

ONTAIR

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Virginie D., CryoConcept employee, working on a dilution refrigerator, an essential system for certain fundamental physics applications.

 **Air Liquide**

Interview



At a time when the world is undergoing profound transformations—from changes triggered by the public health crisis and the energy transition, to developments in healthcare and the technology race—Air Liquide is more committed than ever to inventing a sustainable future. We talked to Benoît Potier about how the Group can commit to preparing for that future today.

This year, Air Liquide announced ambitious sustainable development goals. What does this mean for the Group's strategy?

Financial and extra-financial performance are now inextricably linked—of that, I have no doubt. We can be proud of our strong financial results, as they are necessary for funding our commitments to society in the long term. I firmly believe that taking action for a sustainable future involves achieving success today, and we count a number of strengths in this regard. Our unique and resilient business model is the very foundation of our performance. Our growth outlook is promising. Our position at the heart of future markets is a strong asset moving into this next chapter. Our solutions dedicated to the energy transition, climate protection, healthcare and technology not only present growth opportunities, but also have a positive impact on society. At its core, Air Liquide is a group laser-focused on progress. The Group's history, bursting with innovation and development, is a testament to this. To build a sustainable future, we're drawing on our ability to continually go above and beyond.

How does the Group's innovation relate to its financial and extra-financial performance ambitions?

Innovation plays a key role in these intertwined ambitions. It underpins our competitiveness and allows us to respond to societal challenges, particularly regarding sustainable development. Our solutions in the fields of hydrogen, decarbonization and deep tech are evidence of this. In an increasingly fast-paced world, we must become increasingly more agile and cut the time it takes to bring our innovations to market. This ambition is what fuels our network of Innovation Campuses, nestled at the heart of the largest economies in Asia, the United States and Europe. Researchers, customers, academics and start-ups are working hand in hand to design the solutions of tomorrow.

Every year, the Group celebrates its innovators at the Be Innovation event. What does this recognition mean to Air Liquide?

Innovation is part of the Group's history; it has been woven into our DNA from the very start. We created Be Innovation because we wanted to strengthen this mindset even more. This annual event gathers and rewards employees who are spearheading particularly innovative projects. For the 11th edition, around 300 employees were recognized for innovations that positively impact society. I wish to thank our employees who are the driving force of our innovation. Let's continue inventing a sustainable future together!

THE AEROSPACE SECTOR

PREPARING FOR THE ARRIVAL OF HYDROGEN

Air Liquide and Airbus⁽¹⁾ recently signed two major partnerships, one with Groupe ADP⁽²⁾ and the other with VINCI Airports⁽³⁾. The goal is to prepare for the arrival of the first hydrogen-powered aircraft by 2035. Air Liquide already has a presence on aircrafts and in airports, most notably through the installation of hydrogen charging stations. Now the Group is going one step further by contributing to the emergence of an innovative, strategic French sector working toward sustainable and decarbonized aviation. These two partnerships, along with the development of high-pressure storage solutions for charging hydrogen fuel cells on aircraft, will contribute to this achievement.

(1) European aircraft manufacturer. (2) Aéroports de Paris, a global leader in airport design, construction and operation. (3) VINCI Airports develops, finances, builds and manages 45 airports in Europe, Asia and the Americas.

- **10,000** regional aircraft could be using hydrogen fuel by 2050⁽¹⁾
- **€8 billion** will be invested by Air Liquide in the low-carbon hydrogen value chain by 2035

(1) In Brief: Hydrogen for Aviation, Air Liquide.

Our achievements over the past six months

Development

CHINA, A DYNAMIC MARKET FOR THE GROUP



After celebrating a presence of 30 years in China, Air Liquide is continuing its growth in key sectors of the economy. Three new projects are underway, allowing the Group to leverage its expertise and sense of innovation for the benefit of its customers and partners.

► **HYDROGEN MOBILITY:** Air Liquide technology was chosen for the world's largest hydrogen station in Beijing. With a capacity of nearly 5 tons per day, it can supply 600 hydrogen vehicles every day, a feat made possible by the eight dispenser units installed by the Group.

► **ELECTRONICS:** Air Liquide will invest 70 million euros in a state-of-the-art plant in Wuhan that will produce ultra-high-purity gas to supply a leading manufacturer of flash memory chips.

