

Hydrogen, Clean energy

Press kit
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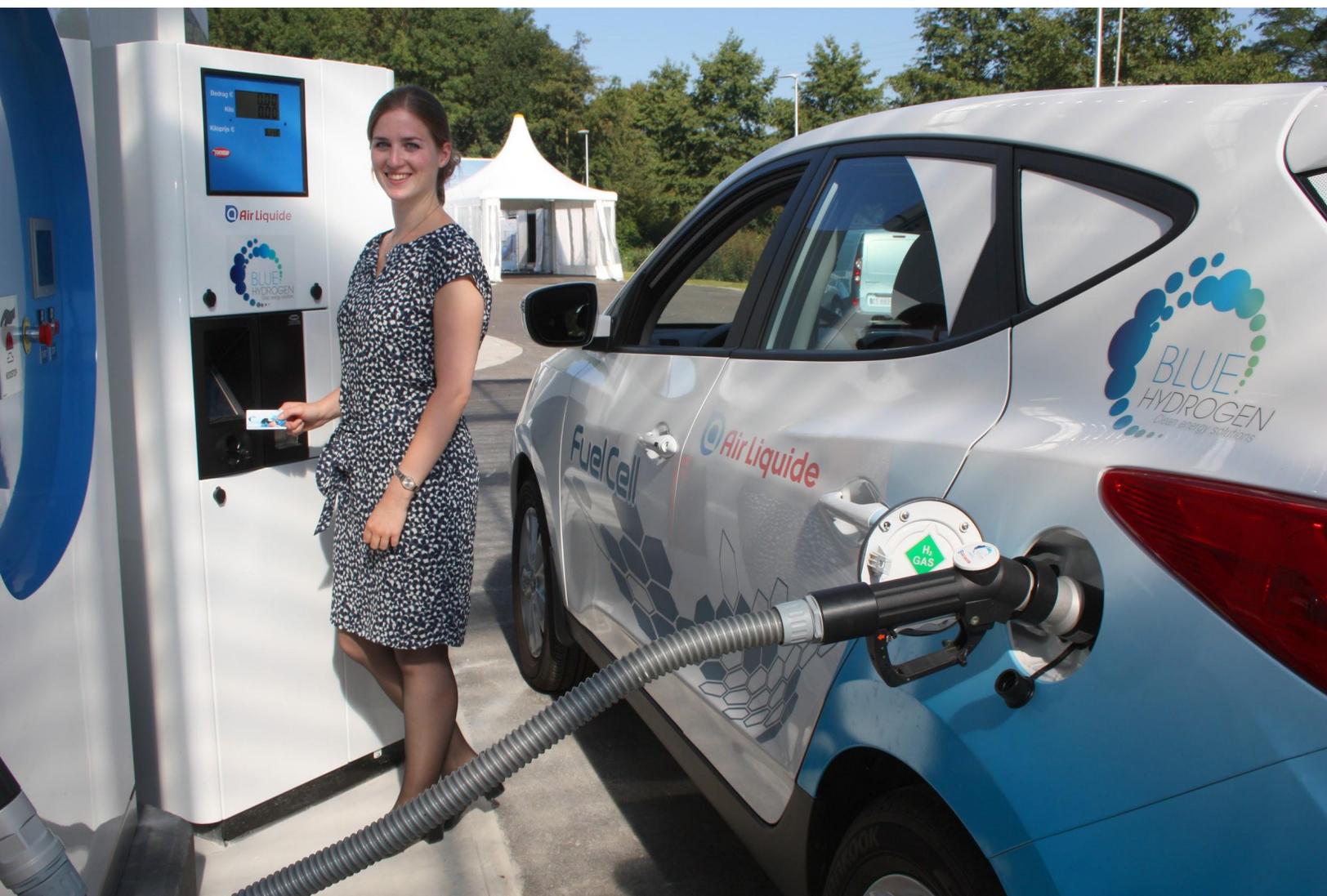
Hydrogen, clean energy

The world of energy is in the midst of deep change and **hydrogen is one of the solutions that offer a response to the challenges of clean transportation**: reducing greenhouse gases, pollution in our cities and dependency on oil-based fuels.

Used in the fuel cell, hydrogen combines with oxygen from the air to **produce electricity, with water as the only byproduct**. Hydrogen can be produced from a various range of energy sources, in particular from renewable energy sources. **Hydrogen thus has great potential to provide clean energy and be an alternative to fossil fuels**.

