
WORK PACKAGE 2

FUEL CELL PASSENGER CARS

# DELIVERABLE 2.3

# EXECUTIVE SUMMARY OF WORK PLAN FOR HYDROGEN PASSENGER CARS

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# EXECUTIVE SUMMARY

## Project ambition

FCH JU has funded the NextHyLights partners for their advice and support to be prepared for the demonstration projects on hydrogen and fuel cells for transport under the last three project calls within its MAIP.

For the fuel cell passenger car sector it was decided early in the project to shift the focus away from the development of a full commercialization and deployment plan as this had already been undertaken by the EU Coalition Study. Instead, it has been decided jointly to add a close-up assessment of European regions most committed to actively pursue applying for funds under FCH JU to carry out demonstration (= Lighthouse) projects involving fuel cell passenger cars together with the related hydrogen refuelling infrastructure.

## Programs and European regions commitment

The analysis of international, national and regional / municipal programs to strategically kick-off or support the commercialization of hydrogen fuel cell passenger cars as clean transport technology showed that these are well spread across the world. With distinctions in focus, all programs aim at the same overarching targets, namely to massively reduce GHG emissions, help to diversify energy supply structures away from fossil energy, and support or develop large, medium and small industries in this new field of technology.

In the U.S., California and some other states such as New York, South Carolina or Indiana all have developed individual programs accompanied by a strong federal program. Demonstration programs have always been an important component in the U.S. at all levels. In Asia, both Japan and South Korea have strong programs, well aware of the need to soon commercialize fuel cell technology, mostly pushed by automobile manufacturers. And in Europe a multitude of supra-national, national, regional and municipal programs and initiatives show that governments seem to have finally understood that Fuel Cell Electric Vehicles (FCEV), Plug-in Hybrid Electric Vehicles (PHEV) and Battery Electric Vehicles (BEV) are all part of a wider move towards e-mobility. Also, for the time being, Germany has developed the most ambitious program towards deployment of hydrogen and fuel cell technology with a total budget of 1.4 B€, even surpassing the European program. With the Clean Energy Partnership (CEP) project the demonstration activities are now stretching out across Germany.

The regions' commitment assessment then showed that further regions are following Germany's quest towards rapid deployment, yet with somewhat lower impact as the major industrial driver, the large automobile industry, is either lacking completely in some regions or, caused by a different product portfolio (a product portfolio comprising smaller cars does under the current policy framework not necessitate a

shift away from the internal combustion engines and/or fossil fuels), is not as committed as some of the German manufacturers. It is assumed that the fast following regions will need about 3-5 years to step up to the pace of the German level of ambition, which had set off with the public-private Transport Energy Strategy (TES) as early as 1998.

Individual face-to-face interviews revealed that currently the most committed fast-follower regions all dock to the German hub, an efficient starting point when it comes to a continuous rollout of the required hydrogen retail infrastructure to refuel the fuel cell passenger cars widely with high utilization. These regions are

- Scandinavia with Denmark, Norway and Sweden,
- northern Italy with the regions South Tyrol, Lombardy, Piemonte, Trento and Veneto with the plan to connect to the German hydrogen refuelling infrastructure via
- Austria (Innsbruck),
- the UK with London, the British Midlands, North East England and Wales and
- the Benelux states with the potential hubs Arnhem/Nijmegen and Brussels.

Specifically the Scandinavian regions provide economically relevant conditions with very high vehicle taxes for conventional cars with hydrogen cars (and other clean alternatives) being exempted.

As result from the personal interviews it was also found that those German regions already profiting or expected to profit from the national German policy support within the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP), are standing strong as public-private programs. All of these regions, comprising Baden-Wuerttemberg, the City of Hamburg, Hessen and North Rhine Westphalia, have stated that in principle they are willing to also participate in AIP 2011 to AIP 2013, if the funding conditions are not too bureaucratic and are open for co-funding.

Yet, it was a message common to all regions that much work still needs to be done to provide appropriate, efficient, reliable and safe approval and certification procedures (e.g. in Italy refuelling of more than 35 MPa is not allowed, neither may private persons refuel their fuel cell cars).

