AIR LIQUIDE

Creative Oxygen

# HYDROGEN, A CLEAN ENERGY

## Press kit

October 2014

# CONTENTS



# HYDROGEN, A CLEAN ENERGY

The world of energy is in the midst of deep change and **hydrogen is one of the solutions that offers a response in the short term to the challenges of sustainable mobility:** reducing greenhouse gases, local pollution in our cities and dependency on oil-based fuels.

Used in a fuel cell, hydrogen combines with oxygen from the air to **produce electricity, with water as the only by-product.** Hydrogen can be produced from a various range of energy sources, in particular natural gas, but also from renewable energy sources. **Hydrogen thus has great potential to provide clean energy and ensure reliability of supply.**

Hydrogen energy is a **fast-growing** field of which the Group masters the entire industrial chain, from production and storage to distribution and uses for the end user.

Air Liquide is actively involved in setting up this industry and allowing the widespread use of hydrogen as a clean energy.

# HYDROGEN ENERGY, A PROVEN SOLUTION

## Fuel Cell Electric Vehicles due to be introduced to the market by 2015-2017

**Fuel Cell Electric Vehicles (FCEV)** are efficient for long-distance journeys, which represent 75% of $CO_2$ emissions from the transport sector. They do not generate any pollution on the point of use (no particles or noise).

The automotive industry has announced that Fuel Cell Electric Vehicles will go on sale by 2015-2017. Air Liquide is contributing to **the emergence of this industry in the transport sector by supporting the creation of the necessary distribution infrastructures** at global scale.
The Group has created hydrogen stations that can fill the fuel tanks of vehicles with hydrogen gas in **less than five minutes with a pressure of 700 bar.** At this point, **more than 60 hydrogen stations** have been designed and delivered by Air Liquide.


→ In **2012**, Air Liquide opened its first hydrogen filling station to the general public for private cars in the town of Düsseldorf in **Germany**. Following this cutting-edge station, **15 hydrogen filling stations will be designed and built** by Air Liquide, as part of a large-scale demonstration project carried out by the German government. Indeed, by 2023, the German network will be expanded to about **400 hydrogen stations** covering the whole country. A distribution network of at least **100 public hydrogen stations** will be set up **over the next four years.**

In **Japan**, the government sees hydrogen as a major source of energy with great promise for the future of the automotive industry and considers building around **100 hydrogen stations by 2015.** Air Liquide expects to be responsible for building many of these stations. Very present in this sector in Japan, the Group has already built **three hydrogen stations,** in Tokyo, Kawasaki, and Saga. In **2013**, Air Liquide signed a partnership with **Toyota Tsusho** to create a new JV company for hydrogen supply of Fuel Cell Electric Vehicles. As a first step, the new company will build **two hydrogen filling stations** in the Aichi area.

In **2013**, Air Liquide also got **the two first Fuel Cell Electric Vehicles registered in France**, which represents an important landmark in the development of the hydrogen energy industry in this country. The two **Hyundai ix35** cars are part of a series of 1,000 vehicles that the constructor will build by 2015.

→ In September **2014**, Air Liquide opened its first hydrogen filling station for the general public in Rotterdam in the **Netherlands** and by the end of 2014, **four new hydrogen filling stations** will be installed in **Denmark** as part of the Copenhagen Hydrogen Network, supported by the European Commission. These four filling stations - two in Copenhagen, one in Aalborg and one in Vejle - will join two stations already in service, located in Copenhagen and in Holstebro.

A new hydrogen station is also planned to be installed in Saint Lô (France) by the end of 2014.



## Buses that run on hydrogen

Besides the market of private cars, public transportation also represents a potential market. The Group supplied a **hydrogen station in Oslo**, Norway, to power **five buses** operated by a Norwegian transport company, and another one **in Aargau, Switzerland**, where the local authorities also operate **five buses.**

# HYDROGEN ENERGY, A PROVEN SOLUTION

*Hydrogen filling station for forklift trucks*

## Forklift trucks

Air Liquide already distributes solutions both for the production of energy and decentralized hydrogen distribution equipment. The creation of captive fleets running on hydrogen improves productivity while reducing emissions in the place of use. **The main applications are destined for fleets of forklift trucks in logistics warehouses and fleets of baggage transportation vehicles in airports.**
Of all the markets for hydrogen energy, the segment for forklift trucks with hydrogen fuel cells is the fastest growing.

