



Digital transformation

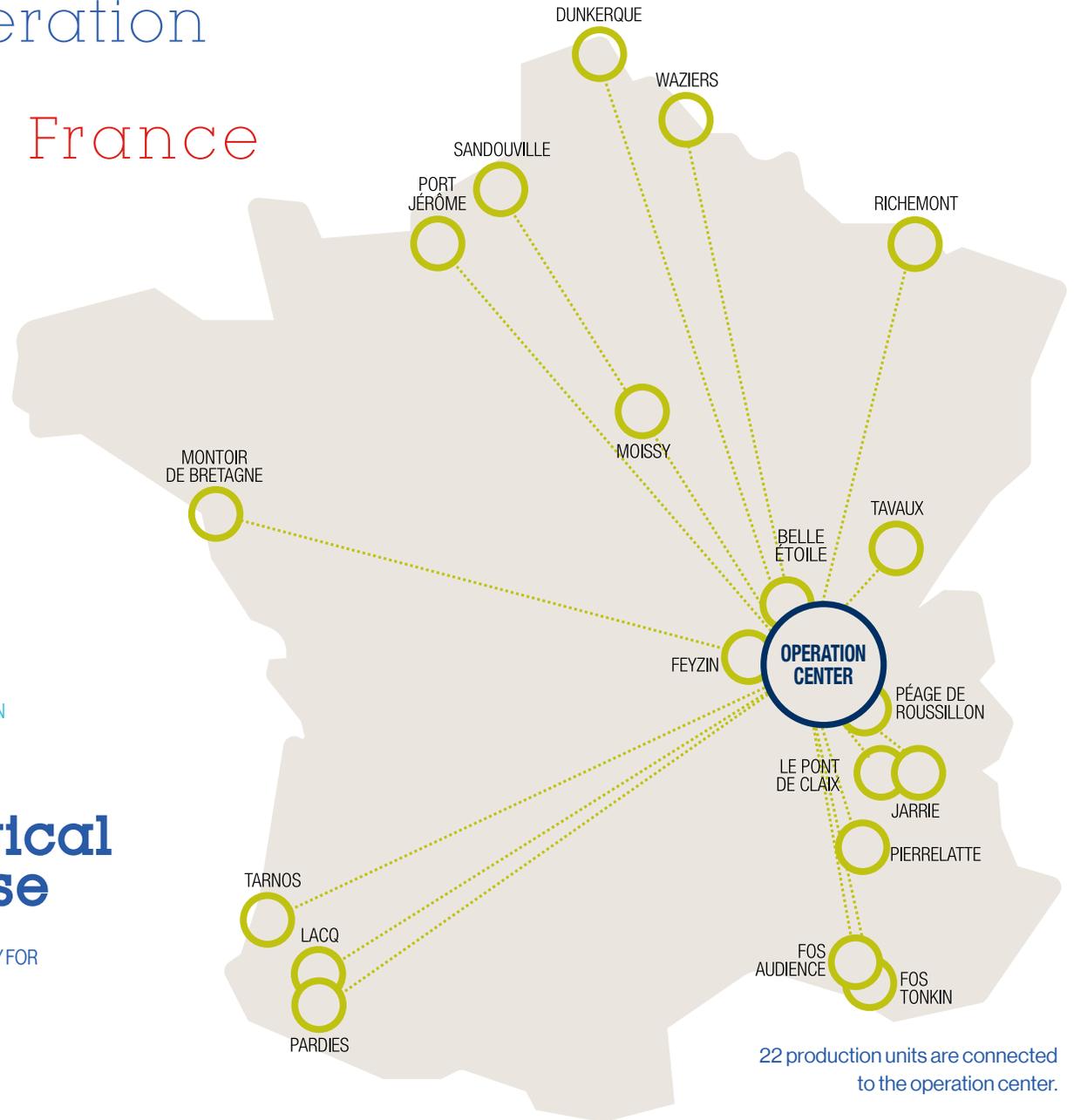
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Air Liquide is transforming
its production units using
digital

#AirLiquideistransforming

A unique remote operation center connected to production units in France

Based in Saint-Priest, the remote operation and optimization center is gradually being connected to 22 units producing gases for industry and health in France.

In the production units, the teams are able to focus on equipment safety and performance.



22 production units are connected to the operation center.

