute to a decrease in costs for end users.

Between 2017 and 2020, the Mobilité Hydrogène France strategy calls for continued deployments of passenger cars and small vans in the order of several thousand units, with the first deployments of buses and fuel cell trucks taking place in parallel. Beyond 2020, a significant increase in light vehicle sales is expected to follow the introduction of lower-priced ‘second generation’ passenger cars from mainstream constructors.

Table 1: Illustrative hydrogen consumption for a range of vehicle types

	Daily hydrogen consumption (kg)	Number of vehicles required to provide a 50kg ‘baseload demand’
Passenger car (private use)	0.5	100
Passenger car (taxi)	2	25
Range-extended fuel cell van	0.3-1	50-150
Refuse truck	10	5
Bus (12 metre)	20	2.5

2.2 Deployment strategy for HRS

The long term aim of the French hydrogen mobility strategy is to enable full national mobility for all vehicle and user types, including linkages to other countries to allow cross-border travel. The key challenge in realizing this aim is balancing the need to minimize investment costs and underutilization while offering maximum convenience to customers. The vehicle strategy based on captive fleets (as described above) helps to overcome this short term challenge, by aggregating demand from fleet operators to reach an acceptable daily hydrogen consumption and reduce losses from operating the early stations. This is in contrast to other national hydrogen mobility strategies in Europe, which focus on building a minimum viable network irrespective of vehicle demand, which provides a ‘future-proofed’ network but creates higher risks of underutilization in the short term.

The HRS deployments in France will be phased, with initial stations in ‘clusters’ where there is strong local demand for hydrogen from vans or passenger cars. Some of these clusters are in France’s largest cities (such as the greater Paris area, Lyon etc.) but others are in smaller towns and cities where there is strong political support or interest from local fleets. During this first phase, connections between cities are a lower priority since taxis and vans have relatively well-defined operating radii and do not often travel long distances between regions. As stations are deployed in more and more cities, natural corridors begin to form that enable travel across the region or between regions. For example, within the Auvergne Rhône-Alpes region of France, stations serving local demand in Lyon, Mâcon, Montelimar and Valence would naturally form a corridor of stations on the main motorway between the north and south of France. Wherever possible, stations are being deployed on sites that are accessible by both local fleets and passing traffic, avoiding duplication of sites and maximizing hydrogen throughput at each one. Following this captive fleet phase, a greater emphasis will be placed on the ‘missing links’ between existing HRS such as on the strategic network, while continuing to build up the network with multiple stations in each city to minimize queuing and the need to cross cities. Station specifications will also be tailored to the types of user expected; early stations will sometimes be deployed with a 350 bar capability to minimize investment costs; however, where passenger car traffic is expected in the short and medium, dual pressure 350 bar and 700 bar refueling stations will be deployed. The expected phasing of the stations is set out in Figure 1.

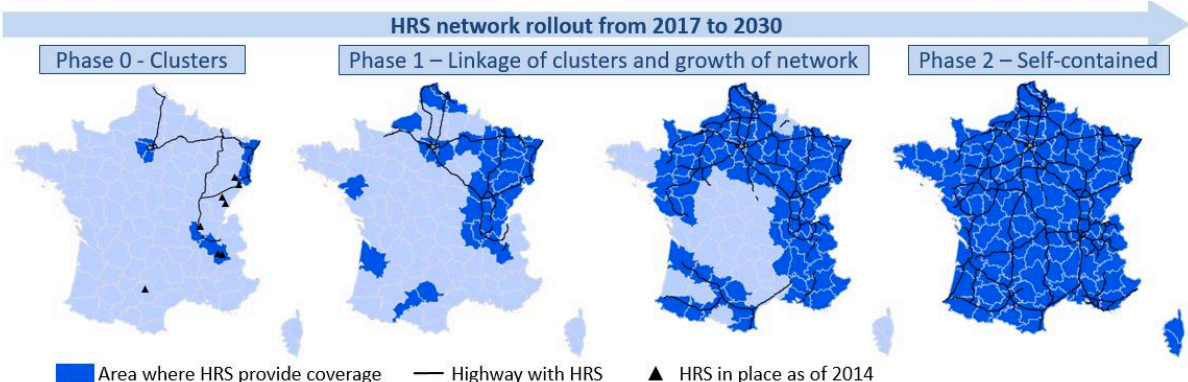


Figure 1: The geographical strategy for hydrogen stations in France

The economics of deploying a hydrogen refueling station network are similar across the various ‘launch markets’ for fuel cell vehicles such as Germany, Scandinavia and the UK. In each case, they are characterized by early investments that are lossmaking due to underutilization, followed by the build out of a profitable network synchronized with vehicle sales in the 2020s. The aim of the French deployment strategy is to minimize the investment costs and risks during this early phase, while also preparing the market for rapid deployments of next-generation vehicles.

