ONAIR

The magazine of the Air Liquide Group

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NOVEMBER
2018

INNOVATE TOGETHER
to meet the challenges of tomorrow

Air Liquide
creative oxygen

CONTENTS

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FROM THE EDITORIAL TEAM

Innovation at the heart of this magazine

In September 2018, Air Liquide inaugurated its new Paris Innovation Campus. A strong symbol of our open innovation approach and our determination to push the technological boundaries to meet the major challenges facing our society in the fields of industry, health, and the environment.

This new issue of ON AIR Magazine is a reflection of this ambition. It provides an open look at our ecosystems, and highlights the people who innovate every day to build the world of tomorrow. Innovation is everywhere:

- at the heart of our digital transformation strategy, to offer our more than 3.5 million customers and patients an optimal experience (see page 8),
- at the heart of our actions in support of the energy transition, to develop new renewable energy sources (see page 14), to help our customers reduce their environmental impact (see page 24 and 26), and to participate in projects of the future, such as that of Bertrand Piccard (see page 36),
- at the heart of new and more open collaboration methods, to involve our customers in our developments (see page 22), to unleash our teams' creative power (see page 33), and to help bring disruptive technologies to market faster (see page 24).

Take a look behind the scenes of this incredible human adventure.

ENJOY YOUR READING
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OPINION COLUMN

Keeping one step ahead

Benoît Potier
Chairman and CEO of the Air Liquide Group

Follow Benoît Potier on LinkedIn
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Our Group was built around an innovative breakthrough, at the beginning of the 20th century. At the time, the challenge was to liquefy air to extract its components—especially oxygen. The original patent has grown into a portfolio of around 11,000 patents, and innovation now drives every sector in which we operate, in 80 countries. Air Liquide is the most innovation-oriented group in the industry; with 300 million euros dedicated to innovation-related expenses in 2017 and 3,800 employees, including 600 researchers, who help advance it.

This capacity for innovation is our strength. It is the key to sustainable growth, and to not only create value but also give a sense of purpose—for our employees, customers, shareholders, and partners. Now, more than ever, given our rapidly changing world, I am convinced that industrial innovations have a fundamental role

"Innovation is not just a matter of technology. It also depends on our ability to open ourselves to the rest of the world."

to play in our upcoming challenges, including climate change, energy transition, changes in consumption modes, and the rise of chronic diseases. Whether we're helping our customers reduce the environmental footprint of their businesses or create innovative breakthroughs in the areas of connected health and clean mobility, we draw on our scientific expertise and technological excellence to address the key challenges facing society.

However, innovation is not just a matter of technology. It also depends on our ability to open ourselves to the rest of the world. The image of a researcher working alone in the lab with a pipette and a microscope is hard to shake! Nevertheless, the reality is much different. In five years, we have deeply transformed our approach by opening up our research centers and turning them into genuine "Innovation Campuses." These sites are open to the outside world, allowing cross-fertilization of skills and helping bring new solutions to market faster. Our open innovation approach can be seen in our one hundred industrial partners and nearly 120 academic partners as well as in our collaboration with over 100 start-ups around the world.

I also apply this principle of openness to myself by participating since 2012 in "learning expeditions", or brief visits to other companies or even sectors to discover their trends and breakthroughs, find new ideas and enhance the Group's strategic thinking. Every region of the world has a lot to teach us. Traveling to the United States shows why customers' needs and digital technologies must be at the core of our strategy. Asia is at the cutting-edge of the electronics industry and digital use. Europe's industrial ecosystem is highly advanced in areas like the energy transition and smart cities.

Keeping one step ahead is a challenging commitment. It is essential in today's globalized and fast-moving world. It is what gives purpose to our actions. It is what will allow us to meet tomorrow's challenges, together.

EXPLORER

EXPLORATEUR
EXPLORADOR
ENTDECKEN
ESPLORATORE
EXPLORADOR
エクスプローラー
ODKRYWCA
探索者
ОБОЗРЕНИЕ

360°

Industry of the future, e-health, the energy transition and the environment, digital transformation: these are all major topics on which Air Liquide works with its expertise and vision. **Overview of developments in 2018.**

Anniversary

10 years

The Air Liquide Foundation celebrated its ten-year anniversary in 2018. Since its creation, the Foundation has supported nearly 300 projects in 50 countries in the fields of environment, health, and local development, thanks to the involvement of hundreds of employees who recommend and support these projects.
The Foundation is renewing its commitment for the next five years – with a budget raised to 5 million euros for the 2018-2023 period – and expanding its purpose to encompass improving air quality and scientific education.

Inauguration

Innovation: Air Liquide is back to campus

On September 27, 2018, Air Liquide inaugurated its Campus Innovation Paris. It hosts its largest R&D(1) Center, which has been fully renovated and now includes 48 laboratories and pilot platforms. By opting for a campus organization, the Group strengthens its open innovation approach by facilitating exchanges with leading universities and colleges, public research institutes, private partners, SMEs and deep tech(2) start-ups. The purpose is to explore new applications and develop technologies linked to the energy transition and environment, healthcare and the digital transformation. The new building, which is innovative from a sustainable development standpoint and offers high energy efficiency, favors primarily renewable energy sources such as biomethane, wind power, and solar power.

(1) Research and Development .(2) Start-ups seeking to push technological boundaries, thanks to scientific advances that will lead to real breakthroughs.

Pilot project

CRYOCITY™: TOWARDS CLEANER AND QUIETER DELIVERIES

Due to a rise in online orders for fresh or frozen products, urban deliveries are on the increase. Considered to be noisy and polluting, they have become a major issue for online sales and refrigerated transport companies. A team of researchers from Air Liquide based at the Paris R&D Center, together with Air Liquide France Industrie, have developed a standalone, clean and silent cryogenic refrigeration unit, specially designed for intra-urban delivery vehicles. The solution, named Cryocity™, uses carbon dioxide.

Key figure

8,292

That is the number of "likes" received by videos that were made in-house to raise awareness among Air Liquide's teams about proper safety habits. In total, over 250 people from the Group participated in the production of videos, posters, and meeting guides for the global "Safety First" campaign, which is still active. China has climbed to the top of the ranks with its cartoon on the following theme: "I do not take shortcuts and avoid overconfidence!"

Trend

The rise of facial recognition technology

Facial recognition has grown significantly in the past few years, and the market shows no signs of slowing down. Its rise has been made possible by image sensors, which allow for the collection of data, and artificial intelligence, which is used to interpret the information. As a supplier of high-purity gases for its customers in the electronics industry, Air Liquide contributes to this market of the future.

Partnership

AIR LIQUIDE AT THE MONDIAL PARIS MOTOR SHOW

Air Liquide was a partner of the 2018 Mondial Paris Motor Show, which took place in Paris from October 4 to 14, 2018, and a sponsor of the Startup Awards Mondial.Tech, an event included in the Mondial program and dedicated to mobility-related innovations. There, Air Liquide presented its hydrogen-based solutions, which offer a cleaner mobility option that generates zero greenhouse gases, zero fine particles, and zero noise. This technology is a concrete response to the challenges posed by sustainable mobility and local pollution in urban areas.