→ In **Europe**, several projects have seen the light of day, including one with the leading specialized retailer **IKEA** for the creation of a **first hydrogen station** in France. This station will initially provide hydrogen for **around twenty forklift trucks fitted with HyPulsion hydrogen fuel cells.**

In **Canada**, Air Liquide teams supply hydrogen for the Air Liquide station to fill the fuel cell **forklift truck** fleet of **Walmart's** logistics center.

Air Liquide also supplies the hydrogen necessary to power a fleet of **37 forklift trucks** in a **Coca-Cola** distribution and bottling center located in **California**.

*Forklift trucks*

## Isolated sites

→ **Stationary, silent, with zero emissions** at the point of use, hydrogen energy is used for equipment that is based far from the power grid (or awaiting connection) in particular for mobile telephone antennas. **Air Liquide has installed fuel cells on over 100 telecoms sites** around the world. For example, since the end of January 2013, a **Belgacom** telecom site in Wemmel, Belgium, has been powered by the **fuel cell system developed** by Axane (Axane is a wholly-owned subsidiary of Air Liquide).

→ **The generation of electricity** for emergency services or first aid during one-off events in isolated locations is another possible use.

*Stationnary Axane fuel cell*

From the production of hydrogen to its use, on average, a **hydrogen fuel cell reduces $CO_2$ emissions by 35 tonnes per year** compared to a generator. The running time of **12,000 hours achieved by Axane fuel cells** make them a competitive system, thanks in particular to the optimized maintenance costs.

# HYDROGEN ENERGY, AIR LIQUIDE'S CONTRIBUTION

Air Liquide contributes to facilitating access to this **clean and renewable energy**. The Group is actively pursuing a twofold strategy, continuing to channel its **efforts into hydrogen research and innovation** to improve existing technologies and to develop new ones, as well as taking part in **major international demonstration projects.**

With a **budget of €1.3 billion** for the period 2014-2020, the **Fuel Cells & Hydrogen Joint Undertaking** (FCH JU) platform is an innovative public-private partnership, jointly managed by the European Commission and European industrial companies active in this sector. **This platform co-finances major research and demonstration projects in Europe to improve and promote fuel cell and hydrogen technologies. Air Liquide has chaired the Fuel Cells & Hydrogen Joint Undertaking since July 2011.**

**The "Horizon Hydrogène Energie" program (H2E)** coordinated by Air Liquide was launched in October 2008. This highly innovative program is based on the expertise of both the Group and the project partners (manufacturers, small and medium sized firms, French public research laboratories). **It aims at building sustainable and competitive hydrogen energy solutions.** The research and development will cover the full hydrogen energy value chain. The total global investment in research and technology amounts to **€190 million.**

Since 2010, Air Liquide is a partner of the **"H2 Mobility"** Initiative aimed at evaluating and expanding the setup of a hydrogen infrastructure in **Germany** to support the series production of Fuel Cell Electric Vehicles. A similar initiative was launched as well in **Great Britain in January 2012** and in **France in July 2013.**

Since 2011, Air Liquide has also been one of the partners of the **"Clean Energy Partnership"**, a public-private partnership aimed at bringing to market hydrogen as the fuel of the future, focusing on testing vehicles and filling stations under real conditions of use.

Air Liquide is a partner in the **CHIC** project (Clean Hydrogen In European Cities). This project, which is supported by the FCH JU, brings together 25 partners and its purpose is to facilitate the introduction of buses that run on hydrogen-powered fuel cells in European public transport.

The European Union's **Trans-European Transport Networks (TEN-T)** program offers financial support for the development of transport infrastructures. Community TEN-T funds have been allocated to the project involving the deployment of the HIT (Hydrogen Infrastructure for Transport) for **the construction in Rotterdam (Netherlands) of an Air Liquide public hydrogen filling station.**

# AN ORGANIZATION ADAPTED TO NEW MARKETS

## On the road to innovation

**Air Liquide advanced Business & Technologies - aB&T -** is the Group's network for incubating new businesses. aB&T is a network of companies animated by the same entrepreneurial spirit, innovative, agile and organized into four main units: **advanced Business, advanced Technologies, advanced IT and advanced Investment.** The advanced Business & Technologies network is positioned at the forefront to market new technologies for new businesses.