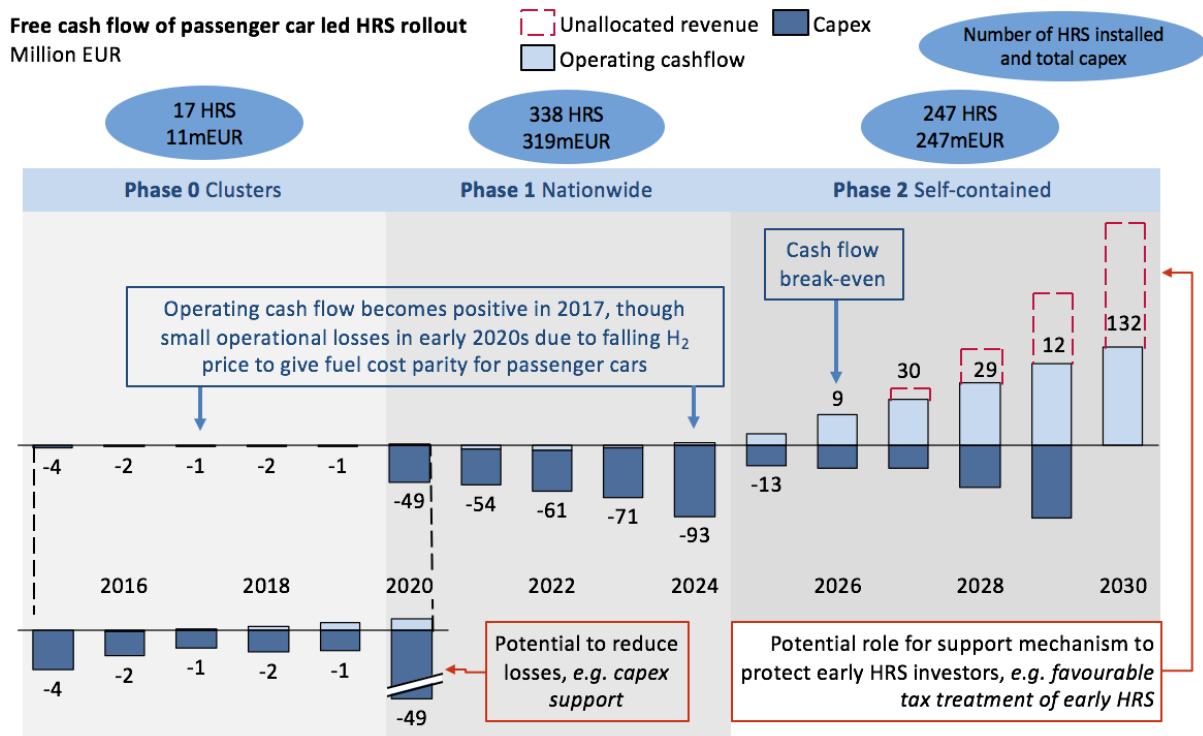


Figure 2: An illustration of the expected cashflows from the HRS network in France

The hydrogen used in vehicles in France will be produced from a number of sources, making use of renewable electricity through water electrolysis and existing industrial capacity (for example by-product hydrogen from chloralkali plants). The majority of the stations funded to date have used on-site water electrolyzers, which eliminate truck distribution costs when daily demand is relatively low. This also maximises the greenhouse gas savings of fuel cell vehicles compared to petrol or diesel, given the high proportion of nuclear and renewables in the French electricity grid mix. In the longer term (beyond 2020), hydrogen demand in cities is likely to grow to a level that makes truck distribution economically viable, since a truck can service multiple stations in the same area. This opens up additional production possibilities, for example ‘centralised’ electrolysis where the production plant is co-located with renewable electricity generators to avoid distribution costs and absorb surplus renewable energy that would otherwise have to be curtailed to ensure grid stability.

3 Implementation of the strategy and monitoring

Since the development of the strategy, the H2M France coalition has continued to collaborate on the first implementation phase, deploying the first 20 stations and hundreds of vehicles (with 10 stations in service so far). This includes participation in the FCH JU-funded H2ME and H2ME2 projects, stations funded by the Connecting for Europe Facility, and national French funding. This early deployment phase is intended to test the technical capabilities of both vehicles and stations, as well as the operation of electrolyzers to support the electricity network. It is also intended to confirm the viability of the captive fleet business model, whereby a minimum level of hydrogen demand is ‘guaranteed’ by local fleets before stations are deployed.

In parallel with supporting these early deployments and monitoring the technical and economic results, strategy work continues on the next phase of the rollout, which focuses on the transition to new user and vehicle types (such as passenger car-based taxis in major cities and delivery and refuse trucks). The transition strategy will ensure that international actors (particularly car manufacturers) view France as an attractive market for deploying their current and next generation vehicles, and confirm that the lower cost early strategy based on captive fleets can be fully compatible with long-term national mobility. The coalition is also working closely with other leading hydrogen markets on the lessons learned from the

French strategy, which has resulted in several other countries introducing the captive fleet approach into their own national strategies to reduce costs and demand risk.

The presentation at EVS30 will provide the latest insights from this ongoing work, including the technical and economic results, and lessons relevant to other markets both in hydrogen deployments and those of other low carbon fuels.

Acknowledgments

This project was supported by AFHYPAC (L'Association Française pour l'Hydrogène et les Piles à Combustible), and the members of the H₂Mobility France coalition (Air Liquide, AREVA Stockage d'Énergie, CEA, AREVA H2Gen, ATAWAY, EDF Eifer, ENGIE, H2 Logic, HDF, Hyundai, IFPEN, INEVA-CNRT, Intelligent Energy, IDEX, ITM Power, Linde, Michelin, McPhy Energy, Plateforme de la Filière Automobile, Pôle Véhicule du Futur, PHyRENEES, Pragma Industries, Renault Trucks, Serfim, Solvay, Symbio FCell, Tenerrdis, WH2 with experts from ADEME, DGEC and FCH-JU).

References

- [1] Mobilité Hydrogène France - Study for a Fuel Cell Electric Vehicle national deployment plan. Available at: <http://www.afhypac.org/mobilite-hydrogene-france/en/>

Authors



Alex Stewart directs Element Energy's low carbon transport team, leading a broad range of projects from technology demonstration, strategy development for rolling out new technologies and providing policy advice to local and national governments. Alex led the analytical work during the first year of the H2M France coalition, and continues to co-ordinate the coalition and support the ongoing working group activities.