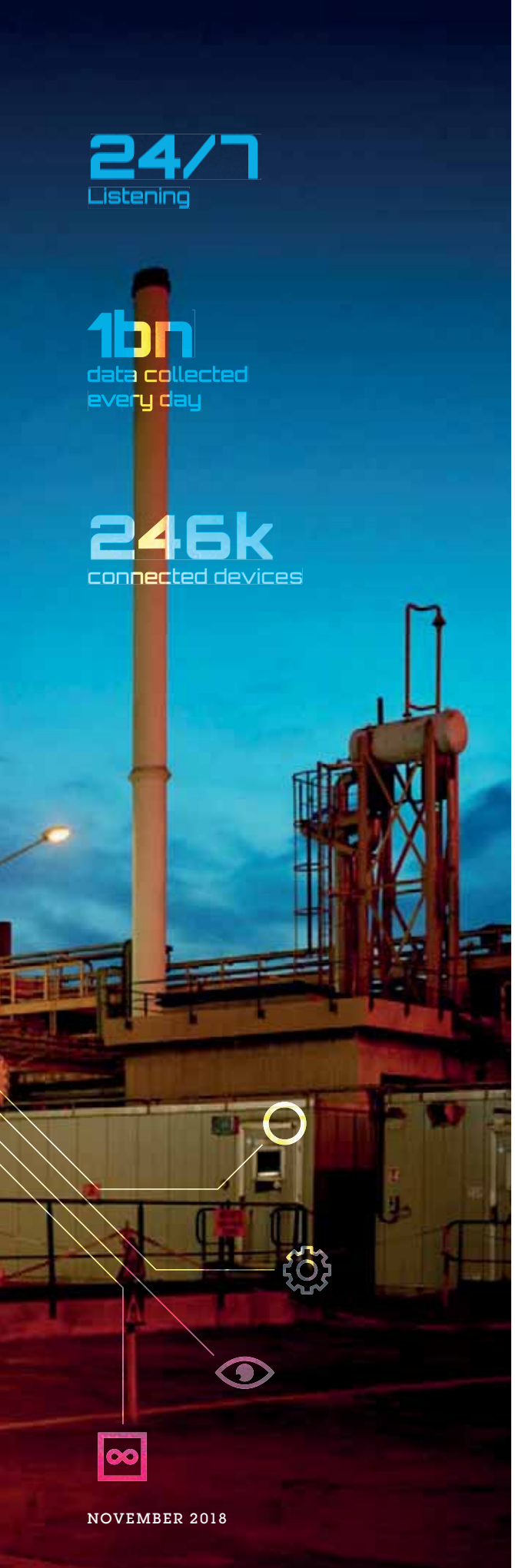
Acquisition

Full steam **ahead**

As part of its strategy to develop its Home Healthcare activity, Air Liquide purchased the start-up EOVE in April 2018. This French start-up designs and manufactures ventilators for home-based patients suffering from chronic respiratory failure. EOVE's innovative solution consists of a connected portable ventilator that takes into account the mobility needs of patients and facilitates the practice of doctors. This acquisition enables Air Liquide to extend its service offering in the area of respiratory diseases through a unique connected solution.

IN REAL TIME

THE POWER OF DIGITAL FOR AN ENHANCED CUSTOMER EXPERIENCE



Efficient, simple, customized: a successful customer experience lies in these three words. It is a core objective of Air Liquide's strategy, which relies on leveraging the power of digital to offer its customers and patients a first class experience.

Home delivery, transport on demand or car rental companies have long been forging ahead in terms of customer experience, offering user-centric intuitive platforms, secure online payment, express delivery...

Today, the industry and healthcare sectors are getting in tune with providing a consistent and customized experience to customers and patients. However, there is nothing obvious about replacing over-the-counter service with an application, or guaranteeing the implementation of a new contract within the hour.
In short, "making it simple" can represent a real challenge when it applies to dozens of countries and involves complex logistics and high tech assets. When talking about digitization, technology alone is not enough. People are at the heart of this transformation, be they customers, patients or employees. Take a look behind the scenes of this transformation.

_MAKING IT SIMPLE: A LARGE SCALE CHALLENGE

This is the challenge now faced by Air Liquide's 65,000 employees. Consistent with the Group's customer-centric transformation strategy, they are contributing, day by day, to offer its more than 3.5 million customers and patients a flexible and transparent experience, regardless of the channel through which they choose to make their purchases, contact Air Liquide or manage their inventories.
Customers and patients now share the same expectations, shaped by digital usages. "Healthcare professionals and patients experience digital services in their daily lives," says François-Xavier Bardot, Vice President Digital Transformation – Healthcare. "They expect Air Liquide to provide an experience similar to that offered through the tools made available by their bank, airline, telecom operator, etc."

In other words, customers and patients are counting on digital delivery to simplify their interaction with Air Liquide, saving them time and improving quality and efficiency. Online experience has even become the first point of interaction in B2B. "In industry, companies looking for suppliers of goods or services, now turn first to the Internet, which represents 70-80% of their customer buying journeys," says Kelly Justice, Vice President Customer Experience Digitization - Industrial Merchant.

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_SCALABLE USER-CENTRIC PLATFORMS

To meet the needs of its industrial customers, and make them more competitive in their own markets, Air Liquide can rely on Airgas' proven expertise in customer experience and digital. The leading U.S. supplier of gases, welding hard goods and safety products has developed a powerful multi-channel approach[1], allowing customers to choose the ways that best suit them to interact with the company: retail branch, phone, e-commerce website, etc. With Airgas.com, thanks to advanced tools including a comprehensive selection of products, fast checkout services and permanent account visibility, customers can save time and increase their competitive edge.

"With the online training provided by Airgas staff, we have used the web portal for ordering gases and hard goods, checking cylinder balances, and viewing invoices. We also use the portal to search for products that are not normally used or bought on a regular basis. We find the ease of using the website to be helpful and a time saver," explains Jackie Adams, Accounting Manager at Clarke & Rush Mechanical which has been a customer of Airgas for many years. The platform is also available to members of the general public who can make purchases as easily as if they were buying a new watch.

In Europe, Air Liquide has rolled out the myGas digital portal, coupled with the "myGas mobile" app which covers the whole customer journey, from seeking information to real-time monitoring of tanks and orders, 24 hours a day. Thanks to customized access, customers can order their gas directly from their smartphone by scanning the barcode on a cylinder, or look for a local distributor using GPS. And to offer an optimal customer experience, the website is constantly evolving, as explained by Vincent Dauchy, Director of Digital Transformation for Europe - Industrial Merchant: "We have put a new process in place to collect and analyze customer feedback. Those who are dissatisfied are called back straight away and we adapt our interfaces in real time to meet their needs. It is a virtuous circle." A strategy which seems to be paying off as the platform has already been adopted by thousands of users in nine European countries and is also available to customers in the Asia Pacific region.

In the healthcare sector also, digital opens up new opportunities to provide innovative services to patients and healthcare staff. This is the case of the digital platform launched by Air Liquide for homecare patients and their doctors. Initially deployed in Spain, it enables doctors to monitor their patients remotely thanks to a reliable and secure interface. Thus, patients, doctors and nurses can keep themselves informed of the most recent medical data and, with the doctor's approval, adapt treatments accordingly. Patients receive better support and are also better informed, as they can directly access their prescriptions and technical data about their medical equipment or information on their pathology. They can also contact the healthcare professionals who are

monitoring them. According to Doctor de la Cruz, Head of the Pneumology Department and Respiratory Diseases Clinical Management Unit (UGC) Director at the Málaga Regional University Hospital (Spain), "this platform makes our day-to-day easier and enables greater efficiency in the way we follow patients. It actually provides us with the patient compliance history as well as objective data on his/her adherence(2), which helps us better assess the impact of the prescribed therapy. We can follow each patient individually and better adapt the therapy to his/her behavior."

_ONE BILLION DATA COLLECTED EVERY DAY

Offering an enhanced customer experience means collecting and analyzing high volumes of data to better anticipate customers' needs, and improve efficiency and visibility. As stated by Ganesh Ramalingame, Integrated Bulk Operation (IBO), Group Program Director at Air Liquide: "one of the objectives is to give transparency of our supply to customers. This requires us to continuously improve our internal processes."

In order to keep this promise, Air Liquide can rely on the high volumes of data collected from its assets at all levels of the organization. Through the accelerated roll-out of the Internet of Things (IoT), the Group can optimize production and reactivity. This is the case in Healthcare where Air Liquide has conducted several pilot projects using technologies for medical oxygen cylinder location at French hospital centers to optimize stock management. This is also the case in the industrial gas sector where IoT allows Air Liquide to improve the reliability and security of product supply (bulk and cylinder). There are many examples: geolocation tags fixed on cylinders, sensors installed on bulk trailers, onboard computers in trucks to

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(1) Multi-channel refers to the phenomenon of simultaneous or alternating use of different contact channels for product marketing and/or customer relations.
(2) Compliance to prescribed treatment.

