



**Hydrogen,  
a new clean energy  
working for the environment**

**FIRST EXCLUSIVE  
TESTS IN FRANCE  
OF HYDROGEN  
ELECTRIC  
VEHICLES**

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[www.airliquide.com](http://www.airliquide.com)

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■	<b>Air Liquide, first tests in France of Hydrogen Electric Vehicles (HEV)</b>	p.3
■	<b>Hydrogen: the clean energy of tomorrow</b>	p.4
■	<b>Blue Hydrogen: Air Liquide's commitment</b>	p.5
■	<b>Hydrogen energy: Air Liquide's solutions</b>	p.6
■	<b>Hydrogen energy: the projects involving Air Liquide</b>	p.7
■	<b>The Air Liquide Group at a glance</b>	p.8
<b>Appendices</b>		
■	<b>Hydrogen working for the environment for industry</b>	p.10
■	<b>Air Liquide, world leader in gases for industry, health and the environment, committed to sustainable development</b>	p.11
■	<b>Contacts</b>	p.12

# First exclusive tests in France of Hydrogen Electric Vehicles



**Air Liquide**, world leader in gases for industry, health and the environment, in cooperation with **Honda, Hyundai, Intelligent Energy, Mercedes-Benz, Michelin, Opel, Peugeot, Renault-Nissan and Toyota**, organizes **the first tests in France of a dozen of Hydrogen Electric Vehicles** on the Marcoussis motor racing circuit, near Paris.

Some European countries and other regions in the world have already made investments in dedicated facilities so that Hydrogen Electric Vehicles can be operated with no restraints. This mature technology offers an additional alternative to meet energy and environmental challenges in transport.

An unseen before event, these tests also gather the French Hydrogen Electric Vehicles (HEV) sector's players. Participants will discuss the integration of these vehicles into sustainable mobility in France and their contribution to industry competitiveness.

The following vehicles and equipments will be introduced during this event:

- **12 vehicles**

**Daimler-Mercedes**  
**Honda**  
**Hyundai**  
**Intelligenz Energy**

**GM-Opel**  
**Peugeot**  
**Toyota**

**2 Fuel Cell Class B**  
**2 FCX Clarity**  
**2 ix35 FCEV**  
**1 zero emission cab** (will be used during the London Olympics)  
**1 Fuel Cell Scooter Suzuki Burgman**  
**2 HydroGen4** (including one branded by Air Liquide)  
**1 FiSyPAC project 307 coupé cabriolet**  
**1 FCHV-adv Hydrogen**

- **A dual-pressure hydrogen station (350 and 700 bar) designed and developed by Air Liquide**, allowing hydrogen vehicles to be filled during these tests.

- An **Axane fuel cell** intended to power a lighting balloon.

Fitted with the latest technologies, these vehicles will seek to prove their abilities in real driving conditions as well as demonstrate their environmental performance.

For Air Liquide, this event is an opportunity to **raise public awareness** of the uses of **hydrogen** as a **clean new energy carrier** in order to **enable the development of this field** for sustainable mobility in France.



# Hydrogen: the clean energy for tomorrow



**Let's imagine sustainable energy and vehicles that don't generate any pollution.**

The world of energy is in the midst of deep change and **hydrogen, as a clean energy carrier, is one of the solutions that offer 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 the fuel cell, hydrogen combines with oxygen from 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 supplies.**

## Guided by innovation

Air Liquide is strongly committed to developing technologies that will bring solutions to our society's major issues. Among these technologies stands hydrogen energy, a **fast-growing field** of which the Group masters the entire industrial chain, from production and storage to distribution and applications.

Air Liquide **in 2001** created Axane, a subsidiary dedicated to developing fuel cells. Axane designs, manufactures and commercializes these fuel cells. Their production costs are now only **one sixth** of what they were ten years ago.