**Automotive industry's commitment**

The analysis of automotive industry's commitment to hydrogen and fuel cells was undertaken in a phase when the economic crises of 2009 and the fresh wake of the rush towards e-mobility, with PHEV and BEV clearly standing out, have changed the scope of development priorities for some car manufacturers. The more astonishing is the level of recent technical advancement in fuel cell systems technology and the continuously strong commitment in vehicle deployment.

Virtually all basic technological challenges have been solved (see Figure 1 and Figure 2), comprising

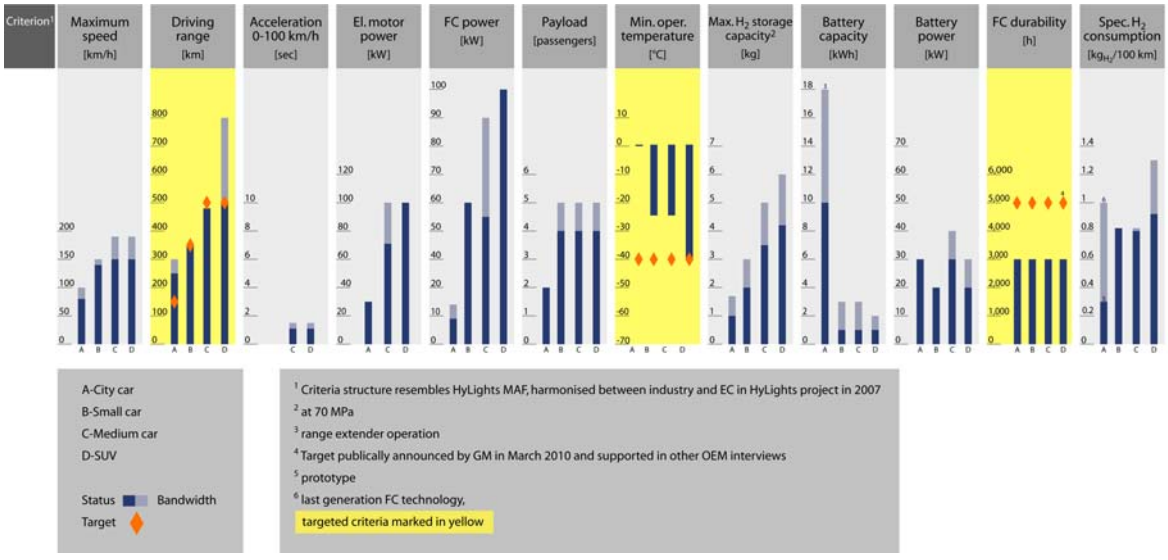
- cold start capability,
- reduction of Pt use,
- hydrogen onboard storage allowing driving ranges of up to 500 km and
- system integration in a way that the next generation fuel cell systems have become compatible with conventional drivetrains for integration in ordinary cars.

**Figure 1: FCEV (passenger cars) performance overview**

| Criterion[1] | Unit | City car | | Small car | | Medium car | | SUV | |
|---|---|---|---|---|---|---|---|---|---|
| | | Status | Target | Status | Target | Status | Target | Status | Target |
| Maximum speed | [km/h] | 80 - 100 | - | 140 - 150 | | 160 - 180 | | 160 – 180 | |
| Driving range | [km] | 250 - 300 | 150 | 350 | 350 | 480 | 500 | 500 – 800 | 500 |
| Acceleration 0-100 km/h | [sec] | | | | | 11 - 15 | | 11 – 15 | |
| El. motor power | [kW] | 30 | | | | 75 - 100 | | 100 | |
| FC power | [kW] | 9 – 14 | | 60 | | 55 – 90 | | 100 | |
| Payload | [passengers] | 2 | | 4 - 5 | | 4 - 5 | | 4 – 5 | |
| Min. oper. temperature | [°C] | 0 | -40 | -25 | -40 | -25 | -40 | -40 | -40 |
| Max. $H_2$ storage capacity[2] | [kg] | 1 – 1.7 | | 2 - 3 | | 3.5 - 5 | | 4.2 – 6 | |
| Battery capacity | [kWh] | 10 - 18[3] | | 1 - 3 | | 1 - 3 | | 1 - 2 | |
| Battery power | [kW] | 30 | | 20 | | 30 - 40 | | 20 - 30 | |
| FC durability | [h] | 3,000 | 5,000 | 3,000 | 5,000 | 3,000 | 5,000[4] | 3,000 | 5,000[4] |
| Spec. $H_2$ consumption | [$kg_{H2}$/100 km] | 0.3[5] – 1.0[6] | | 0.85 | | 0.8 – 0.85 | | 0.95 – 1.3 | |