Data protection: simplicity goes with trust

New services to enrich the customer experience require the processing of very large volumes of data, the analysis of which comes at a price: trust. Used to complying with the highest industrial and health standards, the Group has developed global expertise in data management: acquisition, processing, hosting, using in-house or third-party software, with a very strong focus on data protection. Whatever the business sector, data protection is currently subject to continuous development and adaptation.

Compliance with regulations—reinforced with the General Data Protection Regulation (GDPR) in Europe—is a priority for the Group in its relationships with customers and partners. Air Liquide relies, in particular, on the promotion of best practices among all subcontractors and third parties involved in data processing.

VINCENT DAUCHY,
DIRECTOR OF DIGITAL TRANSFORMATION FOR EUROPE - INDUSTRIAL MERCHANT

"…CUSTOMERS WHO ARE DISSATISFIED ARE CALLED BACK STRAIGHT AWAY AND **WE ADAPT OUR INTERFACES IN REAL TIME TO MEET THEIR NEEDS. IT IS A VIRTUOUS CIRCLE."**

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geolocate the vehicle and ensure real-time tracking of delivery and fleet performance, telemetry on customer tanks to monitor their level of gas and replenish their stock, relieving them of the need to place an order, and so on. The Group therefore benefits from a valuable source of information, allowing improved anticipation of orders, and reductions in delivery times and errors. In the future, these same data will be combined with other information and given back to the customer so that they can improve their speed to market, anticipate supply and demand, and partner with Air Liquide to ensure they always have products to meet their changing needs.

For example, the Airgas Welding Efficiency Analysis (WEA), conducted by the Advanced Fabrication Technologies team, is designed to help new and existing customers improve the efficiency of their welding processes. First, Airgas evaluates the customer's welding process including gas and wire consumption and consumables usage. Once the data is collected, it is entered into the WEA tool. The customer then receives a report summarizing the analysis to help them understand the performance of their welding operation and benchmark themselves against industry averages. Finally, Airgas Welding Process Specialists meet with the customer to review the report and recommend measures to optimize their welding processes and overall competitiveness

Digitization is also at work behind the scenes, in Air Liquide Large Industries production units providing customers with oxygen, nitrogen, hydrogen, and so on. By automating and centralizing its operations, Air Liquide can increase the reliability and flexibility of supply to its customers in metals, chemicals, refining and energy. This is the case for instance in France and in Asia where the Group opened remote operations centers as part of its "Smart Innovative Operations" (SIO) program. These centers enable remote management of production, energy efficiency and reliability. For example, 18 units in eight countries in the Asia Pacific region are managed through the Kuala Lumpur center in Malaysia. Using predictive analysis and digital technologies, the Group can better anticipate and meet the needs of its customers throughout the region, 24/7.

All in all, the Group can rely on the information provided by around 246,000 connected devices (in Healthcare, Industry and new markets) and collects 1 billion data every day.

more than
3.5M
customers
and patients

_LISTENING 24/7

However, technology alone is not enough to improve ease of use and responsiveness. A real cultural transformation is required. It must be customer-centered in order to better understand customer needs and expectations and ensure that the different links in the value chain, from production to the sales service, work in harmony.

The multi-channel approach (see above) demands detailed knowledge of the customer journey. From this perspective, the "Voice of Customer" program, which collects and analyzes customer feedback from

45 countries in real time, is essential and contributes to continuous improvement.

Similarly, the VitalSmile application, downloaded to the tablets of Air Liquide Home Healthcare activity technicians in Spain, enables them to have their patients assess the quality of each procedure (with 5 satisfaction levels). Dissatisfied patients are contacted within 24 hours to identify corrective actions. Launched in Spain, where Air Liquide accompanies several tens of thousands of patients at home, VitalSmile already collects more than 4,500 assessments per day.

What is changing through these programs? For industrial customers, it is the guarantee of increased transparency in the relationship, encouraging trust, and savings in time which improve their competitiveness. For patients, it is the availability of personalized support throughout their care journey, with the ambition to ensure enhanced compliance and better quality of life.

_MORE AGILE TEAMS

Development of new digital platforms, acceleration of assets' digitization, and enhanced customer focus: improving customer experience necessarily involves a transformation of the Group's organization. "To create value, strengthening the adoption of our solutions is key. In this respect, it is essential to unleash collaboration between Digital and Customer Experience teams, IT, World Business Lines and Operations, because of their proximity to customers. In short, it is an inclusive transformation powered by and for people" says Olivier Delabroy, Vice President Group Digital Transformation.

New ways of working have been adopted. Within "Digital Fabs", small multi-disciplinary teams of about ten people work on a specific transformation stream. There are people from different activities and countries collaborating with data scientists, software developers, designers or user researchers. The Group also draws on the expertise of Alizent, which specializes in the Industrial Internet of Things (IIoT), for improvements in monitoring supplies and managing product traceability through sensors put in truck cabins, in particular.

Finally, open innovation is widely harnessed. Air Liquide works with over 100 start-ups, some of which have already contributed to the co-development of innovative digital solutions with the Group: new connected objects, new intelligent navigation systems, geolocation, etc.

In the end, all the Group's stakeholders are involved to accelerate digital transformation and offer an enhanced customer experience, creating value on the long term. ///

BIOMETHANE

Transforming waste into renewable energy

Each day, human activity produces over 10 billion kilos of waste[1]. At a time when the energy transition is a key concern of governments, society and industry, Air Liquide is recycling organic material from farming or from household or industrial waste to convert it into biomethane, a clean and renewable alternative energy source. The Group's strength relies on its ability to operate across the entire biomethane value chain, a true driver for the circular economy. Read on to find out how.

A promising market in figures

+60
bio-NGV/NGV (Natural Gas for Vehicles) stations in Europe

x2
Air Liquide doubled its biomethane production capacity in 2018, to reach 60 MW or 500 GWh/year

~100
million euros invested by Air Liquide in biomethane production in the last four years

(1) www.planetoscope.com

"Thanks to its membrane technology, Air Liquide has developed an expertise covering the entire biomethane value chain, from production to distribution. By doing so, the Group contributes to the development of a new market in support of energy transition."

PHILIPPE MERINO,
Vice President of Global Markets and Technologies at Air Liquide

Whether it is used as a fuel or for any heating purpose, biomethane has penetrated the industrial sector as well as the domestic area. This energy source arouses much interest as it meets the major challenges of the energy transition. These challenges are important ones for Air Liquide, which is actively involved in the development of cleaner production and transport modes to improve air quality and help build a more sustainable world. The Group today is a key player in biomethane, a market with very high potential. It develops technologies dedicated to converting biogas into biomethane for three main uses: the production of clean fuel, domestic use as a substitute for natural gas, and carbon-free hydrogen production (without CO_2 emissions).

A key solution for clean mobility

Since 2016, Air Liquide has teamed up with partners in the mass retail and transport sectors to support the development of clean alternative fuels, including biomethane, one of the few clean fuels available today on an industrial scale worldwide for road freight transport, helping to reduce fine particulate emissions by 85% and CO_2 emissions by 90%. Biomethane is injected into the natural gas grid in order to be used as fuel in bio-NGV stations where it is known as Bio-Natural Gas for Vehicles (bio-NGV). It may also be liquefied to be transported in bulk to these stations. To date, Air Liquide has opened over 60 bio-NGV stations in Europe, which depending on the country, supply either road transport fleets (as it is the case in France and the United Kingdom), individual vehicles or buses (United Kingdom and Nordic countries).

Control over the entire value chain

Thanks to its know-how in gases, Air Liquide has developed expertise covering the entire biomethane value chain: from investment in methanization projects and their operation, to purification using its membrane technology, liquefaction for its transport and storage, and lastly its distribution for various purposes such as bio-NGV stations for clean transport, domestic use as a substitute for natural gas and carbon-free hydrogen production. Depending on the country, the Group recycles various types of sources: primarily agricultural in Europe and from household or industrial waste in the United States. The recycling method also varies: whereas in the United States the phenomenon of methanization takes place spontaneously in landfills, in Europe it is artificially provoked in digesters (also known as methanizers).

