HYPROFESSIONALS

Grant agreement no.: **256758**

Deliverable No: D8

Gap analysis

Status: FD

(D-Draft, FD-Final Draft, F-Final)

Dissemination level: PU

(PU – Public, PP – Restricted to other programme participants, RE – Restricted to a group specified by the consortium, CO – Confidential)

Author:

Carole Barrau, PHyRENEES

Contributes:

FHa, FSV, FAST, PHYR, EnvP

Author is the contact person for this document.

Date of this document: 12/09/2012

Table of contents

1. Objectives and methodology

1.1. Objectives

The deliverable D8 refers to task 2.1 in WP 2. The objective of the task is the identification and analysis of educational gaps and needs. The task will define a European strategic working plan to launch initiatives and proposals which help to solve the situation in a right way. The initiatives and experiences carried out or on-going, the standards of the different educational systems at different levels and the industry and market expectations/needs will be taken into consideration.

In the task are formally involved FHa, FSV, FAST, EnvP and PHYR as task leader.

1.2. Methodology

Due to the importance of the results of this deliverable, we have adopted two types of methodologies. The aim of the first one is to know what industry and education expect from hydrogen trainings. The other one was used to estimate how many students trained in hydrogen and fuel cells will be necessary and in which time (short, mid and long term).

The first methodology adopted try to identify the needs and gaps consists in a questionnaire with a web-form data collection published on the project website, as showed in the picture below, and filled by the contacts of all the involved Hyprofessionals partners.

The questionnaire has been initially created for the task 2.2 but some questions have been added in order to know what are the needs and lacks of the different stakeholders in the field of hydrogen training.

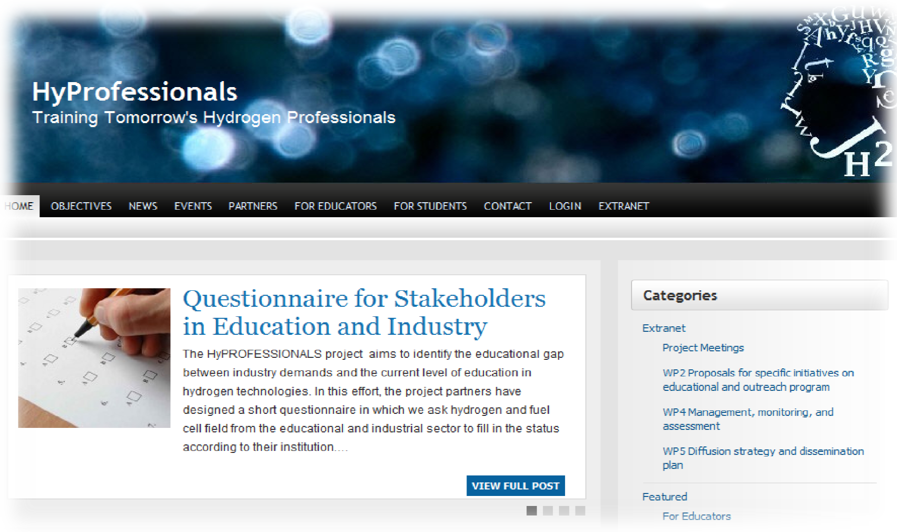


Figure: Link to the web-form questionnaire in the main Hyprofessionals website

Two different questionnaires were created to address specific questions: the first one for the industrial stakeholders and the second one for educational/training bodies.

From the data collection **129 stakeholders were collected from 13 countries**.
In addition, in order to complete the answers from France and Italy, some phone interviews have been made. The questions are opened and allow those questioned to detail some aspects that they find important. However, a list of main questions has been identified in order to guide the discussion.

For Industrial field:

- What is the sector of activity (this information should be already known with the database of the questionnaire)?
- What is the skill level of the workers and what does their task consist of?
- How easy do you find qualified workers?
- What is their curriculum?
- Does an internal formation concerning hydrogen and fuel cells exist within the company? Or have they already followed such a formation?

- Do you have identified gaps in a particular technical aspect of the knowledge?
- According to you, what are the educational gaps and needs of the hydrogen sector?
- What initiative could be develop to fill in the gaps?

For Educational field:

- What is the level of the formation proposed (this information should be already known with the database of the questionnaire)?
- What are the resources (materials, knowledge) that you can use?
- Do you have feedback from students who work now in the field of hydrogen and fuel cells?
- Do you have relationship with a national network of formation centers around hydrogen?
- According to you, what are the educational gaps and needs of the hydrogen sector?
- What initiative could be develop to fill in the gaps?

For Foundations, institutes, associations (they have the hindsight of the situation, and can federate a network):

- What are your relationship with the industrial field and the educational field?
- Do you organize formation on hydrogen or fuel cells? Or have you some contact with formation centers?
- According to you, what are the educational gaps and needs of the hydrogen sector?
- What initiative could be develop to fill in the gaps?

In order to estimate the workforce trained in hydrogen and fuel cell technologies for different applications, we followed the next methodology:

1. Demand - Study of current and future hydrogen application markets, for example: back-up, forklifts, hydrogen production, hydrogen stations, automotive …

2. Supply - Study of current educational training students of the related field:

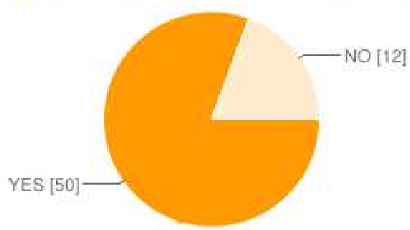
- ✓ Define how many people study each vocational training nowadays (the ones related to hydrogen technologies, such as automotive, vehicle maintenance, electrical…) → HyProfessionals is focused on this.
- ✓ Define how many study by themselves (courses for unemployment, private courses…)
- ✓ And how many study hydrogen technologies by continuous training (people who is currently working)

3. Estimation - Comparison between future supply and demand: Make a relationship between the people who is currently studying each vocational training and which is the current volume of related jobs.

1.3. Results of the questionnaires

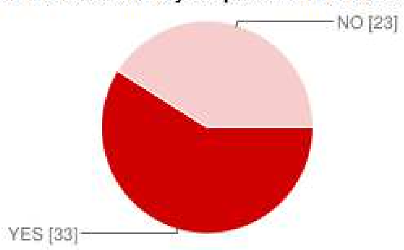
<u>For educational field</u>

Does your insitute have any cooperation with other educational / training centres?



YES	50	81%
NO	12	19%

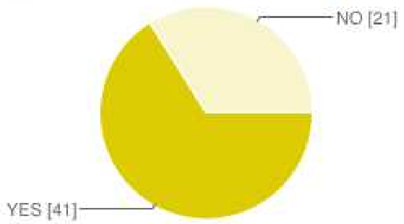
Does your institute have any cooperation with the H2-FC industry field ?



YES	33	53%
NO	23	37%

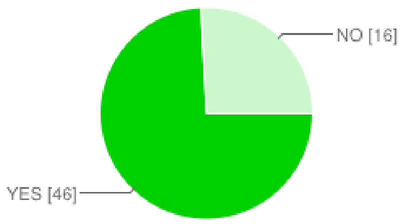
Educational centres are trying to make the relationship between training and companies closer. But for the moment, these first two questions show that the cooperation of institutes is **still quite low**.

Does your insitute propose special courses for H2-FC related activities?



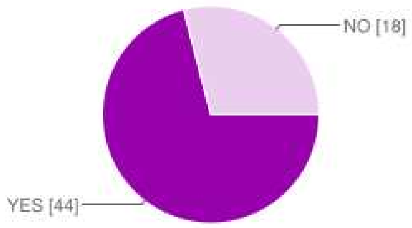
YES	41	66%
NO	21	34%

If yes, does the course insist on technical theoretical aspects?



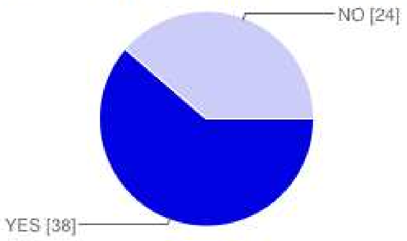
YES	46	74%
NO	16	26%

If yes, does the course insist on technical pratical aspects?



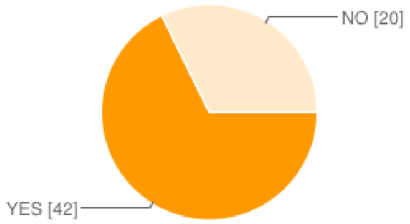
YES	44	71%
NO	18	29%

If yes, does the course insist on regulatory/security aspects?



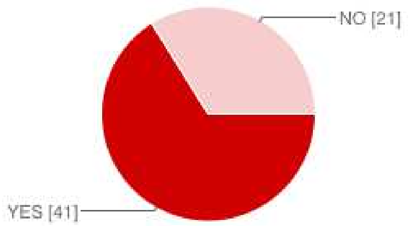
YES	38	61%
NO	24	39%

If yes, does the course insist on other aspects?



YES	**42**	68%
NO	**20**	32%

Does your institute have feedbacks from students who work in H-FC activities ?



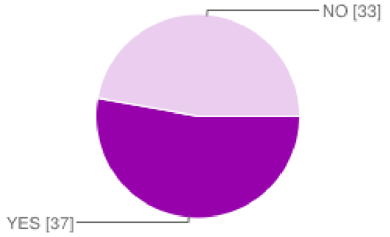
YES	**41**	66%
NO	**21**	34%

These questions, covering hydrogen courses offered by institutes reveal that there is already **a good base in hydrogen courses.**

<u>For industries</u>

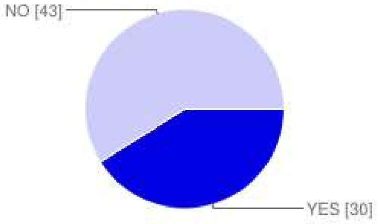
Specific need of training actions

Does the company have any cooperation with educational / training centres?