[1] Criteria structure resembles HyLights MAF, harmonised between industry and EC in HyLights project in 2007 [2] at 70 MPa, [3] range extender operation
[4] Target publically announced by GM in March 2010 and supported in other OEM interviews [5] prototype [6] old FC technology
targeted criteria marked in yellow, empty boxes denote "no data availability"

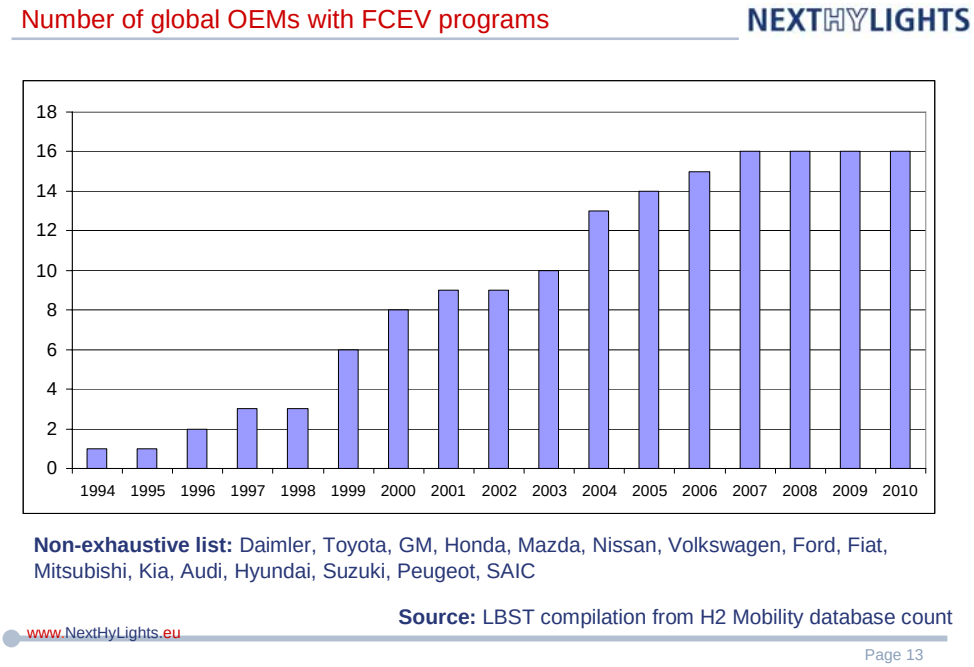
**Figure 2: FCEV (passenger cars) performance overview**



Understanding that the technical hurdles can be overcome in series production, the automobile manufacturers most committed to fuel cell passenger cars (see Figure 3) have now begun to refocus their strategy to

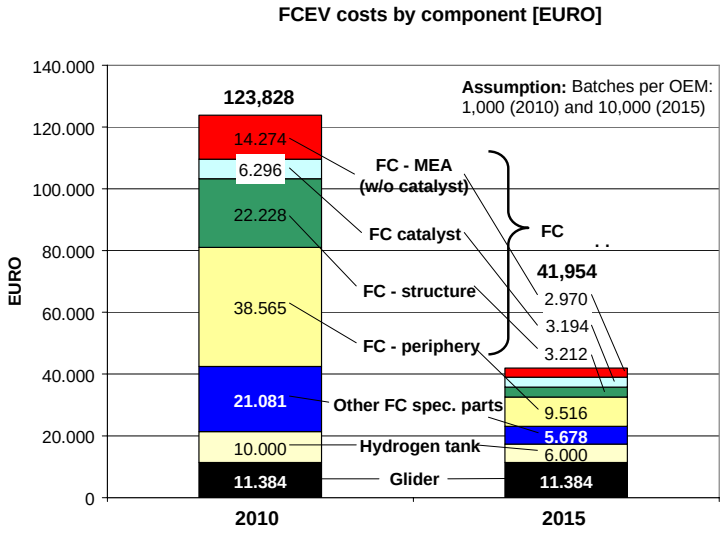
- support energy industry to develop an area-wide hydrogen refuelling infrastructure being the bottleneck to wide public acceptance and
- massive vehicle cost reduction by series production (see Figure 5).