Exclusive positioning on a booming market

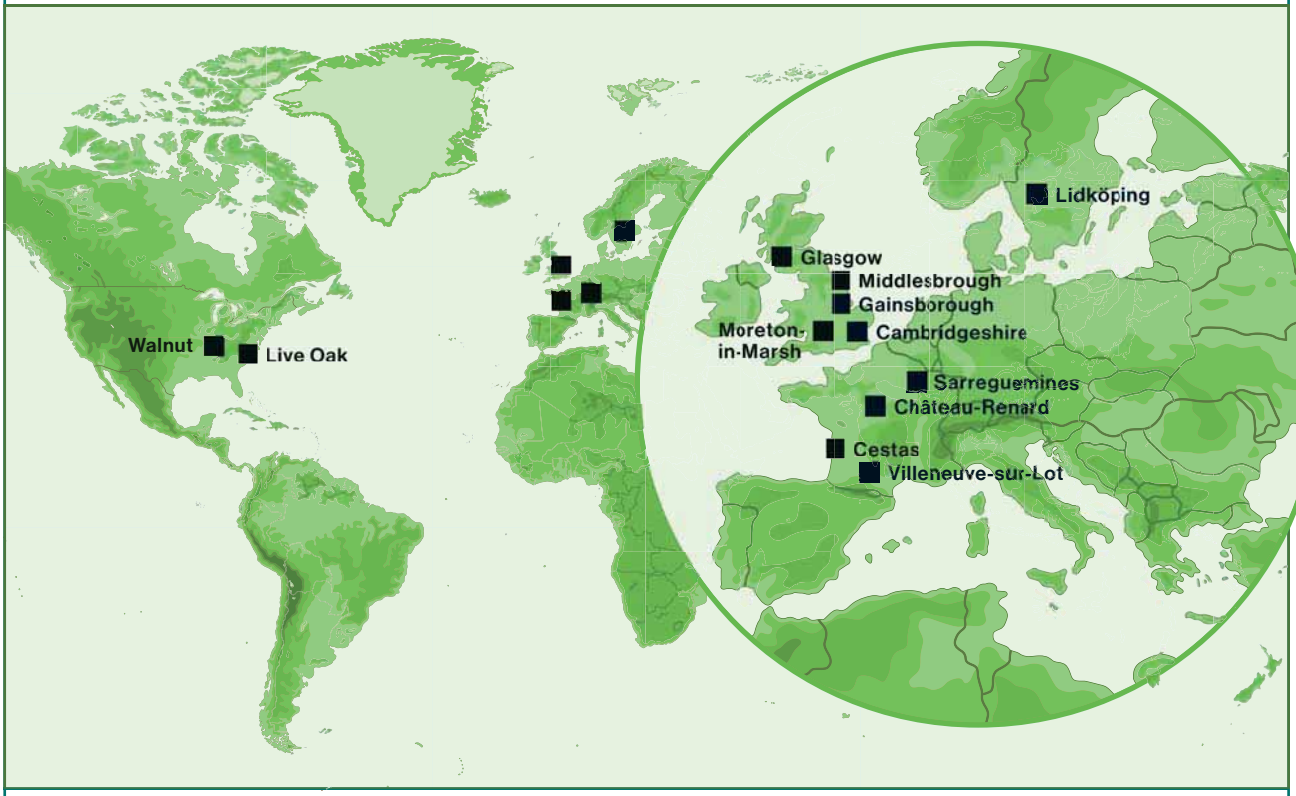
Aware of the potential of biomethane, in just a few years Air Liquide has managed to position itself as the only player worldwide on the market that covers the entire value chain. In 2018 the Group has doubled its production capacity. "By the end of 2018, Air Liquide will have twelve units in operation," says Philippe Merino, Vice President of Global Markets and Technologies at Air Liquide. Two production units were notably and recently inaugurated in France (see our photo feature at Cestas, in the Gironde region, p.18) and in the United States (see our opposite inset).

Did you know?

Biogas and biomethane are two different gases, the latter produced by the former. Made up of around 55% methane and 35% CO_2, biogas comes from the methanization of biomass, meaning the fermentation of waste (farm, household or industrial) without oxygen. For use as a fuel or injected into natural gas networks, biogas is purified to become biomethane. The CO_2 and other compounds are eliminated, keeping just the methane.

Air Liquide biomethane units

FROM EUROPE TO THE UNITED STATES



Air Liquide has 12 production units around the world, designed to purify biogas to convert it into biomethane and inject it into natural gas networks.

Air Liquide inaugurates a new unit in the United States

While in Europe biomethane comes mainly from farming biomass, the situation in the United States is different, where it is produced mainly by landfills. To gain a foothold in this immense market, Air Liquide decided to invest in a biomethane production unit in Walnut, Mississippi. The unit was opened in April 2018. Fully designed, implemented and operated by Air Liquide, it receives 350,000 metric tons of waste yearly, allowing it to inject biomethane into the network to heat around 4,500 homes. A 6.5 km pipeline was built by the Group to connect the production unit to the Walnut downtown area, thus illustrating Air Liquide's ability to control the entire value chain, from biomethane production to its distribution in natural gas networks.

From the farm to mobility, Air Liquide is serving a circular economy

For the first time in France, the entire biomethane value chain is represented at the Pot-au-Pin site, in Cestas near Bordeaux, inaugurated on June 22, 2018. This biomethane production unit, along with a multi-energy distribution station located less than 3 km away, is a great example of the circular economy and is evidence of the strong growth of new energy transition markets. Photo report.

TRANSFORMATION OF INTERMEDIATE ENERGY CROPS

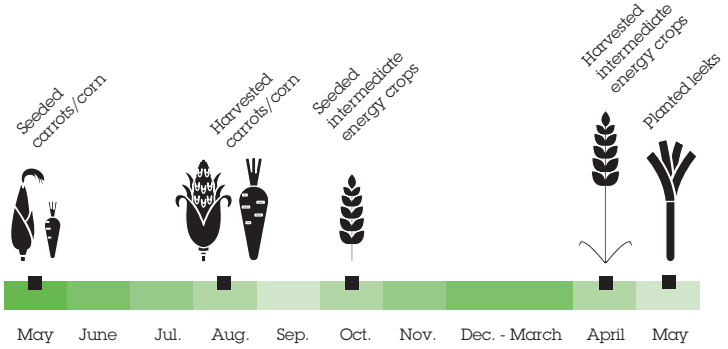
The farm operator Planète Végétal grows carrots and leeks, and sells them to Carrefour, among others. To enrich the soil between two major vegetable crops, the company introduces intermediate energy crops. This biomass is then transformed by Pot-au-Pin Energie (a company formed by a partnership between Air Liquide and Planète Végétal) to produce biomethane.

"This is a circular economy: intermediate energy crops cultivated in alternance with vegetables grown for mass retail are converted into biomethane which is then distributed as a biofuel to Carrefour trucks".

DELPHINE GARNAUD,
Biogas Business Developer

A look at
INTERMEDIATE ENERGY CROPS

Example of crop rotation



Intermediate energy crops are planted between two main crops (vegetables and grains). They are used to cover soils and provide a biomass that is easily stored in silos and has a strong energy capacity. Here, intermediate energy crops are autumnal, harvested immature in spring. They require little irrigation water because they consume natural rains during their growth during autumn and winter.

METHANIZATION: CREATION OF BIOGAS

Intermediate energy crops stored in silos are fed into the biogas plant each day. This is where the "methanization" process takes place. Micro-organisms break down the material in an oxygen-free environment.
This process generates biogas and digestate, a liquid residue which is stored in lagoons before being used as a natural fertilizer in the fields.

PURIFICATION/ REFINEMENT: FROM BIOGAS TO BIOMETHANE

The biogas is then sent to the purification plant operated by Air Liquide as soon as it leaves the methanizer, to be purified using an innovative proprietary technology. It is first pre-treated to eliminate any impurities. Then, using a membrane-based process (see opposite), the methane contained in the biogas is extracted in the form of biomethane.