YES	**37**	51%
NO	**33**	45%

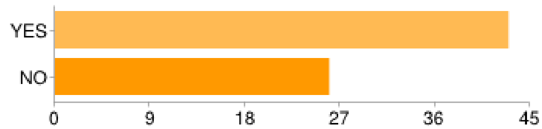
Is it easy to find qualified workers ?



YES	30	41%
NO	43	59%

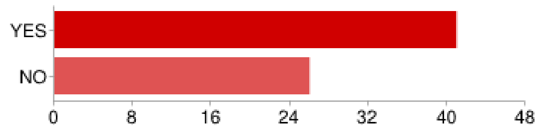
Does the company need to train technicians for H-FC related activities?

Does the company need to train technicians for H-FC related activities? - Internal Training



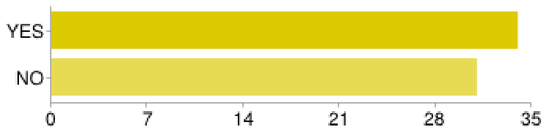
YES	43	59%
NO	26	36%

Does the company need to train technicians for H-FC related activities? - Short Professional Training



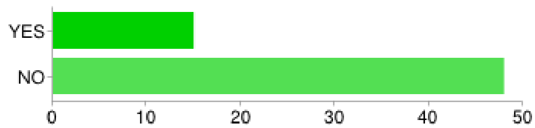
YES	41	56%
NO	26	36%

Does the company need to train technicians for H-FC related activities? - Short Theorical courses



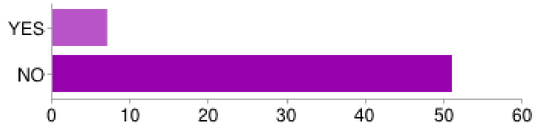
YES	34	47%
NO	31	42%

Does the company need to train technicians for H-FC related activities? - Long formation at University



YES	15	21%
NO	48	66%

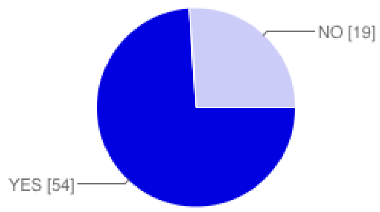
Does the company need to train technicians for H-FC related activities? - Long formation at training centers



YES	7	10%
NO	51	70%

These questions revealed **the needs of industrial**: training their staff (technician) on **short professional training.**

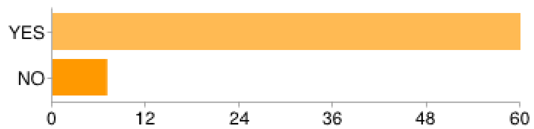
Does the company need to train workers for H2-FC related activities?



YES	54	74%
NO	19	26%

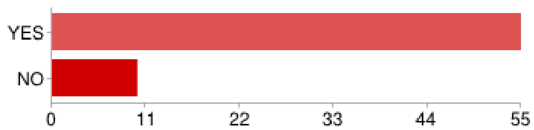
Training aspect of interest:

Training aspect of interest - Technical aspects



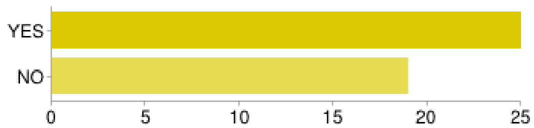
YES	60	82%
NO	7	10%

Training aspect of interest - Regulatory/security aspects



YES	55	75%
NO	10	14%

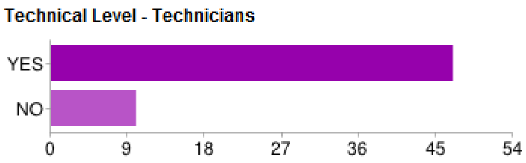
Training aspect of interest - other



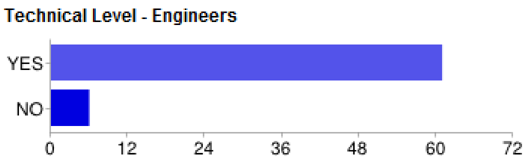
YES	25	34%
NO	19	26%

Interests are **technical and security.**

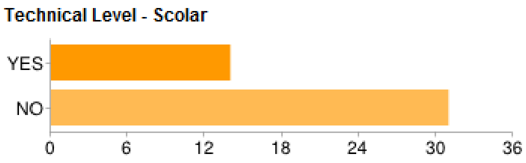
Technical Level of the training person:



YES	**47**	64%
NO	**10**	14%



YES	**61**	84%
NO	**6**	8%



YES	**14**	19%
NO	**31**	42%

These questionnaires reveal a large part (64%) of technicians working in the field.

1.4. Conclusions

The questionnaire was divided into two parts, one for companies, and one for universities / centers of educations. For them what emerged is that academic centers are used to working with actors of hydrogen (industry, other centers ...). These universities offer courses or training on the topic of hydrogen with various issues such as theory, practice, or safety.

At the industry level, there is a great need for training on the topic of hydrogen (mainly short courses). The technical and safety are most important both for technicians and engineers.

To conclude, we note that training on hydrogen already exist, the lack can come the cooperation between the academic centers and industry. Efforts should be made: at the level of industrial in order to work with universities (as shown in the questionnaire - see annex) and at universities to offer more short courses (in high demand by the industrial world).

2. Background and Issues energy in Europe

2.1. Energy issues, climate and economic challenges

Our societies are now facing a convergence of crisis that require a radical rethink our development model.

An energy crisis: limitation of fossil energy resources, especially oil, has necessitated the establishment of a very ambitious policy to reduce energy dependence and avoid the harmful effects caused by both, the price increases and volatility. Example: France, which imports all of the hydrocarbons that consumes, is particularly exposed to this title.

A climate crisis: the impact of our emissions of Greenhouse Gases (GHG) on climate is now. It is urgent to significantly reduce our emissions in order to avoid irreversible damage to the environment, which would call into question the strong organization of modern societies.

An economic crisis: the current economic crisis demonstrates the limits of a model based on an infinite material growth, and is confronted with the limits for a finite world characterized by an increasing scarcity of natural resources. It becomes urgent to propose a new more sustainable economic model, creator of jobs and wealth.
These challenges call for structural changes in the way we produce and consume energy. Strong political support is needed to support this change.

2.2. The international political context, and European

Awareness of our precarious energy situation and economic climate is reflected in the political commitments made by international, European and national for clean energy and low-carbon modes of transport.

International commitments: Kyoto to Copenhagen:

Acknowledging the reality of global warming, political leaders have pledged in the 1990 negotiations in international climate policy.

The Kyoto Protocol, initiated as a result of the Climate Convention, 1992 (Rio), entered into force in February 2005. It sets international targets for reducing greenhouse gas emissions and allows the establishment of a series of tools, such as the mechanism of emissions trading, the Clean Development Mechanism (CDM) and Joint Implementation (JI).

One limitation of Kyoto is the fact that only industrialized countries have seen set binding targets to reduce emissions. The reduction target for all these countries by 2012 is 5.2% compared to 1990.

Reflections on the international climate for the post-Kyoto, which expires in 2012, began in 2002 under the leadership of the European Union. The aim of the negotiations on the post-Kyoto regime is to integrate a binding target to reduce GHG emissions and to involve key players missing, such as the U.S. and major emerging economies. The Copenhagen conference on climate change held in December 2009, although not resulting in the adoption of a new climate agreement binding, has highlighted the need to take coordinated internationally and to continue negotiations.

European energy policy:

Energy is at the heart of the European Union, and since the establishment of European Coal and Steel Community (ECSC) in 1951, which is one of the founding acts of the European construction. The need to coordinate energy policy at European level is recognized. This has been confirmed by integration, for the first time in a European treaty, an entire chapter dedicated to energy in the Lisbon Treaty, which entered into force on 1 December 2009 (Art 194).

The last decade saw the birth of "an ambitious energy policy, marked in 2008 by adopting the "climate package" and the goal of "20-20-20" for 2020. With this objective, European Union is committed to:

- ✓ Reducing emissions of greenhouse gas emissions by 20% compared to 1990 levels (mandatory target)
- ✓ The 20% improvement in energy efficiency (non-binding target)
- ✓ Increasing the share of renewable in total energy consumption to 20% by 2020 (target binding).

In parallel, the EU has developed a strategic plan for the development of energy technologies (SET Plan), which clearly identifies the hydrogen and fuel cells among the priority technologies considered for the transition to a new energy system. The research and demonstration activities for hydrogen and fuel cells are supported by the European Union through the Joint Technology Initiative Hydrogen and Fuel Cells, with a budget of 470 million Euros, which is add at least an equivalent investment of European companies.

3. Gap and need analysis

3.1. Introduction

While hydrogen is widely used for its chemical properties in a range of industrial applications, its use as a fuel is still a niche market. To date the largest demand for hydrogen as a fuel has come from the United States space program. Now, however, fuel cells that use direct hydrogen are opening up new markets for hydrogen suppliers – ones with potentially high demand if some key applications take off.

Those key applications include light duty vehicles, forklifts, buses, stationary power, and scooters. According to a new report from Pike Research, projected **demand for hydrogen as a fuel will be around 107 million kilograms (kg) through 2015, with annual demand reaching 418 million kg in 2020.** While forklifts and backup power applications will drive demand in the first half of the decade, light-duty fuel cell vehicles will create significant new demand starting 2015, the cleantech market intelligence firm finds.

Pike Research's analysis indicates that **forklifts will be the largest driver of hydrogen fuel demand by 2020, representing 36% of the total market by that time**. The other large application categories include **light duty vehicles, which will consume 33% of total hydrogen**, and uninterruptible power supplies (UPS) for **stationary power, which will represent 27% of the total**. Fuel cell buses and scooters will each be a relatively small percentage of total hydrogen demand.