**Figure 3: Automobile manufacturers worldwide developing FC passenger cars**




Specifically Asian automobile companies have already announced they can produce fuel cell passenger cars offering the full customer convenience of ordinary cars under market conditions for prices similar to conventional cars.

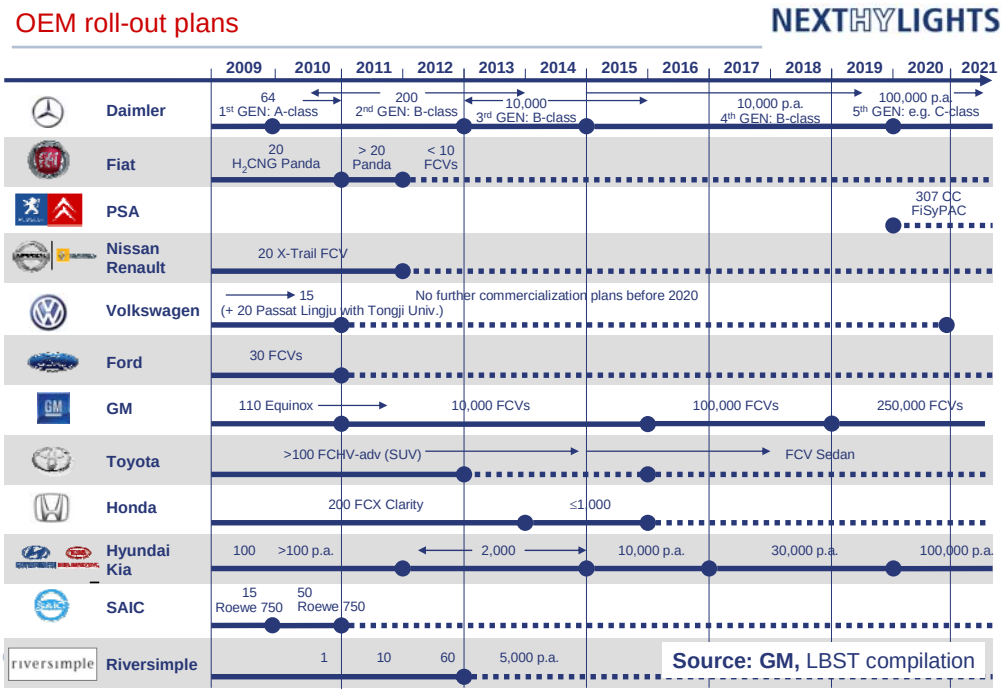
**Figure 4: FC vehicle costs for early market entry**




This commitment is visible in the fuel cell vehicle rollout strategies which have very recently been updated with vehicle numbers produced reaching up to 10,000 in total for individual manufacturers around 2015, also in Europe (see Figure 5). Automobile manufacturers have also contributed clear statements that in order to make fuel cell passenger cars a success in Europe, the framework conditions until 2015 must develop favourably already in the demonstration phase, i.e.

- clear Europe-wide political and widely harmonised support (fuel cell passenger cars becoming an important part of the e-mobility strategies),
- simplified funding conditions and procedures for demonstration projects,
- policy support of efficient fuel cells and $CO_2$-free hydrogen and
- preferential treatment of the new technologies by relevant policy frameworks (e.g. EC Directives) and/or fiscal instruments.