Air Liquide has also offered innovations to the hydrogen logistics chain by developing composite cylinders that can resist pressure of **up to 700 bar** (as part of the H2E program, supported by **OSEO**, the French agency for innovation support), as well as the associated filling centers.

Additionally, Air Liquide has developed hydrogen distribution stations that can fill vehicles' tanks with hydrogen gas **in less than five minutes** at a pressure of up to 700 bar. **About 50 of these stations are already in operation around the world.**



Fuel cell



# Blue Hydrogen

## Clean energy solutions



In terms of mobility, research for new energy solutions leads to a real shift in paradigm: a single energy source will not meet all needs such as oil does today. **A new energy mix is necessary. Hydrogen energy certainly belongs to this new energy mix:** though they may not satisfy all mobility needs, Hydrogen Electric Vehicles (HEVs) and the fuel cell technology are extremely efficient for long-distance travels which currently account for 75% of the transport industry's CO<sub>2</sub> emissions.

Hydrogen is a highly efficient energy vector: for equal distance travelled, HEVs allow to reduce “well-to-wheel” GHG emissions by 20% compared with internal combustion vehicles. Today 95% of the hydrogen produced comes from natural gas.

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 takes a commitment to produce, at least 50%, of the hydrogen necessary to these applications through carbon-free processes by 2020, by combining:

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

### **Blue Hydrogen: a transition model towards the new energy mix of the future**

Our modern industrial society's shift towards more sustainable production processes and consumption habits requires significant resources even though we are entering an era of public asset depletion.

**Blue Hydrogen**, through its gradual process, enables to develop a market and to mobilize industrial players' investments.



# Hydrogen energy: the projects involving Air Liquide



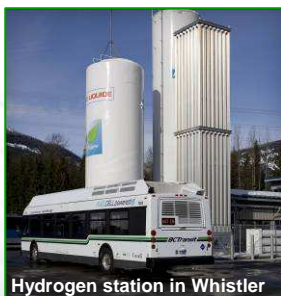
As the world leader, Air Liquide intends to facilitate access to this clean and renewable energy. The Group is actively pursuing a twofold strategy, continuing to channel its efforts into hydrogen research and innovation to improve existing technologies and to develop new ones, and taking part in large international demonstration projects.

Since July 2011 Air Liquide has been chairing the European technical platform dedicated to fuel cells and hydrogen research and marketing (Fuel Cells & Hydrogen Joint Undertaking).



The “**Horizon Hydrogen Energy**” 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.

## H<sub>2</sub> Mobility



Hydrogen station in Whistler

Since 2010, Air Liquide is partner of the “**H2 Mobility**” Initiative which aims to evaluate and expand the setup of a hydrogen infrastructure in **Germany** to support the series production of Hydrogen Electric Vehicles.

In Whistler, **Canada**, Air Liquide signed a ten-year contract for 20 hydrogen powered buses starting in February 2010 on the occasion of the Vancouver **Winter Olympics and Paralympics Games**. This hydrogen buses fleet is the largest in the world.

Other Canadian programs include the **Vancouver and Montreal airports**, which installed hydrogen stations to supply fuel cell and internal combustion engine powered passenger and utility vehicles.



Since 2011 Air Liquide is also one of the partners of the « **Clean Energy Partnership** », a public-private partnership that aims to bring to market hydrogen as the fuel of the future, focusing on testing vehicles and filling stations under real conditions of use. The mobile filling station in Berlin-Friedrichshain was installed within the framework of this "Clean Energy Partnership".



As part of the **CHIC** project, the Group will soon provide a hydrogen station in Oslo, **Norway**, to supply 5 buses from a Norwegian transportation company, and another one in Aargau, **Switzerland**, where local authorities will operate 5 buses.



With a budget of €940 million for the 2008-2013 period, the **Fuel Cells & Hydrogen Joint Undertaking** platform is an innovative public-private form of partnership, jointly managed by the European Commission and European industrial operators from this sector. This platform co-finances major research and demonstration projects in Europe aimed at improving and promoting Fuel Cells and Hydrogen technologies.