A look at
MEMBRANE PURIFICATION TECHNOLOGY

Air Liquide has developed a technology to separate methane and carbon dioxide using an innovative process that uses polymer membranes, manufactured by its subsidiary Medal, in the United States. This effective system generates high-quality biomethane, with a methane content of between 96.5% and 99%.

INJECTION INTO THE NETWORK

The biomethane can then be injected into the natural gas distribution network, operated by the natural gas supplier GRDF which supplies the surrounding area.

MULTI-ENERGY STATION

This same network supplies Air Liquide's multi-energy stations, where Carrefour trucks in particular come to refuel with bio-NGV (Natural Gas for Vehicles). The biomethane thus becomes an alternative to fossil fuels. Present in compressed form, it gives goods transport vehicles autonomy up to 800 km.
Soon, the station will also supply liquid nitrogen to feed refrigerated transport trucks equipped with the cryogenic solution of Air Liquide blueeze™ for their production of cold. Combined with bio-NGV, this clean and silent solution is a real ecological and economic asset for our customers.

EXPÉRIENCES
EXPERIENCIAS
ERFAHRUNGEN
ESPERIENZE
EXPERIÊNCIAS
エクスペリエンス
DOŚWIADCZENIA
经验
ОПЫТ

EXPERIENCES

FIVE THINGS TO KNOW ABOUT

The Advanced Fabrication Center in the U.S.

The Advanced Fabrication Center (AFC) is a **co-project undertaken** by Airgas, the Delaware Innovation Campus and Air Liquide's Industrial Merchant world business line.

The AFC is a manufacturing expertise center to **design new solutions** for industrial challenges with customers.

The first customer projects began in June 2018.

Beyond **traditional metals processing,** the AFC focuses on solutions for **high growth segments** such as laser, plasma, additive manufacturing and welding robotics / cobotics[2].

The new center identifies **future innovation projects** that will grow the business of Air Liquide & Airgas, equipment supplier partners and industrial customers.

Our customers are always looking for new solutions to improve their fabrication processes and the competitiveness of their offers. In this context, increasing the quality of welding or cutting represents a key asset, in particular for metal manufacturers. To address this challenge, Air Liquide has opened an **Advanced Fabrication Center (AFC)** at its Delaware Innovation Campus, in the U.S. — the world's biggest metal manufacturing market.

1

Customer- centric

The AFC puts the needs of customers from the automotive and fabrication industries at the heart of its operations to help them improve the performance of their offers. A true advanced training, testing and development platform, the AFC involves customers and industrial partners early in the innovation process to accelerate the development of added-value solutions – from finding optimal gas compositions for weld quality to operator efficiency and process safety.

2

Collaboration and open innovation

The AFC gathers Air Liquide's experts in arc and plasma welding and cutting, laser and additive manufacturing, and OEM(1) who design state-of-the-art equipment that will serve for tests. "It's a win-win collaboration: it enables us to optimize our gas mixtures and flows, our OEM partners to find the best configuration for their equipment, and our customers to benefit from increased manufacturing speed and quality," says Serban Cantacuzene, Vice President R&D Americas. The AFC will also conduct research with several universities and start-ups.

3

Innovation speed and agility

A key ambition is to speed up the innovation process, by analyzing from the start the many parameters that impact the quality of metal fabrication – from the properties of gases to their interaction with the different materials and welding techniques used. François Court, Vice President Industrial Merchant Americas: "By getting all stakeholders to test together, we will be better able to rapidly bring to market new solutions in innovative fields such as plasma cutting, cobotic(2) welding and additive manufacturing."

4

Bringing added value to metals manufacturing

The AFC's team of experts in metallurgy, welding and electrotechnics will draw on the Group's extensive research into gas and metals processing. Initial projects will focus on achieving faster and more efficient welding, and improving safety. For example, the teams will focus on optimizing gas composition to reduce the generation of spatters during welding, thereby reducing the amount of post-weld cleaning.

5

Combining the best of two worlds

The AFC benefits from Air Liquide's innovation capacity and Airgas' deep market knowledge, customer database and proximity to a wide network of international equipment manufacturers. By fostering collaboration between R&D experts and business teams across the Group, the center will help address current industry issues while working on more long term developments. These will allow Air Liquide to pursue growth opportunities in the U.S. and beyond.

(1) Original Equipment Manufacturers. (2) Cobotics (a neologism from the words "cooperation" and "robotics") is a discipline focusing on direct or remote interaction between an operator and a robotic system. The "cobot" provides assistance to the human operator with his tasks, here welding.

enScribe™ is a concatenation of two terms: "en" for environmentally friendly and "Scribe" which is a synonym for etch.

CASE STUDY

enScribe™: Air Liquide is designing infinitely small to think big

enScribe™ is a new family of **advanced etch materials** designed for 3D production and able to etch the latest chip architectures very deeply, at a nanometric scale.

The launch of the enScribe™ family will serve to **significantly reduce CO_2 emissions** by 100,000 metrics tons per year.

The enScribe™ portfolio brings **environmental benefits,** as its products are designed to reduce the Global Warming Potential (GWP) impact typically associated with most contemporary gases used in etch processes.

While semiconductor manufacturers must meet growing needs for storage capacity - the quantity of data is 300 times greater today than it was 10 years ago - electronics components have now reached nanometric scale. In this new environment, balancing compactness and performance represents an ongoing challenge for semiconductor manufacturers. To support its customers in this goal, Air Liquide has developed **enScribe™,** a new family of advanced etch materials.

The stakes

The challenges faced by the semiconductor industry are both technical and economic: the performance of computers, smartphones and servers must keep improving, while reducing their energy consumption and costs. This goal is ambitious considering that chips are continually shrinking and are essential parts in these devices. In this context, we are seeing the emergence of a new three-dimensional (3D) generation of memory chips that can store more information. Manufacturers also need to reduce the environmental footprint of their activities: many of the gases used in the etching process are fluorocarbons with a greenhouse effect thousands of times more potent than carbon dioxide.

The solution

Air Liquide has developed enScribe™, a new family of advanced etch materials custom designed to etch the latest chip architectures, at a nanometric scale. This solution is the culmination of an open innovation approach with semiconductor manufacturers, universities and customers, in close collaboration with the Group's R&D Centers in Japan and the United States.

The benefits

The enScribe™ offer aims to significantly improve the customer's manufacturing process by designing efficient, customized etching molecules. In addition to addressing the growing complexity of 3D memory chip structures, enScribe™ etch materials have a lower lifespan in the atmosphere, thus helping to reduce greenhouse gas emissions.

"Semiconductors are a technology-challenge driven industry, but the interest in reducing the global warming impact of the etching processes is leading to a paradigm shift. With enScribe™, we're ahead of the curve."

NATHAN STAFFORD,
EnScribe™ Product Manager

JOINT INTERVIEW

Hydrogen: forging the future with SMR-X™ technology

Air Liquide will invest **€80 million euros** to construct the facility.

Air Liquide has signed a new long-term contract with Covestro to supply hydrogen using **new proprietary technology** (SMR-X™) in Antwerp's industrial basin.

Covestro is a global company employing **16,500 people.** Listed on the German DAX, it is one of the 30 most valuable companies in Germany, with sales of over **11 billion euros** in 2017.

The next-generation technology will reduce the consumption of natural gas as well as CO_2 emissions by **5%.**

The unit will start operations in **2020.**

This year, Air Liquide signed a new contract with its long-standing strategic customer **Covestro,** a leading global supplier of high-tech polymer materials. The Group will produce hydrogen directly on Covestro's site in Antwerp (Belgium) using its state of the art SMR-X™ technology.

VOLKER WEINTRITT,
Managing Director Covestro in Antwerp

DIETER GRABENBAUER,
Vice President Strategic Account Management, Air Liquide

What does this new contract involve?