**Figure 5: Worldwide OEM's FCEV rollout plans (passenger cars)[1]**




## Energy industry's commitment

The commitment of energy industry is best documented by its participation in the German H2 Mobility initiative. Eight of the most relevant stakeholders in this field have joined this activity, namely Air Liquide, Air Products and Linde for the industrial gases industry, OMV, Shell and Total for the oil industry, EnBW and Vattenfall for the utility industry. The current plans of this activity foresee the installation of up to 300 hydrogen refuelling stations in Germany by 2015, with about 70 stations being in operation in Europe today (see Figure 7, Figure 8 and Figure 8).

[1] The numbers shown represent a careful assumption, as the focus of NextHyLights was to mostly address the demonstration project phase. As some of the OEMs interviewed were reluctant in disclosing their internal numbers, the numbers tend to show only the lower limit of probable deployment numbers.

**Figure 6: Worldwide HRS rollout strategies**

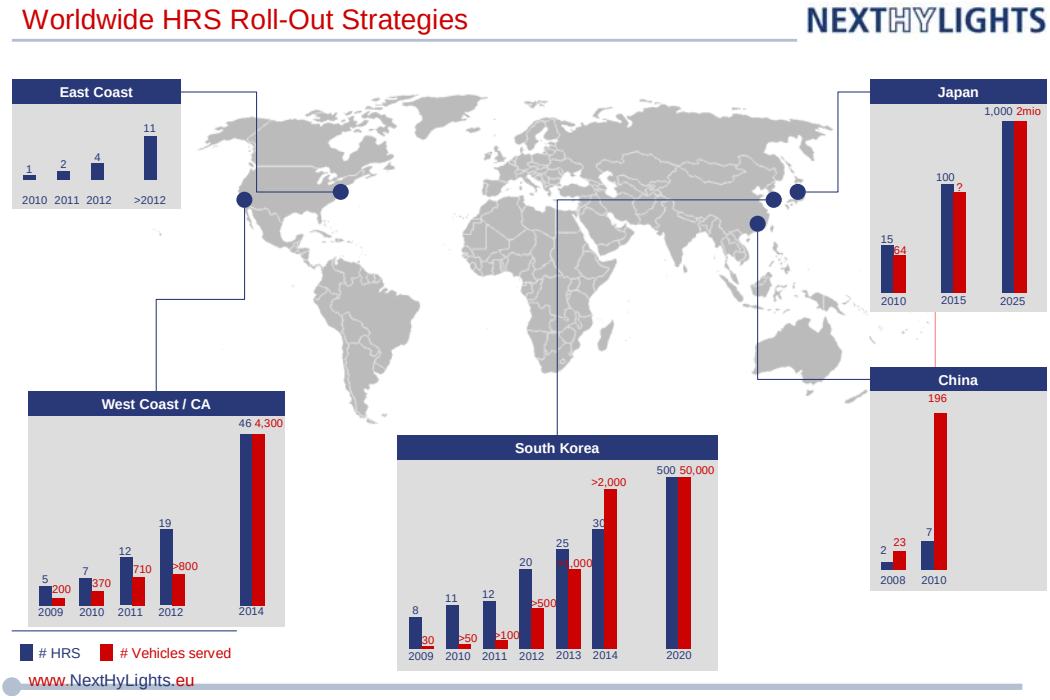
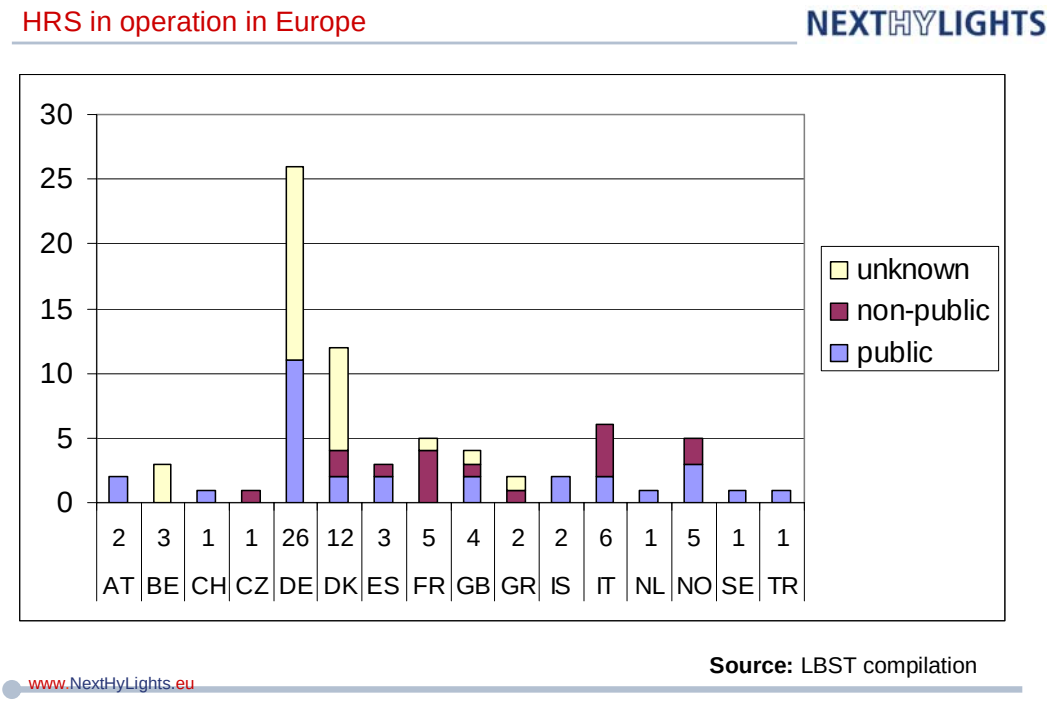
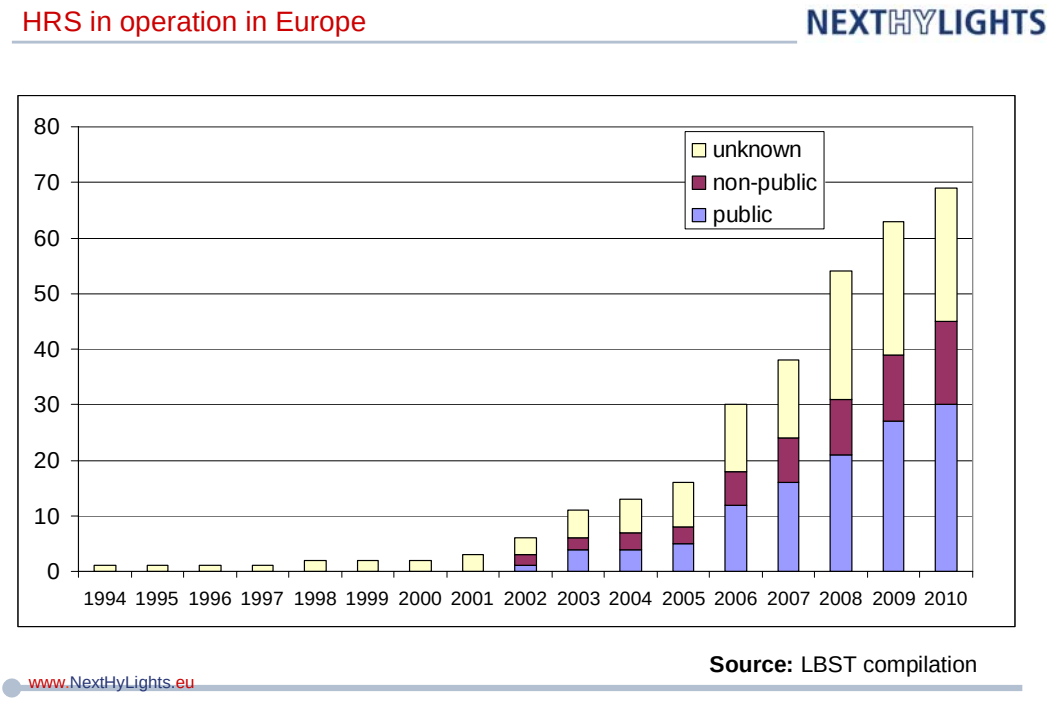