Significant players in the emerging market for hydrogen fuelling include industrial gas companies (IGCs), large energy and gas companies, and other hydrogen infrastructure providers such as electrolyzer companies that are already supplying the merchant hydrogen market. IGCs, in particular, see fuel cell forklifts as a promising new market, and these industrial suppliers are already familiar with indoor hydrogen use. Pike Research further forecasts that, by the end of the decade, annual investment in hydrogen stations will reach $1.6 billion, with a cumulative 10-year investment totalling $8.4 billion.

As a result of this infrastructure investment, more than **5.200 hydrogen fuelling stations for cars, buses, and forklifts will be operational worldwide by 2020, up from just 200 stations in 2010.**

Now we look at six markets for hydrogen energy, and we'll see what the needs are for these different markets:

- Early markets (example forklifts)
- Automotive
- Stationary fuel cell
- Backup solutions
- Production of hydrogen
- Hydrogen stations

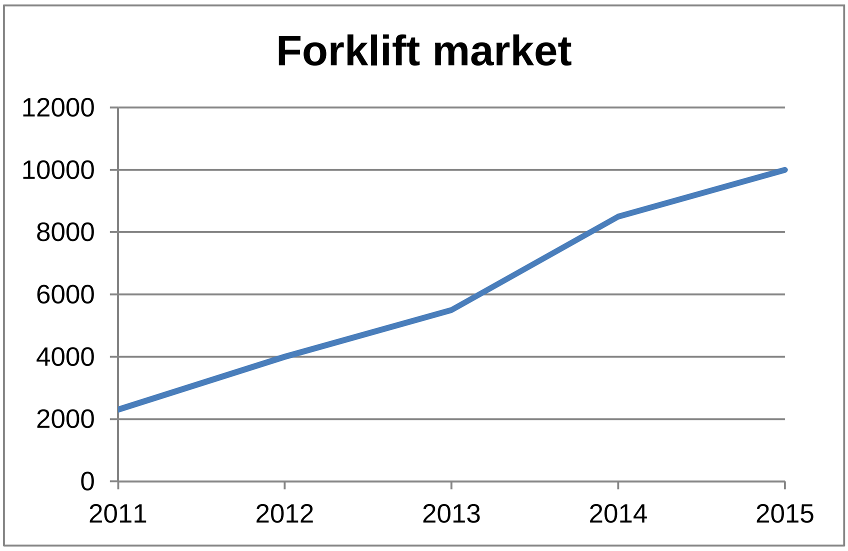
3.2. Early markets: Forklifts

3.2.1. Demand

Nowadays, fuel cell-powered forklifts have emerged as potential alternatives to battery- and ICE-powered forklifts. PEM fuel cell forklifts require minimal time for refuelling and have significantly less maintenance than battery-powered forklifts, whose batteries must be regularly charged, refilled with water, and replaced. In addition, the fuel cell system ensures constant power delivery and performance, eliminating the reduction in voltage output that occurs as batteries discharge. These and other features make fuel cell-powered forklifts potentially well-suited to conditions in multi-shift operations. Fuel cell-powered forklifts also have advantages over ICE-powered forklifts, including zero emissions, quiet operation, and longer runtimes between refuelling. A study exploring the economics of converting an entire warehouse from batteries to fuel cells indicates that sites with high labor rates and multiple shifts are good initial targets of the technology. The process of delivering hydrogen to the fuel cell system and long stack life must be demonstrated for fuel cell technology to be commercially successful.

The current market of forklifts and material handling vehicles is 350.000 units per year sold in Europe.

HyPulsion, the joint enterprise formed by Plug Power (world leader in fuel cell batteries for lift trucks) and Axane (subsidiary of the Air Liquide Group) will ensure the development; production and marketing in Europe of a line of hydrogen fuel cells for power lift trucks. For Europe alone, the development potential of this market is estimated to be around 10.000 units by 2015.
By 2011, in the USA 2.300 fuel cell forklifts had been sold and they expected to sell around 4.000 units by this year (2012).



Some examples around the world:

- Fleets of fuel cell material handling equipment are already in use at dozens of warehouses, distribution centers, and manufacturing plants.

- The U.S. Department of Defense (DOD) supported fuel cell material handling equipment is in operation at Defense Logistics Agency distribution centers in New Cumberland, Pennsylvania and Warner Robins, Georgia with additional installations planned in San Joaquin, California and Fort Lewis, Washington.
- The U.S. Department of Energy (DOE) American Recovery and Reinvestment Act (ARRA) funding is supporting fuel cell material handling fleets operated by Sysco Foods, FedEx Freight, GENCO (at Wegmans, Coca- Cola, Kimberly Clark, Sysco Foods, and Whole Foods), and H-E-B Grocers.
- There are an estimated 24 sites operating nearly 800 fuel cell lift trucks in North America. Notable deployment examples span diverse industries including grocery distribution centers, beverage handling facilities, and automotive manufacturing operations. Central Grocers in Illinois is operating solely on fuel cell-powered material handling with over 200 fuel cell lift trucks in one of its distribution centers, and food supplier, Sysco, is operating fleets totalling over 200 lift trucks for its operations in Texas, Pennsylvania, and Michigan. Additionally, Walmart uses fuel cell material handling equipment for grocery and food handling operations, and Nestle has incorporated fuel cell lift trucks into bottling and beverage handling facilities.
- Fuel cell lift trucks are operated in numerous automotive-related manufacturing facilities, including plants operated by GM, Toyota, BMW, Nissan, Bridgestone-Firestone, and Michelin.

Growing numbers of lift truck installations are demonstrating the economic, environmental, and performance benefits of fuel cells.

- Procter & Gamble Company announced that it is converting its battery-operated forklift fleets at three facilities to ones powered with hydrogen fuel cells. Fuel cells are a leading edge technology that combines hydrogen and oxygen to produce electricity efficiently without combustion, with the goal of producing fewer greenhouse gas emissions. The first three sites (California, North Carolina and Louisiana) will see over 200 forklifts powered with hydrogen fuel cells.

In EU: Applications in the next five years:

This deployment of the first power lift trucks running on hydrogen-powered fuel cells comes on the heels of the recent agreement reached between Plug Power and Axane/Air Liquide Hydrogen Energy. It is part of a larger project aimed at upgrading the Vatry platform.

In all, ten of these hydrogen forklift trucks will equip this platform in just a few weeks. In addition to the reduction in CO2 emissions – of almost 60% that the Air Liquide Blue Hydrogen offers compared with the European electrical mix base (300g CO2/kwh), supply chain platforms equipped with hydrogen solutions can lead to productivity gains of around 10% compared with conventional battery-driven power lift trucks, thanks to multiple replenishment points and rapid fill-up capability.

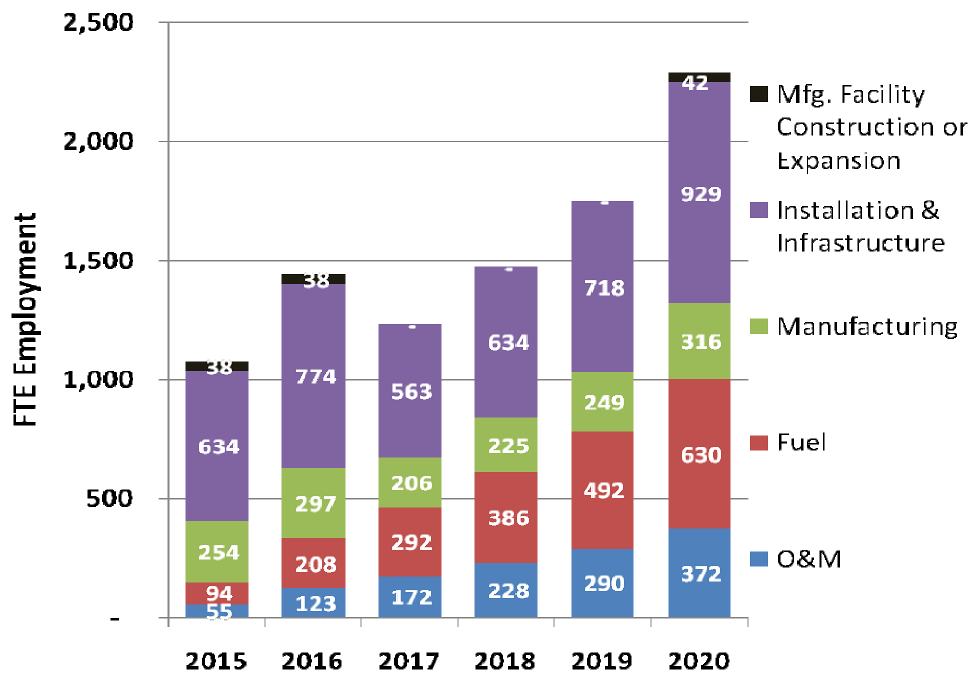
The joint enterprise formed by Plug Power (world leader in fuel cell batteries for lift trucks) and Axane (subsidiary of the Air Liquide Group) will ensure the development, production and marketing in Europe of a line of hydrogen fuel cells for power lift trucks. For Europe alone, the development potential of this market is estimated to be around 10 000 units by 2015.

As part of its Blue Hydrogen initiative, which aims to gradually decarbonize the production of hydrogen for energy applications, Air Liquide takes a commitment to produce at least 50% of the hydrogen needed for hydrogen energy applications without releasing any CO2 by 2020, by combining:

- ✓ the use of renewable energies, the electrolysis of water and biogas reforming;
- ✓ the use of techniques for the capture and storage of the CO2 released during the production of hydrogen out of natural gas.

3.2.2. *Supply - Jobs estimated:*

<u>Jobs created - Fuel Cell Forklift Deployment scenario</u>



Year	Jobs created
2015	1.075
2016	1.440
2017	1.233
2018	1.473
2019	1.749
2020	2.289

Only for forklifts deployment, **between 1.000 and 2.000 jobs** are going to be created in following years, all related to technician level. Most of them will be in the field of Installation & Infrastructure.