D. G.: Covestro has entrusted Air Liquide with the design, construction and operation of a new hydrogen facility on its production site in the port of Antwerp, in Belgium. The unit will feature innovative, proprietary new technology (called SMR-X™) that offers optimal performance in energy efficiency, safety and reliability. The new plant will supply hydrogen to Covestro and will also allow us to supply other customers in this major industrial basin.

V. W.: The significant change this contract heralds is that in the past, we bought hydrogen and carbon monoxide from Air Liquide's pipeline network. In the next phase, this new plant will serve us directly on our site and will be operated by Air Liquide.

How is the technology innovative?

D. G.: SMR-X™ is a new type of steam methane reforming system that has the ability to produce hydrogen without excess steam. This allows us to supply customers with hydrogen as the sole product, without any unnecessary by-products. The result is higher efficiency and a 5% reduction in CO_2 emissions compared with conventional technology.

V. W.: When Air Liquide approached us with this technology, one of the aspects that made it attractive to us is that the reformer perfectly balances the supply and demand needs for steam at our site. We also require CO_2 as a raw material, so the new unit also allows us to capture and upgrade part of the recovered CO_2 so we can use it as feedstock for other processes. This model is part of a circular economy system.

"This next-generation hydrogen plant allows us to meet our customers' needs while offering increased energy efficiency and a reduced carbon footprint."

DIETER GRABENBAUER

“In our decades-long relationship, Air Liquide’s proven expertise in industrial gases has created a solid relationship of trust.”

VOLKER WEINTRITT

What are the advantages of this new technology?

D. G.: It is more efficient as it does not use energy to create an unwanted by-product – this translates immediately to reduced costs. Therefore this process means a more commercially attractive, competitive offer compared with conventional technologies. Beyond that, the lower CO_2 emissions decrease the environmental footprint of the plant, which is an increasing priority for us as well as for our customers. Of course, like all Air Liquide plants, it is designed to meet the strictest safety standards.

What are the mutual benefits of the new partnership?

V. W.: For us, this new arrangement guarantees a reliable source of competitively priced raw materials, which is of utmost importance. Outsourcing their production to Air Liquide allows us to focus on our core business, increasing our competitiveness and our possibilities for strategic development. The flexibility of the supply opens up new ways for us to grow in one of our strongest geographical locations.

D. G.: This contract is a milestone in our relationship, both in terms of business volumes and the new supply arrangement. In addition, we have a number of existing customers on our pipeline network, several of which have future expansion plans. The new unit increases the production capacity available, ensuring that we will be there to meet growing demand in one of the largest chemical and petrochemical basins in Europe.

Why was Air Liquide chosen?

V. W.: A priority for us is Air Liquide's proven expertise in industrial gases. In addition, its pipeline system and strong presence in the industrial basin of Antwerp increase the long-term reliability of the product supply. But aside from the flexibility and capacity that Air Liquide's industrial footprint guarantees, our decades-long relationship with them has created a solid relationship of trust.

D. G.: Yes, I think the fact that Covestro is a key strategic partner of Air Liquide was a crucial factor: we have global business with them, supplying their sites around the world. Our ability to cooperate and to generate value together by discussing industrial solutions has led to a high level of understanding and confidence.

SMR-X™

SMR-X™ is a next-generation steam methane reforming technology that produces hydrogen without excess steam, a by-product that is less in demand by customers. The process works by transforming the feed gas[1] into hydrogen through a reforming process driven by heat (700–900°C), which generates steam. In the case of SMR-X™, the reforming tubes have been optimized to collect the energy from this excess steam and use it in the reforming process. All in all, internal heat recovery results in 5% reduced consumption of natural gas and operational cost, while reducing the carbon footprint.

(1) Typically natural gas, which consists of molecules of carbon and hydrogen.

ÉCOSYSTÈME

ECOSISTEMA

ÖKOSYSTEM

ECOSISTEMA

ECOSSISTEMA

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EKOSYSTEM

生态系统

ЭКОСИСТЕМА

ECOSYSTEM

The pioneering spirit, in the Air Liquide DNA

In 1902, inventor Georges Claude and visionary Paul Delorme perfected the process of liquifying air. Emulating the company founders, Air Liquide would go on to conquer everything from the ocean depths to space, and make major contributions to industry and medicine, each time expanding the possible applications for the "essential small molecules" (oxygen, nitrogen, hydrogen, etc.) at the core of our company's expertise.

Today, Air Liquide continues to push technological and industrial limits, relying on the ingenuity of our teams around the globe to devise solutions for the greatest challenges facing our society. We met some of the pioneers who are propelling our Group forward and helping to build the world of the future. They are doing so by innovating in the fields of clean mobility and healthcare, working on various projects such as overseeing the launch of the largest oxygen unit in the world.

What do they have in common? A passion for their work. The key to their success? Harnessing the power of collective action and testing new working and collaborative methods to unleash creative energies, remove technological roadblocks and open up new possibilities.

Hailing from different backgrounds, they represent the diversity and breadth of careers at Air Liquide. Read on to hear from them.

Life breather

"Follow your roadmap, but keep an open mind!"

In 2014, while he was conducting research on cardio pulmonary ventilation, Jean-Christophe, a professor of resuscitation, joined Air Liquide Medical System (ALMS) as Medical Director with one foot still squarely planted in the world of research. This is where he developed CPV[1], an innovative automated ventilation system used in resuscitation after cardiac arrest. Professor Richard has a conviction: "In order to innovate and to meet patient needs, you need to be willing to veer off the beaten path and question yourself to make progress. Follow your roadmap, but keep an open mind: pay attention to your observations. That is often how the greatest advancements in medicine happen."

(1) Cardio Pulmonary Ventilation.

JEAN-CHRISTOPHE RICHARD, Medical Director at Air Liquide Medical System (ALMS)

CARINA KRASTEL, Project Manager, i-Lab

Intrapreneur

"Adopting new ways of working"

As an intrapreneur at the i-Lab(1), Carina is part of a team that applies a user-centric approach and start-up methodology to create new products. "If an idea isn't working, we can just shut it down," she explains. "On the other hand, we have to convince internal sponsors that ideas are worth pursuing." As part of the i-Lab's "Act for Air" team, Carina is working with her colleague Simon Vidal to develop a new business on air purification for urban pollution hot spots such as car parks, metros and tunnels. "We took part in a pilot project implemented by the City of Eindhoven (Netherlands), with different partners including a local university, to demonstrate that air quality can be improved by installing units which filter out micro-particles while consuming almost no energy."

(1) Air Liquide's innovation laboratory.

Creative explorer

"Be creative with our teams"

Bertus is the first man from Operations to have walked on T17. This is not a new planet but the world's largest oxygen production unit, built by Air Liquide's Engineering & Construction teams and now owned and operated by the Group for Sasol in South Africa. Bertus was responsible for ensuring the startup of this state-of-the-art plant, with a total production capacity of 5,000 metric tons of oxygen per day, commissioned in December 2017. His mission: "to implement processes and governance that offer the best performance in terms of safety, reliability and efficiency". His secret? "Go beyond set goals, explore different approaches, be open to new ideas and support my team with a creative mind."

BERTUS SWART, T17 Plant Manager for Air Liquide in South Africa

Sustainable inspirer

"Blazing a trail. Creating a new path"

Fernando believes in the power of change. Asked by Air Liquide European Procurement and his regional management to reduce emissions in transport services in Iberia, he accepts the challenge. "We identified that natural gas would be the best alternative fuel to date locally, and we committed to Air Liquide's ambition: to have the majority of its trucks in Europe to move towards cleaner solutions by 2025. After we learnt from natural gas experts, we had to convince our hauliers that upgrading made business sense. It was not easy but we were convinced ourselves, so we inspired trust". The results speak for themselves: 25% of the fleet is already running on natural gas. This success could inspire other regions. "We've blazed a trail and showed what can be achieved".