► **LOW-CARBON INDUSTRY:** In July 2021, the Group announced that it will construct and operate an ultra-modern low-carbon ASU (Air Separation Unit) in Zhangjiagang City, Jiangsu Province. The new ASU will produce 3,800 tons of oxygen per day for one of the world's leading steel companies, Jiangsu Shagang Group. It will also produce krypton and xenon to meet the growing demand of the local electronics industry.

Funding

A GLOBAL FUND DEDICATED TO LOW-CARBON HYDROGEN

Air Liquide, TotalEnergies and VINCI are joining forces with other international industry stakeholders to create the world's largest fund dedicated to the development of clean hydrogen infrastructure solutions. Firmly convinced that this molecule will play a key role in the energy transition, the three partners have committed to contributing €100 million each. The new fund will invest in large-scale strategic projects throughout the entire renewable and low-carbon hydrogen value chain in Europe, the Americas and Asia. Aim: to accelerate the growth of the hydrogen ecosystem.

COMMITMENTS OF
€800 M

ALREADY SECURED TOWARD

**A GOAL OF
€1.5 BILLION**

Renewable hydrogen

NEW INDUSTRIAL-SIZED ELECTROLYZER IN GERMANY

Through its partnership with Siemens Energy, Air Liquide will build an electrolyzer to produce renewable hydrogen in Oberhausen, Germany. With a capacity of 30 megawatts, this production plant will be the first industrial-sized electrolyzer to be connected to the existing Air Liquide pipeline network. It will support the carbon-reduction efforts of key sectors such as steel, chemicals and refining, as well as the mobility players in North Rhine-Westphalia that it will supply. The publicly funded unit is expected to become operational in 2023.

Energy transition

SETTING SAIL TOWARD NEW HYDROGEN SOLUTIONS

Air Liquide will be Energy Observer's main partner for the next four years. The two teams have been working together since the autonomous hydrogen-powered and zero-emission laboratory vessel was launched in 2017. By strengthening this partnership, Air Liquide enables the Energy Observer teams to pursue their mission of educating and raising awareness of the challenges of the energy transition—and provides a skills-based sponsorship scheme. Employees from the Group will collaborate on hydrogen research and development projects alongside the Energy Observer teams.



Through our collaboration with Energy Observer and by testing hydrogen technologies in extreme environments, we will be able to accelerate the development of hydrogen solutions and their large-scale applications, particularly in the maritime sector. //

MATTHIEU GIARD,
MEMBER OF THE AIR LIQUIDE GROUP EXECUTIVE COMMITTEE
AND VICE PRESIDENT SUPERVISING HYDROGEN AND INDUSTRIAL
MERCHANT ACTIVITIES



Industry decarbonization

PRODUCING LOW-CARBON HYDROGEN WITH TOTALENERGIES

Under a long-term contract, Air Liquide will take over and operate the hydrogen production unit of the TotalEnergies platform in Normandy, France. With a capacity of 255 tons per day, it will be connected to the Air Liquide network, thus enabling the development of the world's first low-carbon hydrogen network. The two partners also plan to implement a CO₂ capture and storage solution. The CO₂ emissions generated by the unit's hydrogen production should be reduced by approximately 650,000 tons per year by 2030.

Collective intelligence for deep tech solutions

Climate change, chronic diseases, cybersecurity – sometimes, the magnitude of the challenges facing society can feel dizzying. Yet the technology for responding to these trends is not beyond our reach – quite to the contrary.

Air Liquide is one of the companies developing deep tech⁽¹⁾ solutions to tackle them, through a cooperative approach to innovation that will be the key to its success.



4,300

EMPLOYEES CONTRIBUTING
TO INNOVATION



As industries around the world have grown ever more interconnected due to globalization, innovation silos will simply no longer cut it. The technological advancements of the future are defined by one theme: collaboration. “Experience teaches us that innovation is always first and foremost a matter of people, connections and analogies,” says Chairman and CEO Benoît Potier. “Gone are the days when a firm could retain control over its entire R&D efforts... From now on, innovation will take place in an open ecosystem.”

With a network of Campuses in Europe, North America and Asia, Air Liquide has created a flourishing ecosystem of collective intelligence focused on developing and manufacturing disruptive business solutions. “We will see exciting new technologies from our ecosystem in real-world use in the near future,” says Luc Gaffet, Fusion and Big Market Science Director, Global Markets & Technologies.