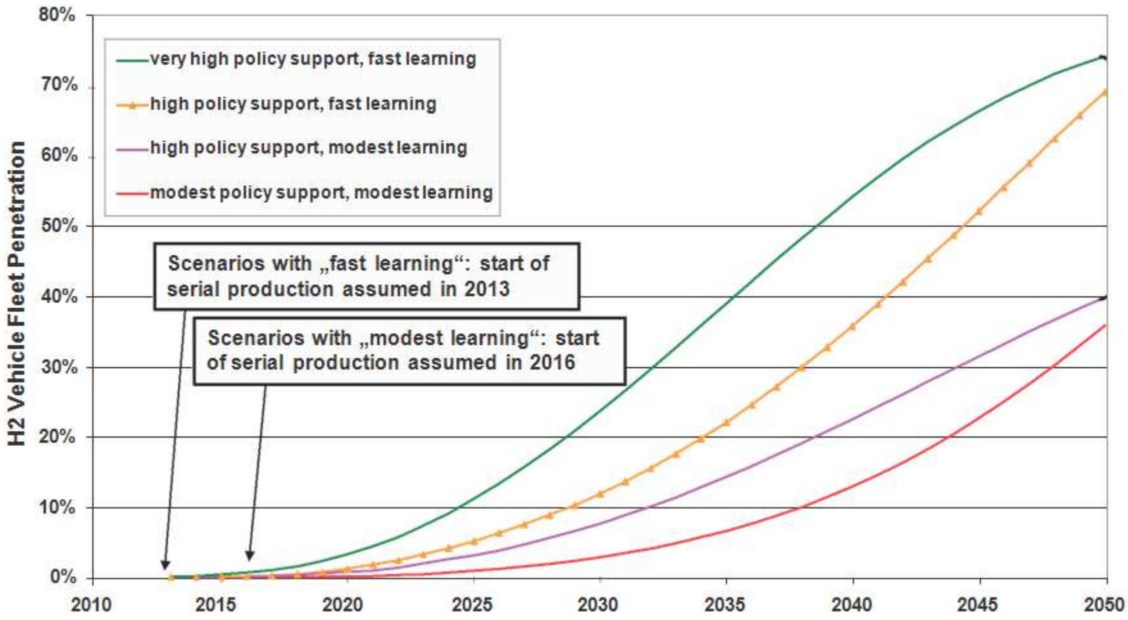
3.3. Automotive

3.3.1. Demand

For a mass-market rollout around 2015 the achievement of the following ‘quality gates’ has been adopted from the Strategic Research Agenda (HFP, 2005b): Based on a successful technology development and validation during the first phase of large scale demonstrations inaugurated by the JTI by 2009 and a consecutive four year period of series development, the market introduction could commence in 2013 in the optimistic case. More conservative scenarios assume a delayed start of the JTI, based on relatively modest policy support and / or slower technical progress than anticipated in the actual planning (compared to the Implementation Plan (HFP, 2007)). Then commercial readiness of the fuel cell technology would not be achieved before 2010. Hence, the process of serial development could start by 2011 for example, leading to an earliest mass-market rollout by 2016, if assuming a more conservative 5 year period for a full development cycle.

For the scenarios defined by ‘fast technical learning’ and ‘high’ or ‘very high policy support’ it has been assumed that mass production of hydrogen and fuel cell vehicles will begin by 2013, led by a group of 5 first movers which increase their capacities each by a new plant of 100.000 units per year anticipating an increase in plant utilization from 5% to 90% respectively in the first three years.

In the more conservative scenarios (modest technical learning) the hypothetic start of mass production has been shifted to 2016 and the number of first movers reduced to 4 which will ramp-up their plant utilization rate from 5% to 90% within a five year time frame (maximum production capacity of each of the four plants 100,000 units per year). After reaching full utilisation of the production capacities of the first movers after 3 (high/ very high policy support in combination with fast learning) respectively 5 years (modest learning in combination with high or modest policy support) it was assumed that followers are entering the market in a similar way and the first movers are doubling their production capacities.



At the World Hydrogen Energy Conference in Toronto, auto representatives from Daimler AG, Honda, Hyundai and Toyota displayed some of their new fuel cell cars. Some have announced the delivery to showrooms as early as 2013, two years earlier than originally planned.

They also confirmed that they are moving ahead with plans to rollout hydrogen fuel cell vehicles by 2015. This timeline was first announced with the signing of a letter of understanding in 2009 by all the major manufacturers.

Some of the highlights of today's industry briefing include:

- ✓ Daimler already has 200 B-class vehicles in service with electric engines powered by hydrogen fuel cells. Three vehicles completed an around-the-world tour in 2011. Daimler will soon open a fuel cell manufacturing facility in Vancouver, British Columbia to produce fuel cell stacks for its new-generation B-Class fuel cell vehicles and the company will introduce fuel cell vehicles to the marketplace in 2014.

- ✓ Honda has been leasing its FCX Clarity fuel cell electric vehicle to a limited number of retail consumers in Southern California since 2008.
- ✓ Hyundai announced that during 2012 to 2015, 1.000 hydrogen fuel cell Hyundai vehicles will be on the road in the United States, Europe, and Asia. By 2015, Hyundai hopes a roomy and fully-featured fuel cell powered Hyundai SUV to be provided at an affordable cost. Recently, Norwegian NGO called ZERO crossed Europe with two ix35 FCEV from Oslo to Monte Carlo using only existing hydrogen stations, showing that with additional supports on the hydrogen infrastructure will allow for fuel cell vehicles to reach every corner of Europe.
- ✓ Toyota will bring a fuel-cell sedan to market by 2015 and currently has more than 100 FCHV-adv vehicles on U.S. roads.
- ✓ Germany and Japan have committed to the construction of hundreds of hydrogen fuelling stations over the next several years.

Other information:

- ✓ Industry analysts at ***Pike Research*** – an American research firm specializing in clean energy – predict sales of fuel cell cars and trucks will reach a cumulative 1 million vehicles globally by 2020. Manufacturers say sales will accelerate as the refuelling infrastructure expands and as fuel cell electric vehicles – known in the industry as FCEV’s – become increasingly price-competitive as a result of larger production runs.
- ✓ Mercedes-Benz, which last month leased a fuel-cell vehicle to its first U.S. customer, is looking to produce at least 1.000 FCEVs available for sale by as soon as 2013. By that time, FCEVs will be cheaper to make than battery-electric vehicles, ANE said, citing Kohler. The primary hurdle for such plans, as we've often reported, is developing an infrastructure to deliver the hydrogen. While countries such as Germany are planning 1.000 stations to support 600.000 FCEVs by the end of the decade, the California Fuel Cell Partnership's plans are far more modest - about 40 statewide hydrogen-

fuelling stations supporting 4.000 FCEVs by the end of 2014 - because of the high infrastructure costs, and California leads the rest of the U.S. in FCEV infrastructure development plans.

- ✓ Hyundai fuel cell vehicles manufactured this year - Many of the major car manufacturers have plans to release fuel cell vehicles in small series for 2015, including Toyota, Honda and possibly General Motors. But Hyundai has taken the first step by announcing the entry into service of its first fuel cell vehicles in 2013. For this, the Korean manufacturer plans to make the first 1.000 fuel cell vehicles at the end of this year for release in 2013. Its main export place northern Europe, where the distribution of hydrogen is more developed.

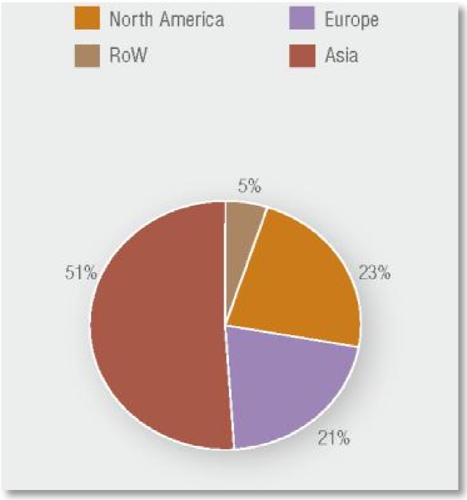
3.3.2. Supply - Jobs estimated:

- ✓ **Fuel Cells 2000's current estimate** of direct fuel cell industry jobs worldwide totals more than 13.000, based on company reports and expert opinion. Supply chain employment is estimated at more than 25.000.

	US	Canada	Europe	Aus-Asia	Lat. Am.	Total
Direct	3.615	974	3.028	5.025	240	13.272
Indirect	7.230	1.948	6.056	10.050	480	25.764
Total	10.845	2.922	9.084	15.075	720	39.036

Source: Fuel Cells 2000, February 2011

- ✓ **According to Fuel Cell Today, the global fuel cell industry could create 700.000** manufacturing jobs by 2020. Its 2010 Industry Review "conservatively estimates that the manufacturing of fuel cells will see the most growth in jobs in the next 10 years, with almost 700.000 cumulative jobs created... over a million total new jobs could be created when fuel cell installation, servicing and maintenance is considered." The estimate includes only direct jobs. "The overwhelming majority are in stationary fuel cells, with almost 500.000 total jobs during the next decade. This is commensurate with stationary fuel cells having the largest proportion of MW shipments in this period and a fairly high ratio of jobs to revenue and productivity."



Source: Fuel Cell Today

About 25% of the jobs, or 175.000 jobs, were projected for North America, but mass manufacturing jobs were expected to go to Asia.

- ✓ A separate study for the European Union put the job potential at 500.000 jobs.
- ✓ Korea has a goal of supplying 20% of the world's fuel cells, creating 560.000 Korean jobs. This implies 2,8 million jobs worldwide with global sales of $126 billion.
- ✓ The American Solar Energy Society contracted with Management Information Services, Inc., in 2008 to estimate then-current employment in the energy efficiency and renewable energy sectors. The study concluded that fuel cells were the third-fastest growing renewable energy industry (after biomass and solar). The study forecast potential U.S. employment from fuel cell and

hydrogen industries of up to 925.000 jobs by 2030 in the maximum success case, with potential gross revenues up to $81 billion per year.