FERNANDO ÁLVAREZ, Purchasing Manager (Transport Services, Iberian Region)

SOMIE KIM, Director, Industrial Merchant & Hydrogen Energy at Air Liquide Korea

Hydro genius

"Teamwork is key to push boundaries"

In 2016, Somie took on a new role as head of the Hydrogen Energy activity in South Korea. Her mission: "to change the face of the Korean automotive industry through the deployment of hydrogen stations". Somie works in partnership with Hyundai Motor Company and is Air Liquide's voice in a public-private consortium dedicated to this issue. She is not afraid of challenges and relies particularly on teamwork in order to succeed. In Korea, meeting the goal of reducing CO_2 emissions and fine dust are both an economic and a public health challenge. Somie's ambition is "to contribute to develop the hydrogen automotive market and then to spread hydrogen as an alternative in other energy sectors".

Start-ups

Accelerating innovation together

In a rapidly changing world, detecting customers' needs is key to anticipate products and services that will meet their challenges—whether they be to gain efficiency, improve the user experience or reduce the environmental impact of their activities.

This is the reason why Air Liquide collaborates with more than 100 start-ups around the world, across all its businesses. In line with our customer-centric NEOS strategy, this approach of open innovation enables the combination of expertise to develop new solutions and speed up time-to-market.

It is a win–win relationship; Air Liquide can access new technologies, and start-ups can accelerate the industrialization of their solutions while benefiting from the Group's industrial experience and global customer base. Air Liquide notably cooperates with "deep tech" start-ups working on technological breakthroughs—generally characterized by long development time—to facilitate their access to market.

All in all, the connection to this innovation ecosystem helps us develop offers that set us apart, creating value for our Group, our customers and start-ups.

AIR LIQUIDE VENTURE CAPITAL (ALIAD)

Since its creation in 2013, ALIAD has invested more than €80 million in 30 technology start-ups in three sectors: energy transition, healthcare and digital. These investments take the form of a minority interest with an agreement for technological or business partnership.

MARITIME TRANSPORT 2.0

JULIEN COTE,
CEO, WAKEO, FRANCE

Can you explain what you are working on?
Our solution enables us to monitor in real time the locations of road, sea and air shipments. By aggregating data from various hauliers and external sources such as satellites, we can provide predictive arrival times using a cutting-edge, algorithm-based processing system.

How long have you been working with Air Liquide?
Since 2017, as part of the Techstars program[1], we have been working with Air Liquide's teams based in Dubai who notably oversee the global maritime distribution of helium.

How will this innovation change the world?
We track containers in real time so Air Liquide can plan for delays, alert its customers throughout the world, and optimize its transportation plan.

Our solution allows us to optimize routes and transport time, thereby helping to reduce the impact this activity has on the environment. This is important given that maritime transportation alone generates 1 billion metric tons of CO_2, i.e. 3% of global emissions[2].

NEXT-GENERATION SEMICONDUCTORS

ANDREW GRENVILLE,
CEO, INPRIA, UNITED STATES

Can you explain what you are working on?
We're developing unique metal oxide-based photoresist[3] materials for semiconductor patterning. The current platform, based on organic materials, is reaching its critical limits, and a new solution is required to unlock the potential of the next generation of imaging technology.

How long have you been working with Air Liquide?
Since 2015, we've partnered with Air Liquide Advanced Materials, then the Group has made a strategic investment in our start-up through ALIAD: a collaboration that has enabled us to leverage Air Liquide's deep expertise in materials analysis and international logistics.

How will this innovation change the world?
For over 50 years, advances in semiconductor patterning—and by extension the electronics industry—have produced smaller, more affordable and more powerful chips. Now performance requirements are exceeding current capabilities: our optimized platform will allow computing power to continue to accelerate.

(1) Techstars is an accelerator for start-ups around the world. Air Liquide is a partner of Techstars Paris.
(2) Source: International Maritime Organization
(3) Materials used in industrial processes such as photolithography or photogravure to form a protective coating added to the surface of a component.

INDUSTRIAL ROBOTICS

JOE LEIST,
CEO, SCANTRON ROBOTICS, UNITED STATES

Can you explain what you are working on?
We develop leading-edge underwater robotics to inspect and clean water tanks without interfering with the facility's normal operations. Our robots are used in hazardous spaces where previously a human diver was required, allowing for improved safety, operational efficiency and productivity.

How long have you been working with Air Liquide?
Since 2015, we've been working with Air Liquide Large Industries and Airgas teams in the U.S. on tank-cleaning projects that use our underwater robotic inspection, sediment mapping, and ultrasonic thickness testing services. It's exciting to work with such a big name!

How will this innovation change the world?
A remotely operated underwater vehicle makes accidents completely preventable. Our robots do the dangerous work, controlled at a safe distance by operators. Plus, our unique cleaning method reduces the risk of hazardous waste entering the environment by recycling the water back into the tank after it is cleaned.

CONNECTED HEALTH

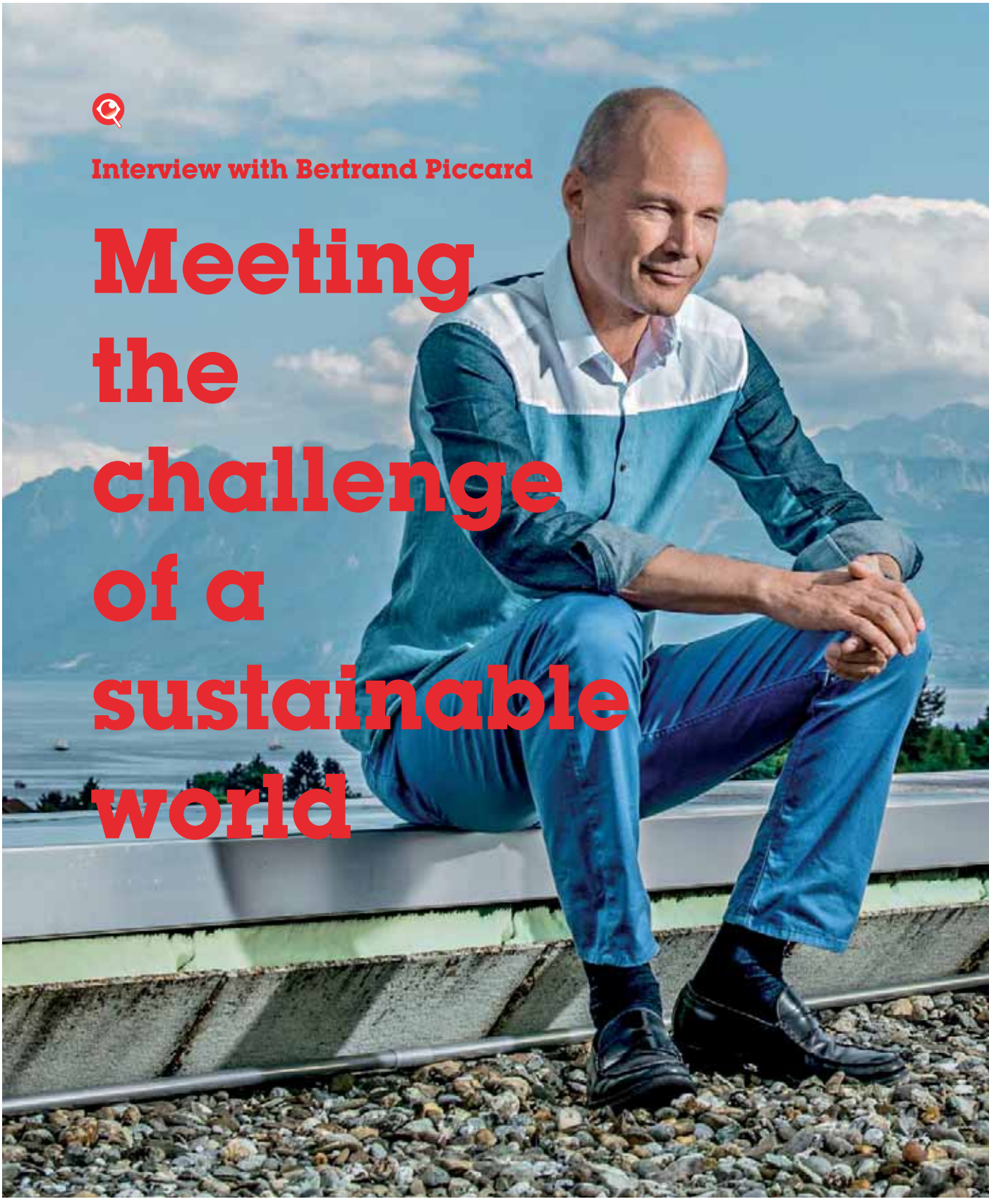
ERIK HUNEKER,
CEO, DIABELOOP, FRANCE

Can you explain what you are working on?
We develop a personalized system that reproduces the functions of the pancreas that have been destroyed by type-1 diabetes[4]. Through an insulin pump and a blood sugar sensor, both connected and driven by an algorithm, the optimal dose of insulin is calculated and delivered to the patient in real time.