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

2015-2018: Mass production of Fuel Cell Electric Vehicles

Hydrogen-powered electric vehicles (or FCEV, Fuel Cell Electric Car) are efficient for long-distance journeys, as with a **charging time of less than five minutes, they offer a 500 km driving range**. Such journeys represent 75% of CO₂ emissions from the transport sector. They do not generate any pollution on the point of use: **zero CO₂ emissions, zero particles and zero noise**.

The automotive industry has announced that hydrogen-powered cars will go on sale by 2015-2017. Air Liquide is contributing to **the growing use of hydrogen in the transport sector** by supporting the creation of the necessary hydrogen station network at global scale. Air Liquide has designed and installed **100 stations around the world** to date, in which 40 were invested and operated by the Group.



→ In Europe

In **Germany**, Air Liquide has opened **nine public hydrogen stations** as part of the Clean Energy Partnership, to which are added two stations under the aegis of the H2 Mobility consortium incorporating Air Liquide's technology. Air Liquide contributes to the construction of the largest hydrogen distribution infrastructure network in Europe: the German government intends to build by 2023 a network of about **400 hydrogen stations** covering the whole country. A network of at least **100** public hydrogen stations will be set up **over the next two years**.

In **France**, a hydrogen station for the **Manche General Council** was installed in **Saint Lô in January 2015**. Air Liquide has also inaugurated in **December 2015** a new charging station in **Grenoble** as part of the **HyWay project***. This complements the existing station at Air Liquide's **Sassenage** site (Rhône-Alpes), which allows the users of the HyWay* project to recharge their vehicles with hydrogen.

On the occasion of **COP 21** in December 2015, Air Liquide has installed the **first hydrogen station in the heart of Paris at Pont de l'Alma**, in partnership with the STEP start-up (Société du Taxi Électrique Parisien of which Air Liquide is a minority shareholder) and supported this start-up in the launch of its hydrogen taxi fleet "Hype", the world's first hydrogen taxi fleet. Today, the fleet counted **75 hydrogen vehicles** (Hyundai ix35 and Toyota Mirai) which can recharge at the new stations installed by Air Liquide next to Paris-Orly airport (dec 2017) and in Les-Loges-en-Josas city near to Versailles (mars 2018). STEP plans **to deploy 100 taxis by the end of this year, and 600 taxis by 2020**.

In **Northern Europe**, Air Liquide opened in September **2014** its first public hydrogen station in Rotterdam in the **Netherlands**. **Five other stations** were also installed in **Denmark** as part of the **Copenhagen Hydrogen Network**, supported by the European Commission. These five charging stations - three in Copenhagen, one in Aalborg and one in Vejle - joined two stations already in service, located in Copenhagen and in Holstebro.



**The HyWay project, coordinated by the Tenerrdis competitiveness cluster, is jointly supported by the French government (ADEME) and the Rhône-Alpes Regional Council, and by Europe through the FEDER regional programme.*

Hydrogen energy, a proven solution

→ In Japan

In **Japan**, the government sees hydrogen as a major energy with great promise for the future of the automotive industry and considers building around **100 hydrogen stations** in next few years. Air Liquide expects to be responsible for building many of these stations. Very present in this sector in this country, the Group has already built **6 public hydrogen stations** in Nagoya, Toyota, Saga, Fukuoka, Kobe and Kawasaki. The Nagoya and Toyota stations, in the Aichi area, were built by a joint venture company between Air Liquide Japan and **Toyota Tsusho Air Liquide Hydrogen Energy Corporation**.

→ In the United States

In November **2014**, Air Liquide also announced plans to develop and supply a fully-integrated hydrogen charging infrastructure with **12 hydrogen stations** in the Northeast of the **United States**, in collaboration with **Toyota Motor Sales USA, Inc.** (Toyota), to support Toyota's introduction of a new hydrogen Fuel Cell Electric Vehicle (FCEV), the "**Mirai**", and its plans to deliver hydrogen FCEVs in the United States. Since **December 2016**, Air Liquide also operates its first station in California (in Anaheim), as part of a State of California program designed to support the deployment and use of FCEV, with **about 50 hydrogen stations planned in California by the end of 2017**.