# Hydrogen energy: Air Liquide's solutions



In the field of hydrogen energy, Air Liquide already offers solutions both for decentralized power production and hydrogen distribution equipments.



Film shooting

## Solutions for

- **Stationary, silent, carbon-free power generation** at the point of use for off-grid equipments (or awaiting connection) especially for mobile phone antenna relay stations;
- **Portable power generation** for emergency units or during events (film shooting, etc.)
- **The deployment of fleets with their refill equipment** (hydrogen distribution station) in order to increase productivity while cutting emissions at the point of use. Main applications focus on warehouse forklifts fleets and luggage transportation vehicles fleets in airports.
- **The supply of 350 and 700 bar hydrogen distribution stations for Hydrogen Electric Vehicles.**



Filling station for  
Hydrogen powered forklifts  
Walmart - Canada

**Fuel cell forklifts are the fastest growing market** among all hydrogen energy sectors.

In 2010, Air Liquide signed a contract to supply the hydrogen and set up a filling station to power **Walmart's new fleet of green forklifts** at the company's new logistics centre located in Alberta, **Canada**.

In 2011, Air Liquide signed a new contract to supply hydrogen to power a fleet of **37 forklifts** at **Coca-Cola's** bottling and distribution center in San Leandro (California), in the **United States**.



Mobile phone relay antenna  
in India  
Musnota (Haryana province)

In 2011 Air Liquide also installed in **India** a **first series of fuel cells** for **Tatva Renewable Energy**, aimed at powering Indian telecom networks.

In France, to date, the **three main mobile phone operators** have **equipped some 30 sites** across the country.

**With around 50 hydrogen filling stations** in operation, **Air Liquide** refilled the equivalent of **75,000** vehicles in 2010-2011. In Asia, after installing stations in **Korea**, Air Liquide supplied two new distribution stations in **Japan** in 2011, including one for the regional government of Saga (Southern Japan). Also in 2011, in **Germany**, a **hydrogen distribution station open to the public** will be soon in operation in **Düsseldorf city center**, and a second one will supply two Daimler shuttle buses linking **Karlsruhe** city center to the **Karlsruhe Institute of Technology (KIT)**.

**Besides these first applications, Air Liquide strongly contributes to building a market and spreading the use of hydrogen for clean mobility.**

- **World leader** in gases for industry, health and the environment
- Present in **80 countries**
- **43,600 employees**
- **8 Research & Development centers, 5 Engineering centers**
- Around **300 patents** registered each year
- A commitment to **Responsibility** to all stakeholders
- Revenue in 2010: **€13.5 billion**
- Net profit in 2010: **€1.4 billion**

\* \* \* \* \*

## **Air Liquide and hydrogen energy**

- Hydrogen produced by Air Liquide in 2010: **9 billion Nm<sup>3</sup>**
- Hydrogen revenue in 2010: **€1.4 billion**
- 63 fuel cell systems deployed, almost half of which are used for telecom applications. To date Air Liquide has equipped all French telecom operators for 30 sites spread across the country
- Over 55 hydrogen stations operated worldwide