Cryogenics: ultra-low temperatures, sky-high potential

One example of a company on the verge of bringing new technology to market is Cryoconcept, in which Air Liquide took an 80% stake in 2020. Over the past two decades, the company has developed a dilution refrigeration solution for getting close to absolute zero⁽²⁾, a necessity for advancing quantum computing capabilities and scientific research.

“By 2030, I expect quantum computers to be carrying out calculations currently beyond our grasp. This will lead to exceptionally powerful algorithms which can work at split-second speed – fast enough for an autonomous car to drive safely,” says Luc Gaffet. Guillaume Desaché, Cryoconcept’s new Managing Director, agrees, citing steering traffic on the ground, the automated development of new medicines and cybersecurity as near-future applications.

“To go beyond research use and into industrial or safety-critical applications, our products need higher reliability and better availability, as well as an overall improvement to their current cooling power,” he says. “With over sixty years experience in both extreme cryogenics and production at scale, Air Liquide is the ideal partner.” “It’s a win-win collaboration,” replies Luc Gaffet, “because Cryoconcept helps us to enlarge our offer to include extremely low temperatures. Also, their technology uses helium 3 and helium 4⁽³⁾, two very rare molecules, which we supply to our customers.”

Helium recovery systems for imaging scanners

Collective intelligence also ensures success in Air Liquide’s collaboration with United Imaging, a Chinese supplier of advanced medical products. “Air Liquide not only guarantees a reliable gas supply, but

(1) Disruptive technologies based on scientific breakthroughs that can fundamentally change design and production methods.

(2) That is -273.14°C, or 0.01°K.

(3) Pure helium 3 is the liquid with the lowest boiling point. Helium 4 is the one commonly referred to as helium.



DEEP TECH INNOVATION AT AIR LIQUIDE

Air Liquide is a key player in deep tech, offering innovative, high-tech solutions through its Global Markets and Technologies (GM&T) Business Unit, in the sectors of aerospace, space and extreme cryogenics for scientific research. The Group has recently inaugurated its Campus Technologies Grenoble (France), dedicated to the design and production of technologies for the deep tech and energy transition (hydrogen and biomethane) markets, and supports many deep tech start-ups through its Accelair accelerator, housed at the Paris Innovation Campus.

it also uses its own pioneering technology to help us recover and reuse helium in our imaging systems,” says LV Yunlei, Vice President of Shanghai United Imaging Healthcare Co., Ltd., and President of Supply Chain Management.

The Group worked in close coordination with United Imaging’s teams to design a turnkey helium solution that greatly increases the recovery rate of helium and further guarantees the stable supply of liquid helium. “This helium is used by United Imaging in MRI⁽⁴⁾ and PETMR⁽⁵⁾ scanners to keep internal temperatures low and ensure the proper functioning of the machines. “Air Liquide provides innovative solutions based on continuously updated technology, enabling us to provide customized services to our customers,” says LV Yunlei.

Developing a low-cost energy storage solution

Another mutually-beneficial relationship with an ecosystem partner can be found at the Air Liquide Paris Innovation Campus. As a participant in Air Liquide’s Accelair deep tech accelerator, energy storage start-up Airthium benefits from office and lab space with on-hand expertise. “We are currently prototyping our seasonal battery to try and scale it up to the kilowatt stage,” says founder, CEO and CTO Andrei Klochko, “and having people we can ask for advice on building machinery to run at high temperatures and under pressure is invaluable.”

Deployed at scale, Airthium’s ammonia-based energy storage solution promises to provide a low-cost way of storing excess solar and wind energy over months or even years. It will make renewable energy

production and storage a sustainable replacement of coal and gas power plants. “As well as the potential for participating in the energy transition market further down the line, in the nearer term, we will be able to offer Air Liquide a solution for guaranteeing renewable energy supplies for its own operations,” Klochko adds.

Air Liquide’s intention to be behind many of the pioneering technologies of the future requires the Group to collaborate with the right partners. By leveraging collective intelligence across industries and partners, the company has already succeeded in creating a global ecosystem of truly open innovation. The key to future success? Expanding this network to support the development of as many deep tech technologies as possible, leading to the opening of new markets and the dawning of new technological frontiers.

(4) Magnetic resonance imaging.

(5) Positron emission tomography – magnetic resonance imaging.