3.3.3. Estimation of students needed

In Spain there are 167 Vocational Training Centers and the average of each center is 25 students/year so we can have the automotive vocational training students per year in Spain:

$$167\ (Vocational\ training\ centers) \times 25\left({}^{students}/_{year}\right) = 4.175\ {}^{students}/_{year}\ in\ Spain$$

We can estimate the students per year in Europe, taking into account the population of Europe (500 million) and in Spain (47.190.000):

$$\frac{4.175\ \left({}^{students}/_{year}\ in\ Spain\right) \times 500\ million\ (EU\ population)}{47.190.000\ (Spanish\ population)} = 44.236\ {}^{students}/_{year}\ in\ EU$$

If in EU there are 10 million people working on the automotive field and there are 250million cars, we have the relation between the number of workers per car:

$$\frac{10\ million\ workers\ in\ EU}{250\ million\ cars} = 0{,}04\ {}^{worker}/_{car}\ in\ EU$$

If we want to know how many people will be necessary for the maintenance of FCEV in following years, we have to extract from the gap analysis the number of FCEV that will be running by 2015, 2020 and 2030 which are, according *HyWays* road map:

- ✓ 2015 – 10.000 FCEV units
- ✓ 2020 – 500.000 FCEV units
- ✓ 2030 – 4.000.000 FCEV units

$$10.000\ FCEV\ by\ 2015 \times 0.04\ {}^{worker}/_{car} = \mathbf{400\ people}\ needed\ with\ FC\ knowledge$$

$$500.000\ FCEV\ by\ 2020 \times 0.04\ {}^{worker}/_{car} = \mathbf{20.000\ people}\ needed\ with\ FC\ knowledge$$

$$4.000.000\ FCEV\ by\ 2030 \times 0.04\ {}^{worker}/_{car} = \mathbf{160.000\ people}\ needed\ with\ FC\ knowledge$$

	2015	2020	2030
FCEV	10.000	500.000	4.000.000
People needed with FC knowledge	400	20.000	160.000

In conclusion, for automotive field:

- ✓ By 2015, only some specialization courses will be enough to satisfy the demand.
- ✓ By 2020, half of the Automotive vocational training students will need to have fuel cell knowledge → Automotive vocational training has to be updated and adapted to the FC technologies, at least in some centers.
- ✓ By 2030, more than 3,5 times the Automotive vocational training students will need to have fuel cell knowledge → all centers need to train FC technologies.

3.4. Stationary Fuel Cell

The diversification of energy sources, promoting energy do not emit greenhouse gases, is a major focus of European energy policy. The objective is to reduce by 2050 the emissions of greenhouse gases linked to human activity in terms of what the planet seems able to recycle naturally. This is a major challenge, due to the global growth in energy demand and the majority use of fossil fuels. In this perspective, it will be necessary to industrialized countries to reduce their emissions of greenhouse gases by 3 to 5 by 2050.

The stationary sector remains one of the leading contributors to emissions of greenhouse gases in the energy landscape and thus represents a major challenge both an energy and environmental perspective. Stationary applications cover areas such as housing, services and industry.

The use of fuel cell systems for stationary applications includes a variety of applications:

- ✓ Micro residential cogeneration: a few watts to kilowatts (Callux, ClearEdge Power, Ceres Power, CFCL ...)
- ✓ Cogeneration and electricity production: 100kW to MW (FuelCell Energy, UTC Power, Nedstack ...)
- ✓ Relief and UPS (Electro Power, Idateck, Helion, Axane ...)
- ✓ Valuation of renewable energy and storage (Hydrogenics, Enertrag, Helion)

For example, in the housing sector, various options are currently worked to improve the performance of buildings: the building "positive energy", decentralized systems of energy-efficient, implementation of energy carriers to lower carbon content. It is in this context that the distributed generation fuel cell technology is presented as an option. It would be more accurate to talk "technology". Indeed, there are several technologies of fuel cells (PEMFC, PAFC, PCFC, MCFC, SOFC...).

Micro-CHP (several kilowatts)

Today there are two technologies of potential interest: micro-cogeneration PEMFC and SOFC. The stack of a power of 1 to 2kWe is alimented by natural gas. The main advantage of micro-CHP lies in energy efficient fuel cell (Combining electrical and thermal performance). This helps contribute to Improving the efficiency of buildings.

PEMFCs are Already in Some Markets-through this Pilot Programs, Usually subsidized. Several thousand units were Deployed and tested in recent years Especially in Japan. We Aim to run year electrical efficiency of 40% year overalls and efficiency (Electricity + heat) above 85%.

SOFCs, less mature, higher energy efficiency, Should APPEAR on the market by 2015. The main advantage of SOFCs is their high electrical efficiency, overalls potentially 60% yield (Electricity + heat) Greater Than 90%. Nevertheless the operation at high temperature SOFC (around 1000 °C) Undermine the materials and their potential sustainability. Technological developments toward moving intermediate temperatures (around 700 °C) less restrictive for m aterials and startup time systems.

The average CHP (tens to hundreds of kilowatts)

The two emerging technologies for these markets are the MCFC and SOFC. These technologies are not designed to be fired by the hydrogen. They include a natural gas reformer and delete would necessitate major changes in the design of the stack. In theory, however, we can replace natural gas with biogas to reduce a little the carbon footprint. As micro-CHP, the main advantage of cogeneration is the average level of energy efficiency of the CAP.

The MCFC are almost mature. They offer a temperature of use and flexible enough interesting (possibility of use of biogas). Experts predict a demonstration period between 2010 and 2015 for commercial launch in 2015. The electrical efficiency is about 45% and should reach 50% around 2015. The MCFC already offer an interesting and reliable service life sufficient to target the mass market (between 30 000 and 40 thousand hours). Costs must be reduced in future years to a level competitive with competing technologies.

SOFCs for average cogeneration are on still at the stage of R & D. According to experts, research should be continued until a few years in order to begin a demonstration phase of by 2015 in order to launch a mass market around 2020. The main challenges relate to the improving the reliability and life of one hand and lower costs other.

Cogeneration high power (greater than megawatt)

Cogeneration units of average power can be "stacked" to achieve high power. The applications are in the industry and electricity production. High-power cogeneration is still in R & D. The demonstration phase could begin around 2020.

3.4.1. Program Callux an example deployment in Europe

The German program "Callux" aims to facilitate the deployment of domestic micro-CHP. Part of the "National Innovation Programme", it aims in a first phase to install hundreds of micro-CHP home that will work for a period of 8 years. The objective of this first phase that runs until 2012 is to demonstrate the techno-economic viability of this solution to enable mass deployment in 2015. The total project cost is 84 million euro, financed to the tune of 40 million euro by the Ministry of Transportation and Buildings. This budget provides subsidies almost 50% of the investment made to the purchase of equipment. Strength of the program is to enable the mobilization of all actors interested in the contract around specific objectives: system developers and integrators of heating fuel cells (Vaillant, Viessmann, Baxi Innotech, Hexis), major energy companies (EnBW E.ON, EWE, MVV, VNG) and the scientific community (Center for Solar Energy and Hydrogen Research in Stuttgart).

All the ingredients are together in this program to produce the desired effects on development and technology deployment.

3.5. Backup power market

Fuel cell systems market has found a growing niche market in backup power solutions. Although technical feasibility of Hydrogen and Fuel Cells (HFC) as Back-Up Power (BUP) and Uninterruptible Power Systems (UPS) has been demonstrated in different applications the full deployment of these technologies at real market scale has yet to be achieved. In commercial applications the Total Cost of Ownership (TCO) is the leading parameter which drives the success of new technical solutions.

The real benefits HFC solutions provide over standard solutions (diesel gensets and batteries) are still difficult to measure due to the lack of market size both for the core technology and the supporting infrastructures (e.g. fuel, service and maintenance). Some funded initiatives are on-going in Europe as well as in United States in order to demonstrate on field the real benefits in comparison with traditional backup power solution in term of TCO. Telecom companies are the main final users of fuel cell backup systems both in OECD and not OECD countries, with several different request in term of working requirements.

3.5.1. Demand

Nowadays, fuel cell-powered UPS have emerged as potential alternatives to battery- and ICE-powered systems as for the forklift market. Fuel cell systems can fit some specific telecom companies requirements where uninterruptible power is a mandatory requirement. Demand is articulated into two main areas with different characteristics:

- ✓ Infrequent grid fail (less than 10 per year)
- ✓ Frequent grid fail (more than 1 per week)

These two segments have found a reliable and cost effective solution in fuel cell systems. Manufacturers have not, at present, identified a standard power size for their UPS, but they have different solutions for the two market area. The concept is to avoid unusual cost where possible, so for infrequent grid fail area they prefer to install static hydrogen storage in cylinders while for frequent grid fails area they develop self-producing hydrogen storage (built-in electrolyzer).

The benefits of Fuel Cells for UPS can be summarized as follows:

- Autonomy – Fuel cells are able to work as long as there is available fuel, depending on the onsite storage size.

- Remote monitoring – Fuel cells can be fully monitored from one central location alerting the operator as to when the system is in use and how long before refuelling is required to ensure no downtime
- Footprint –The space required for the same period of runtime is considerably less for fuel cells than for battery banks. Fuel cells do not require cooling like batteries which eliminates the need for spacious cooling systems.
- Fuels - The majority of these systems operate on hydrogen (in this instance the only emission is water), which can be generated from renewable sources (electrolysis) or from reformed methanol or diesel.
- Temperature tolerance – unlike batteries, fuel cells do not degrade a high temperatures and their range can be between - 40℃ and +50℃
- Integration – fuel cell systems provided as either a standalone unit similar in size to a small refrigerator (for applications like base stations) or can be inserted in existing 19” racks
- Cost – over the lifetime of the unit can offer cost savings over existing technologies. This include: maintenance, repairs, transport and disposal
- Reliability - In many cases, fuel cells are able to offer higher reliability and MTBF (Mean Time Between Failures) and there is no degradation of voltage over time. Failures tend to be less critical and easily dealt with.
- Environmental – Unlike generators, fuel cells do not use combustion and therefore there are no NOx, SOx or particulate emissions from the unit. These characteristics can reduce complications with site placement and integration
- Maintenance – fuel cells have very few moving parts which reduces the need for regular maintenance.