→ In the United Arab Emirates

In October 2017, Air Liquide inaugurated in **Dubai**, in partnership with Al-Futtaim Motors the exclusive distributor of Toyota in the country, **the first hydrogen station installed in the United Arab Emirates**. This station was designed and installed by Air Liquide to support the deployment of zero-emission fuel cell electric vehicles (FCEVs) in the UAE, notably Toyota Mirai hydrogen vehicles.

The station comprises **cutting-edge technologies** which have been tailored to suit the specific climate conditions of the region. This initiative is fully aligned with the UAE Vision 2021 aiming at lowering CO2 emissions, and promoting cleaner and sustainable mobility in the Emirates.

Hydrogen energy, a proven solution



Hydrogen charging station for forklift trucks

Forklift trucks

The creation of captive fleets running on hydrogen improves productivity while reducing CO₂ emissions in the place of use. The main applications concern **fleets of forklift trucks in logistics warehouses and fleets of baggage transportation vehicles in airports**. Two hydrogen energy markets showing strong growth. These advantages have been highlighted in the North American market **where currently some 15,000 hydrogen-powered forklift trucks were deployed**. The potential development of this market in Europe could be around 10,000 units by 2020.

→ In **Europe**, several projects have seen the light of day, including one in France with **Prélodis**, logistics provider for the Grand Frais chain stores, that chose Air Liquide for the construction of a hydrogen station on the Prelocentre platform where **all forklifts run on hydrogen**.

This station **powers 50 forklifts**. In France also, as part of the **HAWL** project (Hydrogen And Warehouse Logistic) supported by the European Public Private Partnership **FCHJU** (Fuel Cell and Hydrogen Joint Undertaking), Air Liquide installed a hydrogen station on FM Logistic's Neuville-aux-Bois' platform to power **47 forklifts**.

→ In **Canada**, Air Liquide supply hydrogen for four stations to power the **hydrogen forklift truck fleet** of four **Walmart** logistics centers.

→ In the **United States**, Air Liquide also supplies the hydrogen necessary to power a fleet of **47 forklift trucks** in a **Coca-Cola** distribution and bottling centre located in **California**.

Buses that run on hydrogen

Besides the market of private cars, **public transports also represent a promising market**. Air Liquide has installed a hydrogen station in Rosenholm near Oslo in Norway, which can recharge five buses of a Norwegian transport company; the Group also supplies hydrogen to buses operating in Rotterdam in the Netherlands thanks to a station installed in Rhoon.

In France, Air Liquide installed a hydrogen station near Versailles (Ile-de-France) in 2018 to recharge cars and heavy vehicles. This station will supply the first hydrogen bus line in France, commissioned in 2019 between the municipalities of Vélizy and Versailles.



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) and Ergosup (a french start-up) 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".

New “Hydrogen Council” launched in Davos

39 global industry leaders join together in promoting hydrogen to help meet climate goals



In the first global initiative of its kind, the ‘Hydrogen Council’ is determined to **position hydrogen among the key solutions of the energy transition**. Hydrogen is a versatile energy carrier with favourable characteristics since it does not release any CO₂ at the point of use as a clean fuel or energy source, and can play an important role in the transition to a clean, low-carbon, energy system. Hydrogen technologies and products have significantly progressed over past years and are now being introduced to the market. The Council will work with, and provide recommendations to, a number of key stakeholders such as policy makers, business and hydrogen players, international agencies and civil society to achieve these goals.

Hydrogen Council

During their first meeting in Davos in January 2017, the members of the ‘Hydrogen Council’ confirmed their ambition to **accelerate their significant investment in the development and commercialization of the hydrogen and fuel cell sectors**. These investments currently amount to an estimated total value of €1.4 Bn/year¹. This acceleration will be possible if the key stakeholders increase their backing of hydrogen as part of the future energy mix with appropriate policies and supporting schemes. In one year, the Hydrogen Council has almost doubled its membership since its creation.

The Hydrogen Council has published two studies to date, [How hydrogen empowers the energy transition](#) (January 2017) exploring the role of hydrogen in the energy transition, including its potential, recent achievements, and challenges to its deployment and [Hydrogen, scaling up](#) (November 2017) presenting the first comprehensive vision of the long - term potential of hydrogen and a roadmap for deployment.