**Figure 7: HRS in operation in Europe – geographic distribution**



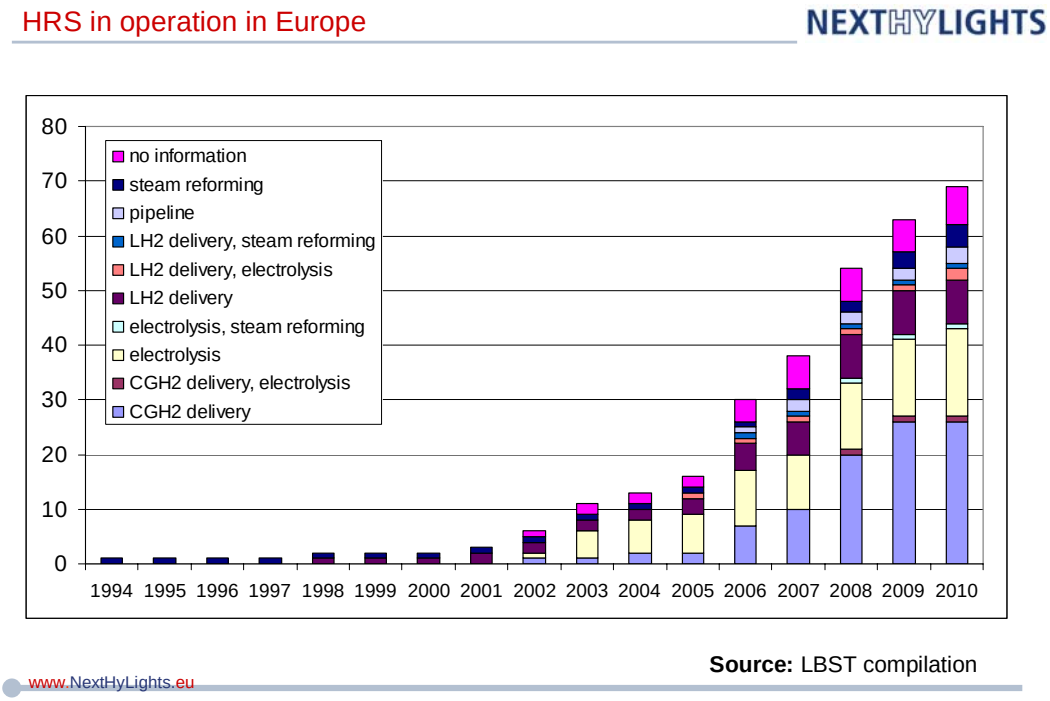

**Source:** LBST compilation

**Figure 8: HRSs in operation in Europe – timely development**




In general the maturity of hydrogen refuelling station technology allows this deployment roadmap even if some technical details such as compressor reliability or hydrogen metering still require some efforts but do not present major hurdles. Today hydrogen provision is based on a variety of input energies (see Figure 9).

**Figure 9: HRSs in operation in Europe – hydrogen supply**




In order to bring the costs of hydrogen refuelling stations down, industry calls for standardization at both station and component level. With the definition of specifications for four hydrogen refuelling station sizes this process is already well underway. Further cost reductions can be achieved by larger order numbers (economies of scale) and technological developments.

Energy industry urges to move away from demo project scale towards market preparation ('market preparation projects') for a commercial launch in 3-5 years. The aspect of focusing and concentration of activities was put in focus by the majority of industry stakeholders as they can no longer afford to dilute their efforts.

### Work plan AIP 2011 to AIP 2013

Based on the information and data collected from automotive and energy industry, and furthermore based on the EU Coalition Study, a sensitivity study has been carried out to scope the size and extent of the coming demonstration projects. This revealed that the Program's ambition should point towards deployment and early market preparation, aiming at e.g. about 300-350 fuel cell passenger cars and about 6 further hydrogen refuelling stations to be deployed as part of the coming FCH JU demonstration projects across Europe. Then a total budget of about M€ 130 will be required to finance this activity.

Given the limited FCH JU funds available for vehicle demonstration in AIP 2011 to AIP 2013 of about M€ 53 (out of which about M€ 32 for passenger cars) and given that automobile industry will roll out their new fuel cell vehicle generation only after 2013, it will be the task of FCH JU to identify ways to

- activate other sources of (co-)funding (e.g. national resources) and
- adapt budgets and timelines (e.g. allow stretched vehicle rollout across project duration).