CONNECTED TO INNOVATION ECOSYSTEMS

Our Campus network extends across the globe and embodies the Group's open innovation approach. The Campuses are defined by their local and national environment and complement one another. They bring together all our innovation partners, attract new talent, and foster skill sharing and collective intelligence to accelerate the development of solutions for our customers.

GRENOBLE, FRANCE

Technology solutions for customers in the deep tech and energy transition markets

1,200
employees
1
technical testing area

20,000
m² of production workshops

PARIS, FRANCE

R&D flagship at the heart of one of Europe's largest innovation ecosystems and home to Accelair, the deep tech start-up accelerator

350
employees
59
laboratories

8
technical platforms

SHANGHAI, CHINA

Energy efficiency solutions at the heart of China's center of technological excellence

230
employees
10
laboratories

11
industrial experimentation platforms



DELAWARE, UNITED STATES

Close to Airgas and its one million customers

130
employees
7
laboratories

6
experimentation platforms

TOKYO, JAPAN

Customer-centric innovation to improve process performance

100
employees
12
laboratories

6
industrial experimentation platforms

FRANKFURT, GERMANY

Energy processes and solutions within the leading European economy

59
employees
27
laboratories

2
technical platforms for testing full-scale solutions

Encounter

Where collaborative innovation grows

When an industry giant collaborates with customers, start-ups and researchers, the results can be remarkable. Our partners' experience tells us that trust, communication and synergy provide a breeding ground for impressive sustainable solutions.



“Bridging the innovation gap”

GIJS VAN DER VELDEN

CEO and Co-Founder of MX3D

MX3D, a Dutch technology start-up, inaugurated the world's first robotic 3D printed bridge in Amsterdam in July 2021. As an R&D partner on this groundbreaking project, Air Liquide contributed its welding and additive manufacturing expertise, along with ARCAL™ shielding gases.

“Air Liquide was a logical partner because we were not welding specialists and we were looking for expertise for this pioneering project. Beyond the supply of gas, the R&D teams accompanied us in the early stage by defining some general rules of thumb for using the protective gas. They also supported us with the rules, regulation and installation when setting up our factory. Thanks to them, we were able to develop much faster. They made a point of advancing the project without trying to be secretive of their technology or knowledge. That's the definition of open innovation.”

“Cooperation moves technology forward”

BRUNO G. POLLET

Professor of Chemistry, Hydrogen Research Institute, University of Quebec at Trois-Rivières



“We’re aligning to ensure zero-emission hydrogen aviation”

GLENN LLEWELLYN

Vice President of Zero-Emission Aircraft, Airbus



Air Liquide is partnering with the University of Quebec at Trois-Rivières (Canada) to build expertise in power electronics for electrolyzers that produce low-carbon hydrogen and to contribute to the next generation of electrolyzers. The project will first investigate power conversion efficiency and optimization at Air Liquide’s Bécancour plant to improve electrolysis system performance and help create a local low-carbon hydrogen hub.

“We all want new technologies that are low-cost, highly sustainable and high-performance. It’s good to innovate in the lab but we need to have a real impact to deploy the technology industrially. This is only possible by working closely with companies like Air Liquide. We also want to create a hub of innovation and expertise and a hydrogen supply chain in Bécancour and Air Liquide’s plant is contributing to it. It’s a pole of attraction for academic and industrial talents and it triggers a lot of hydrogen-related initiatives in the region. It’s the starting point for building a low-carbon hydrogen value chain in Quebec.”

Airbus is aiming to launch zero-emission (“ZEROe”) aircraft by 2035 – a world first, based on hydrogen propulsion. To make this happen, the company is collaborating with Air Liquide on liquid hydrogen storage, production and distribution, all of which are key to the success of the project.

“We’re working together on on-board aircraft technologies to develop and adapt liquid hydrogen for commercial aviation. We’re also studying hydrogen infrastructure at airports alongside operators. Our relationship is based on common goals, and we have a healthy, open dialogue to solve any issues as they arise. It’s essential to have a partner who can constructively challenge us and we’re grateful for Air Liquide’s hydrogen expertise. Innovation often comes from synergies and new perspectives.”

Air Liquide, main partner of **Energy Observer**

The first energy-autonomous and zero-emission ship, Energy Observer is exploring concrete solutions and developing technologies to accelerate the ecological transition.



To find out more about Energy Observer:

 energy-observer.org/

 Air Liquide