In Europe there are 3 main manufacturers of FC-UPS:

- Dantherm Power
- Electro Power Systems
- Future-E

While some other contenders are working around the world as ReliOn, Idatech and Hydrogenics as shown in the Pike Research study on FC-UPS:

Figure: Main players in the fuel cell manufacturer panorama as show in the Pike Research Executive Summary on UPS/Backup Power Stationary Fuel Cells (Q4 – 2011).

Vocational training is mainly required for:

- Installers
- After sale operations

Manufacturers are actually training their installers internally because the product line is still evolving quite rapidly, as well as certification requirements for the installations, different from country to country.

3.5.2. Estimation

At the moment the 3 main players in Europe have installed around 2000 units worldwide, but the market is growing especially in Indonesia, China and India.

According to Kerry-Ann Adamson, a director at Cleantech Research and consulting firm Pike Research, the market for fuel cell backup units for telecom installations to balloon to \$3.6 billion by 2017, from \$38 million in 2010. This means a really rapid growth in term of installations and operators, installers and so on.

According to that estimation, supposing a linear increase of the installers, there will be close to 2 million installers worldwide.

It is very difficult now to forecast where those installers will be employed, as this mainly depends on the manufacturer directives and strategies: one hundred for country could be a rough estimation for 2017.

3.6. Production of hydrogen

3.6.1. Different means of production

If hydrogen is not naturally available, it enters into the chemistry composition of different body. We can produce this gas through processes that use different primary sources, renewable or not:

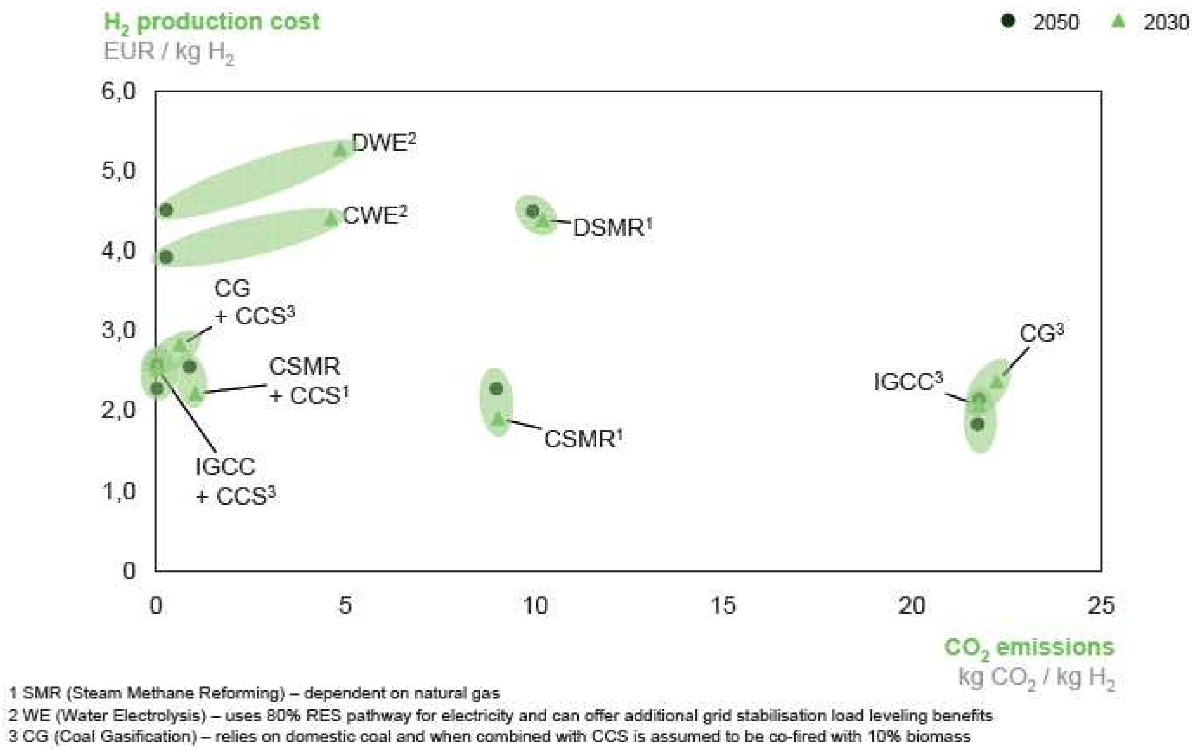
→ Steam reforming of natural gas is the most widely used (90% of production World), with a yield of 70-80%. It generates CO2, which can be captured, stored or recovered. Hydrogen can also be produced from biogas. This pathway is supported by Air Liquide in France and SMEs: N-GHY, Verde Mobile and Albhyon. Seventy of the 250 French sites (for hydrogen production by biogas) value already this biogas (cogeneration), averaging 157 tonsH2/year per site (7000 operating hours). Hydrogen has a distributed cost of 9 € / kg H2;

Picture -Reforming Plan - Air Liquide

→The thermochemical gasification and pyrolysis of solid biomass produce a gas mixture (CO + H2) where we can extract the hydrogen;

→Electrolysis of water is very small. This process may produce the molecule of hydrogen without carbon, subject to use electricity renewable, with a yield of 50-60%.

Picture -Electrolyser -Air Liquide



Picture -Assessment of future costs of hydrogen production versus the rate of co-CO2 *

(*) This chart compiles the production costs per kg of H2 in two installments, in 2030 and 2050 for various production methods; it does show the level of co-production of CO2 related to these types of production.

Source: Mc Kinsey & Co study, A portfolio of power-trains for Europe: A fact-based analysis (2010)

Other processes are the subject of research: thermochemical decomposition of water, photochemical decomposition or production of water by biological means.

Hydrogen is also co-produced in some chemical (chlorine, coking, petrochemical, etc..). It is to be valued in a process, is burned or rejected.

The natural gas network may contain up to 20% hydrogen by volume. Technological obstacles remain to be lifted, in order to separate and purify hydrogen downstream.

3.6.2. The future challenges

Clean production of hydrogen

Hydrogen can be produced from low-carbon energy sources (wind, solar, hydro, nuclear, solid biomass, and biogas) and appears as a way to store, transport or distribute these energies.

Especially for intermittent renewable, it can be considered as long-term means of regulating their production, use to be compared with storage devices: by batteries (especially Li-ion), the specific capacity is expected to double by 2015. Its transformation through cell fuel produced electricity and heat for a job in the main energy uses mobility, use of electricity, thermal requirements of buildings, increasing the potential for substitution between energy sources conventional and renewable energy sources.

The benefits depend on the energy efficiency of the energy chain, including optimization is a factor determining the potential energy this vector. For now, the production process is the most widely used steam reforming of methane, very transmitter of greenhouse gas emissions.

Production, centralized or decentralized

Different levels or degrees of centralization can be imagined in the implementation of these means of production. So far, two logical infrastructures can be distinguished:

→<u>Centralized hydrogen production</u>

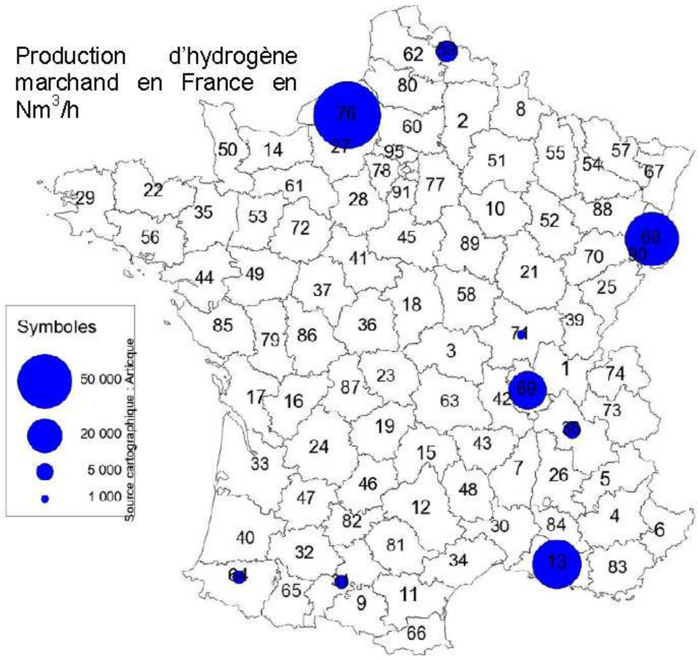
Hydrogen is produced in large quantities on some sites. Facilities large capacity based on the following processes: the steam reforming of natural gas; electrolysis high and low temperature on a dedicated site or backed production sites. Electricity large (offshore wind, nuclear) gasification biomass and steam reforming of biogas new processes: thermochemical decomposition of water, biological processes. The production must be transported in a secure manner (important issue). This transport can be carried by truck in liquid or gaseous form, or as a pipeline gas;

→Decentralized hydrogen production

Production is ensured by many dispersed facilities: gasification of biomass and steam reforming of biogas electrolysis, high and low temperature connected to network or backed by parks renewable electricity small size, new processes: photochemical decomposition of water processes biological.

3.6.3. Example of France

The production of hydrogen is in France a total of 640 000 tons per year (HyFrance3) including 280 000 tons is distributed (the rest being "captive" in a process of refining or fertilizer, for example).



Picture -Hydrogen production in France/ hydrogen for distribution

LINDE GAS and AIR LIQUIDE are the only two players in the market in France. 7 production sites have been identified for AIR LIQUIDE and 3 LINDE GAS.

