Air Liquide Roadmap for Hydrogen Energy

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1 Context

Climate change, pollution, reliance on fossil energies, surging energy demand have become critical global challenges today. The energy industry is undergoing a complete transformation, and while it is essential to ensure our energy supply, it is also of the utmost importance that the new production methods are able to limit the impact of their usage on our environment. In the frame of those global challenges, hydrogen can play a key role in the development of new energy alternatives.

As a carrier that is compatible with other types of energies, it can be produced from a wide variety of sources including renewable, while presenting unique storage options and, combined to a fuel cell, efficiently produces electricity with zero direct pollution.

The presentation will illustrate how Air Liquide envisages and contributes to the raise of this new Hydrogen Energy economy.

2 Air Liquide and Hydrogen today

2.1 A challenge for committed players

New energies cannot appear without great investments, as the markets they are aiming do not exist yet. Thus, only experimented players have the expertise, the knowledge and the capacity to impulse the technologies and infrastructures needed. Air Liquide is the world leader in gases for industry, health and the environment, and is present in over 75 countries with 42,300 employees. For almost 50 years, Air Liquide has built up considerable credibility in the hydrogen field and has put every measure in place to ensure the reliability and efficiency of its equipment. In 2008, the 200 plants of the Group produced 7 billions Nm3 of hydrogen for 1.2 billion € sales for industrial applications. The Group's global hydrogen network encompasses R&D innovation, engineering development, gas production, product transport and distribution, and customer service and maintenance, covering the whole chain of application from generation to demanding end users. On this basis, the group has built a strong expertise from which it can transfer its skills and know-how to emerging markets.

3 Air Liquide and the New Economy of Hydrogen Energy

3.1 Our vision

For Air Liquide, a new sustainable economy policy requires a larger strategic approach of the environment. The Group decided to build his strategy to drive and inspire every activity in the business lines on 5 growth drivers, of which Energy & Environment:

"Our activities lie at the heart of the most important challenges facing the planet. To meet those challenges, Air Liquide develops innovative technologies and sustainable solutions,

optimizing the use of air and the planet's natural resources, enabling progress and preserving life".

When applied to our day-to-day environment, these principles naturally go along with sustainable mobility. Therefore, with the substantial progress that has been achieved in hydrogen energy technologies these past five years and, thanks to the different players in the industry including Air Liquide, financial investment decisions and technical breakthrough should allow for hydrogen vehicles to be ready for the commercialization on the market by 2015.

3.2 Innovation, starting from an existing basis

However, getting more companies to cooperate, public funding to be budgeted and technologies to reach performance and targeted costs might not be easy. If creating breakthrough technologies is a key factor to prepare the energy consumption transformation [1], it can only be done within the expected time span with a solid industrial basis. That's the reason why Air Liquide decided to increase innovations on H2 plants energy efficiency, CapEx reduction, CO_2 mitigation and H_2 transport for a global investment in 2008 of almost 300 millions €. More than 40 hydrogen filling stations are now operated around the world including the largest one in Vancouver – BC – Canada.

Moreover, preparing the new energy markets requires to design a completely new supply chain from production to end-user distribution. Transfers of knowledge and know-how from existing industry may speed up greatly the transition to a sustainable energy. As a consequence, Air Liquide has been underpinned for several years by the teams of R&D Corporate and Advanced Technologies, as well as some subsidiaries of the Group, such as Canada, together with Axane, its wholly-owned subsidiary founded in 2001 that develop and manufacture PEM Fuel Cells. Due to this specific context, Air Liquide enjoys a unique position among gas producers, and will build on this basis to better understand and anticipate hydrogen energy markets and user's expectations and offer equipment or service solutions.

4 The Foreseen Potentials of the New Hydrogen Energy Markets

As a rule of common sense, estimations of potential growths do pilot the investments decisions. In addition, if environment preservation is the goal for our society, the economic viability of a new energy is the key for its development. As early as today, several hydrogen energy markets are already accessible, thus justifying the name of "early markets". On the other hand, the mass transport market considered today as the most promising one and for which the Fuel Cell Vehicle (FCVs) brings a solution is deploying first infrastructural and social prerequisites to create the conditions of its success.

4.1 Early markets

An early market grants almost immediate access to the player who enters it. Consequently, not only for technology replacement but also for new utilizations, the hydrogen energy encompasses at the same time the possibility to promote economic growth and to improve its new technologies in real-life conditions. Finally yet importantly, such deployments are the initiation of further cost reductions by series effect.

When combined to a fuel cell, hydrogen efficiently and silently produces electricity with zero direct pollution. Air Liquide believes in fuel cell applications within four distinct early markets selected for their potential:

- Specialty vehicles: already an important market in terms hydrogen volume, hydrogen specialty vehicles and captive fleets can grant significant productivity gain to customers. Hydrogen forklift deployment in the US have already capture 4% market share of electric truck fleet in the US
- Off-grid sites: Supplying energy to isolated off-grid sites is the next biggest early markets. Hydrogen offer autonomy and preserve the environment at the point of use
- Back-up power: This market presents also a big potential, mainly conditioned by reliability and safety.
- Mobile energy: High visibility with applications amongst cinema, special events, rescue & safety and architecture design is typical for this market.

All the early markets also hold the advantage of enabling the transition towards and opening the way for future applications such as in transport. When the new mass transport market is mature enough, they will be able to follow their own way, accompanying the developments of hydrogen technology.