**aB&T** offers **innovative solutions for the hydrogen energy market:**

### → For stationary applications

Sustainable energy for the power supply of remote sites, using high-pressure hydrogen logistics and Axane fuel cell systems.

### → For captive fleets, cars and buses

Development of a hydrogen distribution network using high-pressure hydrogen supply and filling stations to supply vehicles powered by fuel cells.

Development and sale of HyPulsion hydrogen-powered fuel cell for forklift trucks. HyPulsion is a joint-venture 80% owned by Axane, a subsidiary of Air Liquide, and 20% owned by Plug Power, world leader in fuel cells for forklift trucks.

### → For hydrogen storage technology

Air Liquide has recently invested in the companies Hydrexia (a spin-off of the University of Queensland in Australia) and McPhy Energy (a young and innovative French company) through **ALIAD**, its venture capital subsidiary, which takes minority stakes in young innovative companies offering new technologies. Both developed an effective and reliable hydrogen storage technology using a new magnesium alloy in a solid form called "hydride".

# BLUE HYDROGEN, AIR LIQUIDE'S COMMITMENT

With **Blue Hydrogen,** Air Liquide is firmly moving towards a gradual decarbonization of its **hydrogen production dedicated to energy applications.**

**In practical terms, Air Liquide has made a commitment to produce at least 50% of the hydrogen necessary to these applications through carbon-free processes by 2020, by combining:**

- the use of renewable energies during water electrolysis,
- biogas reforming,
- carbon capture and storage technologies during the hydrogen production process based on natural gas.

BLUE HYDROGEN
Clean energy solutions

Today 95% of the hydrogen produced comes from natural gas and is already a highly efficient energy carrier: for equal distance traveled, Fuel Cell Electric Vehicles allow to **reduce** "well-to-wheel" **GHG emissions by 20% compared with internal combustion vehicles**.

# HYDROGEN APPLICATIONS FOR THE ENVIRONMENT

## Sulfur removal from hydrocarbons, main current use of hydrogen

Today, the most important current use of hydrogen (nearly 2/3 of the quantity sold by Air Liquide) is the **desulfurization of hydrocarbons** to produce **sulfur-free fuels.**

This desulfurization of hydrocarbons is mandatory to comply with increasingly stringent environmental standards, requirements adopted in most countries to **reduce sulfur oxide emissions into the atmosphere**. Sulfur oxides can cause respiratory problems in humans. Not only are they responsible for the emergence of urban smog but also for acid rains, which cause deforestation and the acidification of water. Moreover, sulfur quickly deteriorates the performance of catalytic converters of vehicles.

In **2013**, the hydrogen supplied by Air Liquide to refineries all over the world avoided discharging **960,000 tonnes of sulfur oxides into the atmosphere**, which is more than twice the sulfur oxides emissions of a country like France.

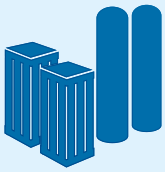
# KEY FIGURES

## AIR LIQUIDE AND HYDROGEN ENERGY


Over **60 hydrogen stations** in the world

More than **280 fuel cell systems** deployed

Axane's fuel cells reach **12,000 hours in operation**



Hydrogen produced by Air Liquide for the refinery and petrochemical markets in 2013: **12.5 billion m³**

**The current production could allow to fill around 10 million Fuel Cell Electric Vehicles.**

Revenue from hydrogen for refineries and petrochemical markets in 2013: **€1.9 billion**

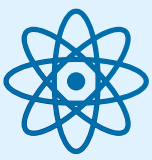
## THE AIR LIQUIDE GROUP


**World leader in gases, technologies and services for Industry and Health**

Present in **80 countries**

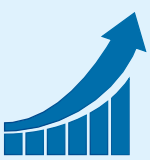
More than **50,000 employees** (2013)

More than **2 million customers and patients**



**9 Research & Development sites, 15 main Engineering centers**

Around **300 patents** per year



2013 Revenue: **€15,225 million**
2013 Net profit: **€1,640 million**

AIR LIQUIDE™

*Creative Oxygen*

For any additional information, please contact:


**Corporate Communications**

Caroline Philips

+ 33 (0)1 40 62 50 84

**Air Liquide advanced Business & Technologies**

**Communications Director**

Dominique Lecocq

+ 33 (0)4 76 43 64 97


Follow us on Twitter **@AirLiquidenergy**

**www.airliquideadvancedbusiness.com**

**www.airliquideadvancedtechnologies.com**