The Hydrogen Council members:

The ‘Hydrogen Council’ is currently made up of **39** various industries and energy companies committed to help achieve the ambitious goal of reaching the 2 degrees Celsius target as agreed in the 2015 Paris Agreement. Current members include **24 leading multinationals** - 3M, Air Liquide, Alstom, Anglo American, Audi, BMW GROUP, China Energy, Daimler, ENGIE, General Motors, Great Wall Motor, Honda, Hyundai Motor, Iwatani, JXTG Nippon Oil & Energy Corporation, Kawasaki, Plastic Omnium, Royal Dutch Shell, Statoil, The Bosch Group, The Linde Group, Total, Toyota and Weichai– as well as **15 dynamic players** from across the value chain - Ballard, Faber Industries, Faurecia, First Element Fuel (True Zero), Gore, Hexagon Composites, Hydrogenics, Marubeni, McPhy, Mitsubishi Corporation, Mitsui & Co, Nel Hydrogen, Plug Power, Toyota Tsusho and Royal Vopak. The coalition collectively represents total revenues of over € 1.6 trillion and more than 2.5 million jobs around the world².

¹ How Hydrogen empowers the energy transition, Report, 2017, Hydrogen Council

² companies’ figures from financial years 2015 and 2016

Air Liquide's contribution to international programs

Air Liquide contributes to facilitating access to this **clean energy**. The Group is actively pursuing a two fold 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 from July 2011 to June 2016.**



The **“Horizon Hydrogène Energie” program (H2E)** coordinated by Air Liquide and co-financed by the Public Investment Bank (BPI France) 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.**



Since 2015, Air Liquide is a founding partner of the **H2 Mobility Deutschland** joint venture, an initiative aimed at evaluating and expanding the setup of a hydrogen network in **Germany** to support the series production of hydrogen Fuel Cell Electric Vehicles. Started in 2010, the H2 Mobility project will expand the existing network of hydrogen stations to around 400 by the end of 2023.



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 a key energy of the future, focusing on testing vehicles and charging 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 than 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 charging station.**



The European HyBalance project aims at producing hydrogen for transportation by water electrolysis. It is the first project to demonstrate the complete value chain from hydrogen renewable energy production to end users. Started on October 1st, 2015, this pioneering project is coordinated by Air Liquide and supported by the European Fuel Cells and Hydrogen Joint Undertaking. This hydrogen production site was commissioned in early 2018.

Blue Hydrogen: Air Liquide's commitment

Blue Hydrogen® is an Air Liquide initiative that aims to gradually lower the carbon content of Air Liquide's hydrogen production dedicated to energy applications. **Concretely, Air Liquide is committed to achieving at least 50% of low carbon (a) hydrogen necessary for these applications by 2020, by combining:**

- the use of low carbon energies, water electrolysis, and reforming of biogas,
- carbon capture and valorization technologies for the CO₂ emitted during the production of hydrogen from natural gas.



Even when produced using natural gas, hydrogen is a virtuous energy: over an equal distance traveled, the use of hydrogen fuel cell electric vehicles **decreases greenhouse gas emissions by 20% compared with combustion vehicles and does not emit any particulate matter.**

Hydrogen applications for the environment

Sulfur removal from hydrocarbons, a long existing use of hydrogen

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

In **2017**, the hydrogen supplied by Air Liquide to refineries all over the world **resulted in the avoidance of 1.5 million tons of sulfur oxides being discharged into the atmosphere**, which is more than ten times as much as the total sulfur oxide emissions of a country like France.

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.



Key Figures

AIR LIQUIDE AND HYDROGEN ENERGY



100 hydrogen stations designed and installed in the world



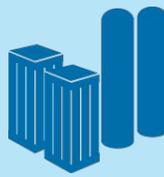
A hydrogen station can recharge vehicles in **less than 5 minutes**



A hydrogen car can ride **more than 500 km** with one charging



Zero CO₂ emission
Zero particle
Zero noise pollution



Hydrogen produced by Air Liquide in 2016 for the refinery and petrochemical markets: **14 billion m³**
The current production could allow to recharge around 10 million hydrogen Fuel Cell Electric Vehicles



Revenue from hydrogen for refineries and petrochemical markets in 2016: **€2 billion**

THE AIR LIQUIDE GROUP



The world leader in gases, technologies and services for Industry and Health



Present in **80 countries**



approximately **65,000 employees**



More than **3.5 million customers and patients**



292 millions euros of innovation expenses, almost 60% of these expenses are related to the improving of the environmental footprint, air quality and healthcare



Around **300 patents** per year



2017 Revenue: **€20.3 billion**
2017 Net profit: **€2.2 billion**

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