How long have you been working with Air Liquide?
In 2017, Air Liquide invested in our French start-up through ALIAD and is now helping us bring this system to the market. In addition to our connection to patients and hospitals, this collaboration gives us access to home healthcare providers who help patients in their day-to-day lives. Their experience is essential.

How will this innovation change the world?
This disruptive innovation will help improve the daily lives of the millions[5] of people affected by this disease in Europe. By making the management of this condition partially automatic, this technology will spare patients the burden of making complex calculations.

(4) Diabetes refers to an excess of glucose in the blood over a prolonged period of time. In the case of type-1 diabetes, or insulin dependent diabetes, this imbalance is caused by the destruction of pancreatic cells specialized in insulin production by the patient's own immune system (INSERM).
(5) There were 60 million people with diabetes in Europe in 2016 (WHO). The type-1 diabetes represents between 6% and 10% of the diabetic population.



Interview with Bertrand Piccard

Meeting the challenge of a sustainable world

Mark your calendars! COP24 will take place in Poland in December 2018. At the event, Bertrand Piccard, the head of the Solar Impulse Foundation, will present 1,000 profitable solutions for a more sustainable world. **Interview.**

1. What prompted you to launch the brand-new 1,000 solutions challenge on the heels of the Solar Impulse project?
The round-the-world flight in a solar aircraft boosted the credibility of renewable energies and clean technologies, proving that they not only work, but are also capable of achieving the impossible. With this feat accomplished, we had to move on to the practical phase by providing governments and public authorities with concrete proof that clean, profitable technologies exist and are available and ready to replace the old polluting and inefficient systems. The way we are exhausting natural resources is totally illogical. We need to think not just ecologically, but logically. The current challenge is to change laws to help draw innovations to the market. This is a necessary prerequisite for succeeding in the energy transition. And to convince public authorities to change paradigm, we have to be concrete, we have to speak the language of cost-efficiency, and we have to highlight job creation and economic growth.

2. How can you prove that these solutions are viable and profitable?
This is why we created the Global Alliance for Efficient Solutions: a platform developed to bring together solution creators and investors, thereby creating synergies that will speed up the implementation of these solutions. We are forging bonds between all stakeholders.

Anyone is welcome to submit a solution, so long as it has attained a certain level of maturity (prototypes must be at least at 1:1 scale), or is already commercialized on the market. The goal is to showcase what already exists and what it can do, not what may be available in the near future. The solutions must contribute

"Combining logical and ecological thinking: protecting the environment affordably by showing businesses and industries the value this can create for them."

Testimonial

ALENA FARGERE, Air Liquide, Solutions Expert Analyst

Passionate about issues related to the energy transition, I work as an economist in the Hydrogen Energy team at Air Liquide. I also serve as an independent expert for the "1,000 solutions" challenge of the Solar Impulse Foundation. In this role, I am tasked with evaluating solutions related to my area of expertise in energy and clean mobility: energy and cold production from the ocean in Asia, solar boat solutions for large European cities, range extenders for zero-emission vehicles, smart electricity grids in Africa. I've analyzed several promising solutions, some of which, I hope, will obtain the label. And I would also like to see this happen with hydrogen technologies. I am proud to participate in this project that will help build a sustainable world.

to at least one of the five UN Sustainable Development Goals (SDGs) that we have chosen to prioritize: namely goals 6, 7, 9, 11 and 12[1].

They are then analyzed by independent experts, some of whom are from Air Liquide, using three criteria: technical feasibility, social and environmental impact, and economic profitability. When two independent experts have approved the solution, the Solar Impulse Foundation issues the "Solar Impulse Efficient Solution" label. To my knowledge, this is the first-ever label to certify the economic profitability of an environmental product or action. This label provides an independent guarantee and a certain objectivity (see inset).

3. Of the submitted solutions, can you give us three examples that really caught your eye?

The first one that comes to mind is WeNow, which sells a device that can be plugged into one's vehicle for real-time guidance on more responsible and eco-friendly driving. The REGMAX solution is also very interesting. This is a system that recovers and reuses waste generated by industrial pickling processes[2], ultimately reducing the amount of water wasted by 99%. Lastly, the Mascara start-up has developed a reverse-osmosis desalination system for seawater that runs on solar power.

4. Do you believe that companies like Air Liquide have a role to play?

Every company has a role to play, but many of them never do. Not only does Air Liquide have a role to play, it is filling it: it is doing so by providing a panel of experts to analyze solutions, and by funding the promotion of labeled solutions as a Solar Impulse Foundation partner. The Group is also fully capable of submitting solutions. By investing in hydrogen energy, Air Liquide holds extraordinary promise for clean mobility. This solution means refueling takes a few minutes, instead of over an hour as in the case of battery-powered electric vehicles. Hydrogen also plays a central role in energy storage: half the time, countries produce too much electricity and it goes to waste. It would be entirely possible to stabilize consumption spikes by storing excess energy in the form of hydrogen so that it can be used when needed. This would enable us to reduce a country's energy production by 20% over the entire year and achieve major savings in terms of costs and CO_2 emissions. Energy storage is key.

5. You will be presenting these solutions at COP24. How can you build on the momentum of this major event?

We have been preparing for a long time now! After COP24, we will be attending other big events like the Global Covenant of Mayors, the R20 and the Union for the Mediterranean, all with the same vision: to get governments to set their sights higher when it comes to environmental goals and energy policies.

Now that we've circled the globe in a balloon and on Solar Impulse, we are embarking on a third round-the-world trip in 2019! I think a lot of doors will open as a result. We are not asking for anything. We are simply here to offer solutions.

(1) 6 (clean water and sanitation), 7 (affordable and clean energy), 9 (industry, innovation and infrastructure), 11 (sustainable cities and communities) and 12 (responsible consumption and production).

(2) Industrial process used by stainless steel manufacturers to remove metal impurities.

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On Twitter: The Group's news and live monitoring of major events
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The inauguration of the Paris Innovation Campus at the "Plateau de Saclay".

On airliquide.com website: Contents to push back boundaries
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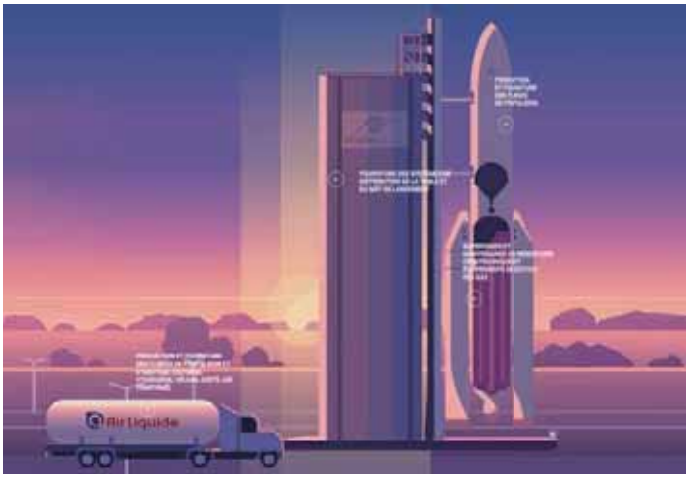

Discover how we support the propulsion of the space titans.

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Air Liquide
creative oxygen