# APPENDICES

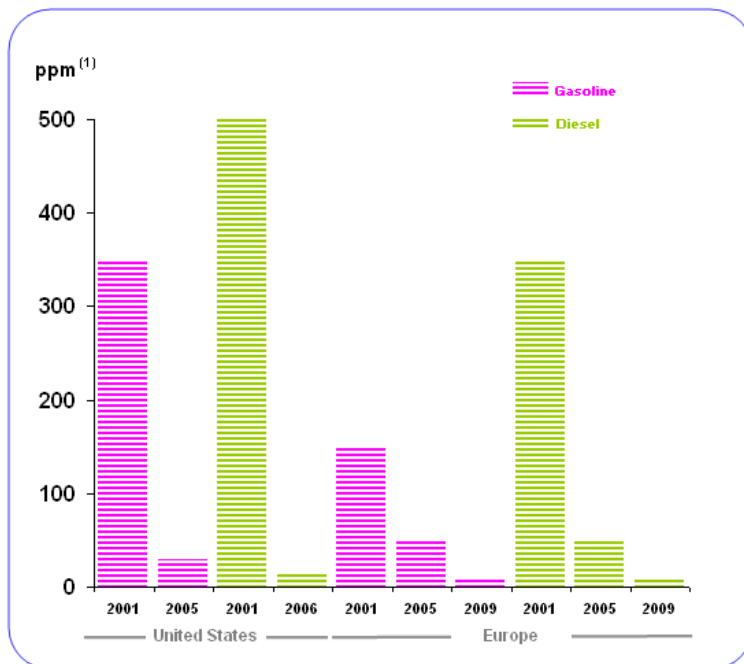
## Removal of sulfur from hydrocarbons, main current use of hydrogen

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

This de-sulfurization of hydrocarbons is necessary to reduce the level of sulfur oxides emissions into the atmosphere and is mandatory under European and American regulations. Sulfur oxides can cause respiratory problems in humans. They are not only responsible for the emergence of smog in certain built-up areas but also for acid rains, which cause deforestation and the acidification of water. Sulfur also quickly deteriorates the performance of catalytic converters of vehicles.

The hydrogen supplied by Air Liquide to refineries all over the world avoided discharging **740,000 tonnes of sulfur oxides** in 2010 into the atmosphere, which is twice higher than France's sulfur oxides emissions.

### Fuel sulfur content regulation



# Air Liquide, world leader in gases for industry, health and the environment, committed to sustainable development



**42% of Air Liquide's revenue** comes from applications which contribute to preserve life and the environment.

**More than 60% of Air Liquide's R&D budget** is devoted to life and to developing technologies designed to preserve the environment (energy savings, cleaner production, future energy development).

**86% of gas deliveries are made by pipelines or through on-site units.** These pipelines, environmentally friendly and safe, span a network of over 8,700 kilometers worldwide.

**17 cogeneration units** replace steam and electricity production units that would have produced more CO<sub>2</sub> emissions. **In 2010**, the Group's cogeneration units **enabled the avoidance of 954,000 tonnes of CO<sub>2</sub>** that would otherwise have been discharged into the atmosphere. They were about **17% more efficient** than the separate production of electricity and steam.

## Proposing alternative energy solutions

Air Liquide intends to play an active role in creating viable alternative energy solutions.



## Understanding and anticipating environmental challenges

Using **oxygen for oxycombustion** in industrial furnaces reduces nitrous oxide (NO<sub>x</sub>) emissions into the atmosphere and facilitates the capture of carbon dioxide. Hydrogen is indispensable for reducing the sulfur content of hydrocarbons and, consequently, the sulfur oxides (SO<sub>x</sub>) emissions caused by their combustion.

Air Liquide is constantly increasing its involvement in areas such as cogeneration, second generation biofuels and hydrogen energy, which also offer significant potential for reducing CO<sub>2</sub> emissions in the years to come.



For more information, please contact:

**Corporate Communications**

Corinne Estrade-Bordry  
corinne.estrade-bordry@airliquide.com  
☎ + 33 (0)1 40 62 51 31

Garance Bertrand  
Garance.bertrand@airliquide.com  
☎ + 33 (0)1 40 62 59 62

**Air Liquide Technologies of the Future**

Dominique Lecocq  
Dominique.lecocq@airliquide.com  
☎ + 33 (0)4 76 43 64 97

[www.airliquide.com](http://www.airliquide.com)

<http://mobilite.planete-hydrogene.com/>

**Air Liquide Energy on twitter:**

<http://twitter.com/AirLiquidenergy>