4.2 Mass transport market

Today, transport vehicle technology has reached its maturity. The internal combustion engine technology, known for years, shows limitations for further development.

It is penalized by low energy efficiency and only marginal improvements can be expected. On the basis of equal power supply, its consumption and therefore its emissions can only be reduced to a certain extent. Faced with demands for energy efficiency and lower emissions, car manufacturers are proposing new wheel drive alternatives, such as electric and hydrogen vehicles. Not only do higher energy yield electric engines power them both [2], but they also eliminate the need for oil-based liquid fuels since they rely on new energy carriers: electricity and hydrogen.

By using hydrogen in transport applications, greenhouse gas emissions will be reduced and city pollution levels, including noise, will be lowered.

FCVs have developed significantly over the last 5 years and several car manufacturers anticipate strongly that from 2015 onwards a quite significant number of them could be produced. This number justifies the efforts and investments needed and opens new playgrounds for technology developers. Such complex and massive market cannot be approached without a convergence of the industry players.

Moreover, to deal efficiently with the sustainable transport stakes, the hydrogen industry needs to:

- foresee the roadmap to achieve a complete “green” supply-chain [3],
- validate its technological advances in real-life conditions,
- convince society of the value of the technological innovations (social acceptance [4]),
- implement regulations and codes for daily use,
- and create an infrastructure base on which future fleets of hydrogen vehicles can rely.

The presentation will explain further how to answer those concerns within the partnerships.

5 On the Path to the New Hydrogen Energy Economy

5.1 Hydrogen biggest challenges can't be overcome alone

On the path to the new Hydrogen Energy economy, Public-Private Partnerships (PPP) are required. In Europe, the main hydrogen energy funding programs are based on a "Fuel Cells & Hydrogen" Joint Technology Initiative, launched in 2008 by the European Commission with €80 million/year [5].

Several projects in the past have initiated the demonstration of hydrogen efficiency, some of them still being active, and have prepared the path for early markets partnerships. On a longer-term basis, mass transport partnerships are gathering the key players into a convergence of means and visions.

Air Liquide subscribes to this frame and is an active actor of the following programs:

5.1.1 The Hychain project

Over the period 2006-2010, Hychain [6] is a €37 million program, which deploys in four European countries small urban vehicles: minibus, tricycles, utility vehicles and wheelchairs. The project also tests a dedicated infrastructure for exchangeable hydrogen cylinders.

5.1.2 The Horizon Hydrogen Energy (H2E) project

The Horizon Hydrogène Energie (H2E) [7] program is the latest of Air Liquide's commitment. This ambitious program represents a global investment of 190 million Euros over 7 years in research and technology development and federates 19 partners in order to implement a new industry for hydrogen energy.

H2E is a unique occasion to promote France and Europe into the implementation of a sustainable energy industry and has been tailored especially to fit the targeted early markets.

In summary, H2E is a program:

- aiming at building sustainable and competitive hydrogen energy solutions in the targeted markets
- investing in research & technology over seven years
- aiming at breakthroughs in the entire industry on electrolysis, fuel cells, hydrogen production and high pressure storage technologies
- opening early markets to ensure the transition towards and open the way for future applications such as in transport.
- deploying several thousands of systems throughout Europe by 2015 and in subsequent years
- opening early markets that, in Europe, represent a potential of several billions of Euros beyond 2015.

5.2 Mass transport partnerships

As briefly presented formerly, the sustainable mobility for mass transport implies three main stakes, namely

- to preserve the environment,
- to define a third-countries-independent and sustainable energy,
- to generate economy growth based on an affordable energy.
- and to offer the same conditions of use as today's vehicles

To reach such goal, industries and customers benefit from drivers of change which are the environment policies, the energy policies and the economical context. However, cost reduction is the major stake to influence the economical context and is the responsibility of technology makers. With fuel cells for example, Axane has been able to divide the cost of its cells by ten thanks to breakthroughs. Yet, to reach cost objectives compatible with the various markets, notably in transport, it is imperative to continue to raise the equipment performance and reach large-scale production levels.

Air Liquide decided to promote and to play a leading role in the following transport programs:

5.2.1 British Columbia Transit project

The BC Transit project in Vancouver [8] have deployed with Can$ 89 million the largest hydrogen bus fleet operating in a single location with 20 buses refuelled at the largest hydrogen station ever built today. The project has been launched on the occasion of the last Vancouver Olympics.

5.2.2 H2 Mobility Project

"*A comprehensive infrastructure for hydrogen refueling will be in place in Germany by 2015*." This statement is the origin of a three-phase plan of action. In the first phase, concepts for the expansion of new hydrogen refuelling stations should be developed by 2011 with the help of funding from Germany's economic stimulus package. In the second phase, this infrastructure will be realized, while the third phase will be marked by electric vehicles powered by fuel cell technology hitting the roads around 2015 in Germany as regional starting point.

Air Liquide decided to share his efforts with the signing manufacturers; NOW, Daimler, Linde, Air Products, Shell, Total, OMV, ENBW, Vattenfall) in order to prepare the FCVs mass market in Europe.

In a second deployment phase, similar concepts for the market penetration of hydrogen infrastructure could be developed in other regions of the world, including Europe, USA, Japan and Korea as further starting points.

6 Conclusion

Air Liquide is confident Hydrogen Energy applications will create tremendous growth opportunities. All those partnerships, combined with the development of their associated technologies, should allow for hydrogen vehicles to be ready for the commercialization on the market by 2015, contributing to the raise of the new Hydrogen Energy economy.

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