Production capacities of sites identified are summarized in the table below:

Company	District	Capacity (Nm3/h)	Process
AL	Haute Normandie	47 000	SMR
AL	PACA	25 000	SMR
AL	Rhône-Alpes	15 000	SMR
AL	Nord pas de calais	5 000	SMR or electrolysis
AL	Rhône-Alpes	3 000	SMR
AL	Aquitaine	1 800	SMR
AL	Bourgogne	800	SMR
LG	Alsace	30 000	SMR
LG	Midi-Pyrénées	2 000	SMR
LG	Ile de France	100	Electrolysis

Of these 280 000 tons of distributed generation, Air Liquide produces about 100,000 tons per year in three factories mainly, the rest is produced by competitors.
For a production of 100 000 tons, Air Liquide jobs a hundred technicians (source: Air Liquide).

Evolution of the number of technicians in the future

Hydrogen production is a large and growing industry. Market size of global hydrogen production was estimated to be 53 million metric tons in 2010, of which 12% was shared by merchant hydrogen and rest with captive production. With decreasing sulfur level in petroleum products, lowering crude oil quality and rising demand of hydrogen operated fuel cell applications, global hydrogen production volume is forecasted to **grow by compound annual growth rate of 5.6% from 2011 to 2016**. The Hydrogen production market in terms of value was estimated to be approximately $150 billion in 2011. (Source: marketsandmarkets).

*Note: **Compounded Annual Growth rate** (CAGR) is a business and investing specific term for the smoothed annualized gain of an investment over a given time* *period. CAGR is not an accounting term, but remains widely used, particularly in growth industries or to compare the growth rates of two investments because CAGR dampens the effect of volatility of periodic returns that can render arithmetic means irrelevant. CAGR is often used to describe the growth over a period of time of some element of the business, for example revenue, units delivered registered users…*

Hydrogen production in Europe is currently **around 18 million tons per year.**
This represents **1,800 technicians working in production** (direct or indirect) **of hydrogen in Europe** (based on extrapolation of data by Air Liquide France).
Now look at the evolution of the number of technicians in the next 5 years. If the number of technicians that evolves with the evolution of hydrogen production. We therefore need in **2016 to have one hundred technicians more.**
This figure is quite small; **the training can be done directly in the companies for the next 5 years.**

We cannot estimate the number of technicians in the sector in the longer term, because it is very difficult to determine the consumption of hydrogen for future years.

3.7. Hydrogen service station

The distribution of hydrogen for vehicles will probably modeled on the existing stations essences. More than 300 hydrogen stations were built during the past two decades in the world.

To prevent investment represented by a fairly heavy hydrogen station at the starting phase, the use of a mobile hydrogen station appears as an alternative. In this case, a filling system in liquid or gaseous hydrogen is mounted on truck. This option was favored in several demonstration projects in Germany in recent years.

Hydrogen can also be distributed as a gas or liquid in dedicated stations using refillable cartridges. The project HyChain conducted by several European regions, the Rhone-Alpes Region, is currently testing this type of distribution system.

There are currently worldwide over 200 gas stations to hydrogen to power the first fleets of motor vehicles to hydrogen (or possibly internal combustion fuel cell). Most of the compressed gas to deliver 300 to 350 bars and some are starting to supply gas to 700 bars. Others supply of liquid hydrogen or liquid and compressed gas station at Munich Airport. Some are fixed and others mobile and the ability of these stations is to measure the consumption: lots are sized to provide a few tens of kg of hydrogen per day for a few bus or a few ten vehicles. Europe was the first to launch a coherent evaluation of gas stations to fuel fleets of buses in urban fuel cell. The first stations of the CUTE (Clean Urban Transport for Europe) started to be operational in 2003. These stations can be powered by liquid hydrogen trucks or by generators on site (SMR or electrolyzer), until some can be directly fed by a pipeline.

Figure -Hydrogen stations in Europe (www.h2stations.org/)

One problem specific to a service station, is to ensure rapid filling of the tank of a vehicle. But the sudden compression of hydrogen to 700 bar in the tank is almost adiabatic, and it therefore causes heating of the gas and therefore composite walls. This therefore requires having a source at higher pressure (800 bar) to compensate for this heating, or cooling the hydrogen before filling. On the other hand the filling of liquid hydrogen at 20 K implies huge precautions and a fast connection sophisticated. These topics as well as the acceptability and safety of these stations in urban areas are the primary concerns of designers and installers.

This is California, which launched the first highway project of hydrogen ("hydrogen highway"; See website: http://www.hydrogenhighway.ca.gov). It is in this case to create an infrastructure of 170 service stations hydrogen supply along major highways in California. Highway projects for hydrogen are being studied in Germany. But to turn these projects funded by economic reality we must solve the problem of matching supply and demand while hydrogen vehicles are still rare.

3.7.1. Transportation: Plan H2Mobility

In the transport sector, Germany develops the concept of electro-mobility (development of battery vehicles and the vehicles fuel cells). This concept seems to have helped manage conflicts of industrial strategies (at least for now) between the automakers and energy companies between, and allowed to defer some decisions and political choices Industrial delicate, trying to highlight the synergies possible on vehicles and opportunities for renewable energy storage.

In the field of hydrogen, the plan “H2Mobility” understanding signed in September 2009 by Linde, Air Liquide, Air Products, Daimler, EnBW, NOW, OMV, Shell, Total and Vattenfall aims deploy a hydrogen infrastructure for mass production of hydrogen vehicles by 2015.

The agreement provides for the development and validation of an economic model by 2015-the first phase in a non-binding for the partners. If successful, the car manufacturers (including Daimler, Ford, GM, Honda, Hyundai, Nissan and Toyota) are committed to producing hundreds of thousands of hydrogen vehicles for 2015 while energy companies and gas will in place the necessary infrastructure to supply vehicles with hydrogen.

The year 2015 will therefore probably a point of tipping in the German strategy in electro-mobility.

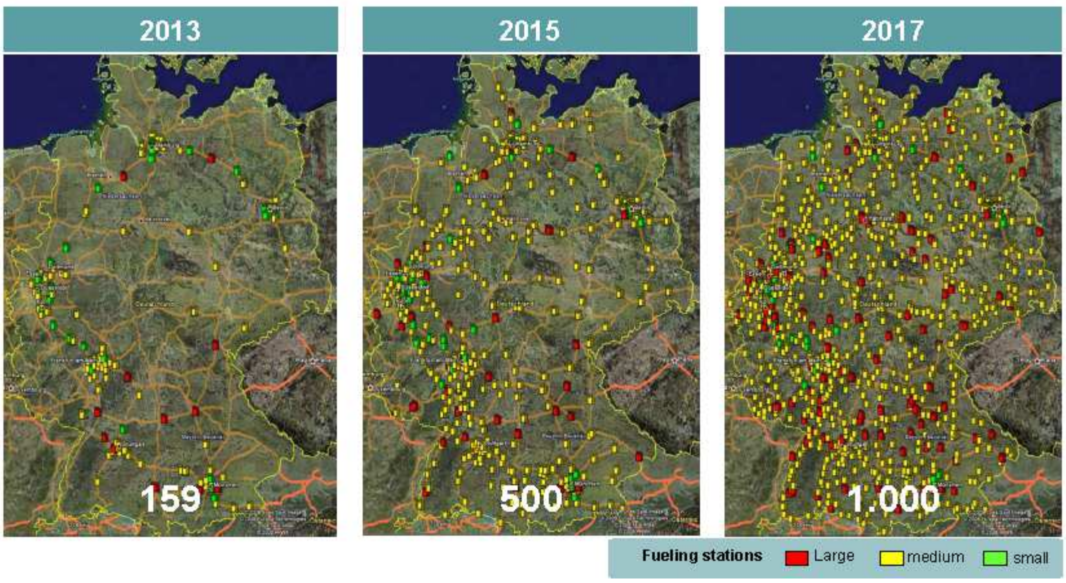


Figure -Evolution of the stations in Germany

The German example shows the evolution of H2 infrastructure in future years, and **in 2020 over 5200 stations are planned in the world.**

4. Conclusions

4.1. The different Impacts

4.1.1. International outlook:

The report FuelCellToday Industry Review 2010 published in January 2010 estimated in late **2009, the sector to about 75,000 fuel cells installed worldwide** (including the two-thirds were the last 3 years) and a production capacity of approximately 220MW/an globally.

Despite the global recession, the report notes an increase in deliveries by 41% over 2009 in total and an average annual growth amounting to 53% over the past 3 years.
At 2014, the report forecasts a significant increase in deliveries of equipment including stationary applications (1.5 GW installed annually, or about 300.000 systems, of varying sizes).

The European Technology Platform Hydrogen and Fuel Cells Combustible projected in its 2005 Strategy Deployment to **2020: 100.000 to 200.000 stationary systems installed annually.**

4.1.2. Impact on jobs in Europe

In terms of jobs, **FuelCellToday Industry** Review 2010 estimated that the industry could generate **overall 700.000 jobs by 2019 in manufacturing**. Including services installation and maintenance, this could potentially represent more than one million jobs. The creation of jobs in manufacturing would be mainly based in Asia, while **jobs in the Installation and maintenance** are mainly located in North America and **Europe.**

For its part**, the European HyWays project** funded by the European Commission and aimed at developing a European Hydrogen Energy Roadmap", evaluates in its final report the potential impacts of the development of hydrogen energy in terms of jobs in Europe. Following scenarios (mainly related to carbon constraints, political support and learning curves) the industry could generate more than **800.000 jobs in Europe by 2020 in an optimistic scenario or otherwise destroy 1.2 million jobs in Europe because of the inaction and massive imports of non-European technology.** Details are presented in the graph below:

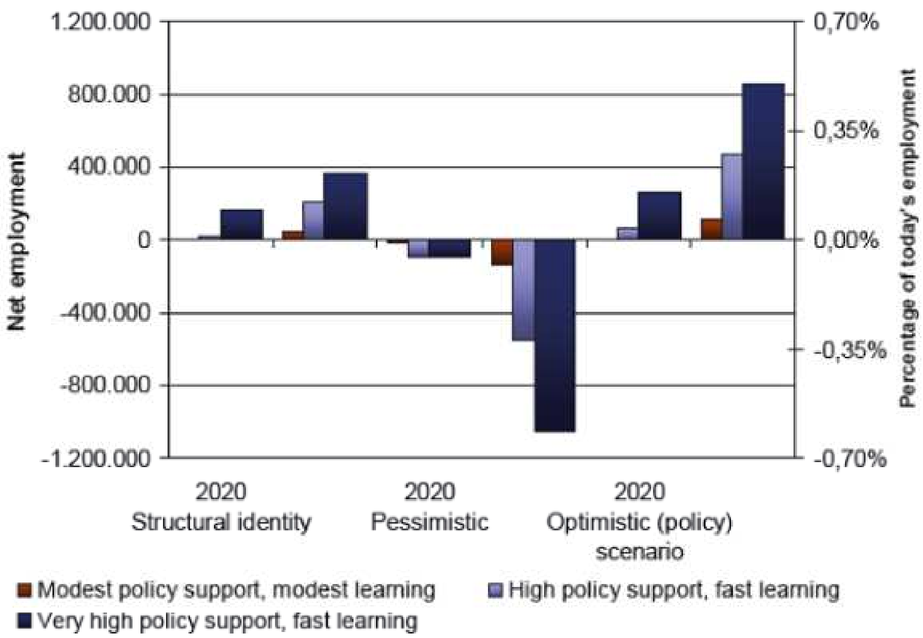


Figure 4.5 *Net employment effects for the ten HyWays countries*

Figure -H2PAC impact of the sector in terms of jobs by 2020

4.2. Conclusions on the studies

The questionnaires and interviews show that at short term, young people information is needed in order to increase awareness. In addition, hydrogen topic can be added in existing trainings (course of several hours) at technician and engineer levels.

At middle term, the needs will concern:

- short trainings adapted to engineers but more particularly to technicians: internal and/or external trainings
- all the industrial sectors concerning technical and regulatory aspects. And the industrial sectors concerned by hydrogen topic are numerous!

Cooperation between institutes and industries must be improved in order to develop hydrogen trainings.

The "Gap and Need Analysis" for automotive market has highlighted the need of workforce trained in hydrogen and fuel cells technologies between 5 and 10 years for the sector (hydrogen mobility). For this application the hydrogen demand by 2015 will only be very small (a few thousand vehicles per year). So technician training could be done incrementally, that is to say first in-house training (short course) and then from 2020 (when demand is greatest) integrate training in technicians initial training (vocational training).

This deliverable shows that there is already training on hydrogen, but the industrial sector and the education sector do not work together enough to move forward in a good logical training.

Annex

A.1 – Results

FRANCE

Industries:

McPHy Energy is a small enterprise of 36 workers, created in 2008, specialized in storage by metallic hydride. Concerning hydrogen, the activity sector concerns essentially massive hydrogen storage for stationary and transport uses. Storage vessels are already commercialized in different countries like Japan.
The creator of this enterprise has an initial training in metallic hydride, not in hydrogen. But thanks to different exchanges with the national center of scientific research and with different enterprises, he became conscious of possible uses of metallic hydride for hydrogen storage.
His collaborators have initial training in mechanics or electro-mechanics for technicians or in physics or magnesium metallurgy for engineers and doctors. The reason is that hydrides fabrication and handling are more complicated than hydrogen technologies handling. Only the Commercial director has an experience in hydrogen technologies. It's the reason why he is in capacity to train the new engineers or technicians in hydrogen technologies and hydrogen markets.

In the future, hydrogen training will certainly be necessary but will depend on the different markets and hydrogen uses: transport, aeronautic, metallurgy, glass-houses, iron-ore reduction, alternators cooling in nuclear centrals, etc…

Today, hydrogen training could be introduced in existing professional trainings in the fields cited previously. General information could be delivered in high schools in order to increase young people awareness of hydrogen.

In order to accelerate hydrogen development in France, it could be useful to create an institute like the research institute on hydrogen in Quebec with 60 engineers, technicians, researchers and graduate students who work in the fields of hydrogen production, hydrogen storage, safety and hydrogen use. But it would demand implication of big enterprises and research centers.

b) Dassault Aviation

For aeronautic sector and more particularly for falcons which are developed by Dassault aviation, hydrogen can be interesting for electrical applications inboard.

It's the reason why systems engineers are interesting in hydrogen and fuel cells. Two people work on this topic. They take part in different stakeholders groups and make technology watch. Sometimes, interns are necessary in order to support them. These interns are specialized in aeronautic, physics, energy, hydraulics and pneumatics.

The needs for Dassault aviation are knowledge:

- in fuel cell integration
- in fuel cell mechanism
- in H2 production and distribution because a falcon can land everywhere and so, hydrogen must be available.

Training needs are the following:

- hydrogen distribution infrastructures : what technologies?
- hydrogen safety concerning refueling, maintenance, storage
- fuel cell and stacks : electro chemical mechanism, thermal release, yields, cooling systems and necessary electric power for aeronautic application.

Perhaps these trainings can be introduced in existing trainings dealing with aeronautics.

Institutes:

IUT Marseille

The University institute of technology of Marseille proposes 2 years of training (2 years study degree) dealing with energy and thermal engineering.

In addition, they propose a “licence professionnelle”: one year dealing with energy save, renewable energy, new technologies, regulation, legislation …

Fuel cell and hydrogen applications are integrated in the training. Lectures deal with hydrogen market and process in the field of transport. During practical works, students use test benches like “BAHIA” bench. This material is mainly constituted by a fuel cell PEM delivering 1kW electrical and 1kW thermal and software which allow users to simulate different variations of the parameters. The theoretical contents of the software constitute basic knowledge on hydrogen and fuel cells and can be completed by teachers.

The possibilities of the material cover:

- the fuel cell system study: stack and auxiliaries to optimize the overall system operation,
- fuel cell applications: programming of miscellaneous profiles for a better understanding of the technology use in back-up generator systems, naval applications, energy storage in conjunction with renewable energy sources, and cogeneration applications...

The particularity of this didactic test bench is that it has been elaborated by different partners in an educational aim: it can be used from the secondary school to the university.

BAHIA didactic test benches are found now in several universities and engineering schools (not really in secondary schools yet) and it is used at different levels of formation (bachelor, master). It has been commercialized in 2009. Sometimes, students make presentation of the bench to training centres.

The idea to make such a didactic bench came from the strategic comity of the competitiveness pole “Cap Energy”. As industrial partners working in the field of hydrogen have an important place in the pole, they suggested the idea and interested teachers followed them.

Even if hydrogen takes place in several French teaching programs like in the university institute of technology, there are not specific trainings on the hydrogen topic. But the need doesn’t exist because the hydrogen market doesn’t exist in France! If specific hydrogen training was proposed to students, they would probably not found a job after their training. So, for the moment, it is sufficient if hydrogen is introduced in existing training. Once hydrogen market will emerge, specific hydrogen training will be developed at technician and engineer levels.

In spite of the hydrogen training session developed in the university institute of technology of Marseille, only one student work actually in the hydrogen field.

Associations:

Alphea is an association which proposes services in the field of hydrogen and fuel cells: watch technology reports, project set-up and public awareness at local, regional and national level. 6 people work for this association. They have a list of contacts of 2000 people. They teach “hydrogen” at university level.

Hydrogen training must concern qualified people (5 years degree) because hydrogen technologies are advanced technologies.

General information can be given in secondary schools and high schools with didactic benches or education kits.

ITALY

Industries:

a) SOL Group

SOL is a multinational group with headquarters in Italy, focused in production, applied research & marketing of industrial, medical, pure and special gases, in the production, handling and installation of equipment and plants for their use and production onsite, as well as in the Health Care Sector.

The skill level of the workers is composed as follows:

- University degree: 30%
- Secondary/high school degree: 60%
- Primary school degree: 10%

And the background of new employees has the following average distribution:

- about 75% new graduate applicants in engineering/ scientific field
- about 25% applicants with at least one previous job experience

The recruiting of new workers is made through three main channels: contact through web announcements, selection through recruiting agencies and relationship with universities.

The evaluation of a new specialty worker for technical sector requires a selection extended to 5-6 applicants average.

To the development of applications and technologies related to hydrogen and fuel cells within SOL Group it is dedicated a specific and qualified engineering staff: “Hydrogen, Fuel Cells, On-site Units Project Department”. The staff is coordinated by senior and junior engineers whose technical university background is completed by a theoretical and practical “training on the job”.

Since hydrogen and fuel cells is a sector characterized by a high level of innovation, it is necessary a continuous upgrade of the technical skill and knowledge acquired during graduate school/university by the staff dedicated to such sector that can be obtained through training on the job.

However according to our experience there are two main areas of knowledge where is more difficult to find expertise in a job candidates:

- knowledge about the normative requirements involved in the different hydrogen sector application
- sensitivity in the proper evaluation of the potential of the different hydrogen in terms of real market application

Maybe a special course or post-graduate master focalized to the above two topics will be necessary.

a) Industria Nuvera

Nuvera Fuel Cells is a global leader in the development and advancement of multi-fuel processing and fuel cell technology. We believe that in the next decade hydrogen will be present in day-to-day society, and fuel cells will be the power of choice. Our mission, as a clean energy conversion business, is to create and develop innovative technology solutions for power systems, to design and develop power systems focused on end-use customer needs, and to manufacture, market and service power system products delivering value to customers.

The workers of Industria Nuvera are mainly Engineers (from any discipline and newly graduates) and their task is the design and development of fuel cells systems.

They do not follow any hydrogen training but they think that it would be useful to train people to avoid general fear of the hydrogen and develop some code and standards for the hydrogen usage or general information to the public.

Institutes:

In Italy exists a Thesis for “laurea specialistica” in Materials Science and Engineering or in Physics (Master degree).

After the Master degree, some of the students have now a job in national or foreign research Institutions or in private companies.

They do not have relationship with national network of educational centers around hydrogen because this network is lacking in Italy. It would be valuable to have more programs and resources by the National Government to include formation in a national platform to develop technologies on hydrogen and fuel cells.