1

REMOTE OPERATION AND OPTIMIZATION CENTER

20

MILLION EUROS OF INVESTMENTS

22

PRODUCTION UNITS CONNECTED TO ONE REMOTE OPERATION AND OPTIMIZATION CENTER

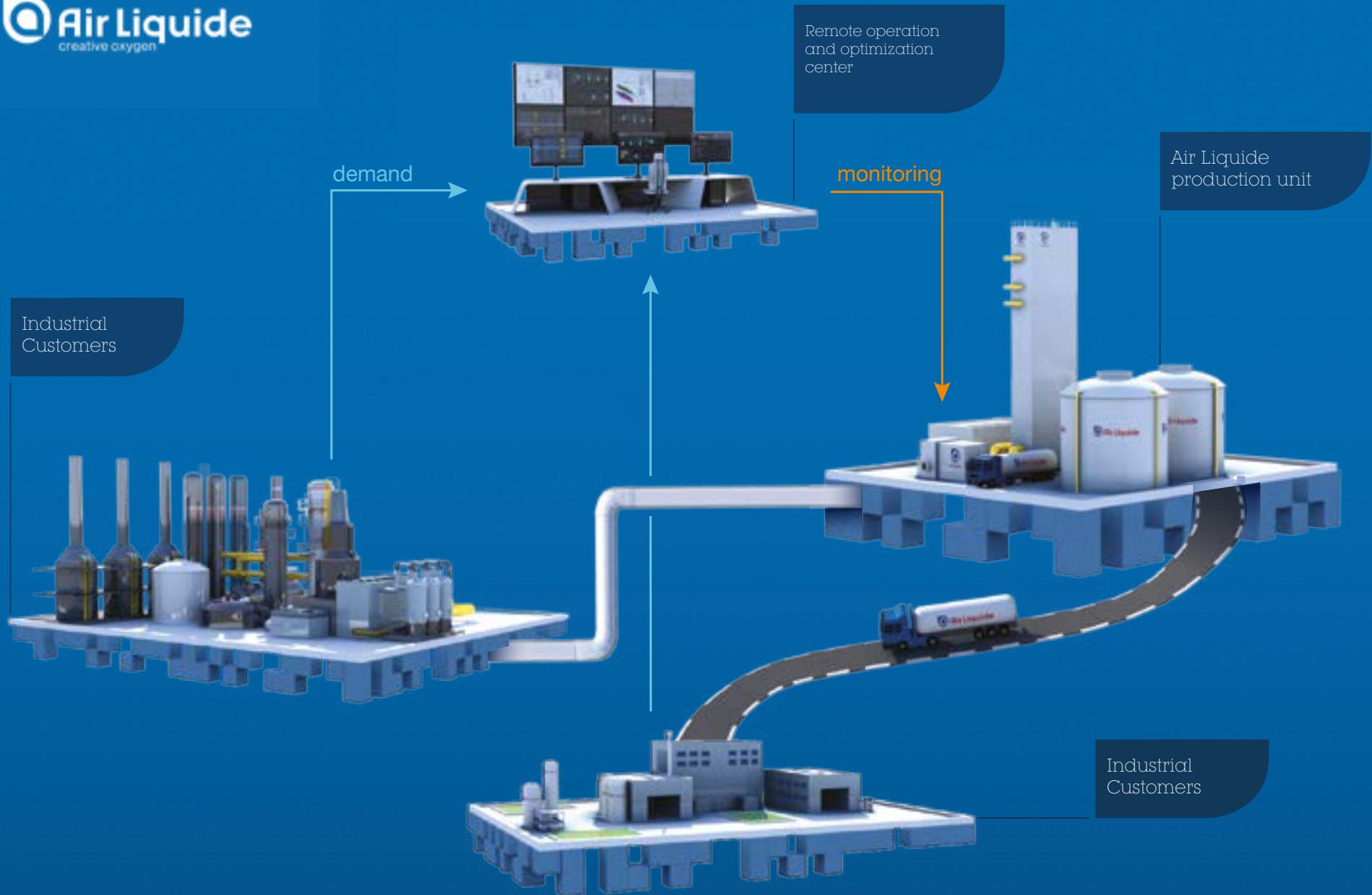
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PROVIDING SERVICE TO CUSTOMERS SUPPLIED IN INDUSTRIAL GASES

Technological showcase

CERTIFIED BY THE INDUSTRY FOR FUTURE ALLIANCE¹

1. Alliance Industrie du Futur



The operation center remotely manages the production of the Group's units in France so as to meet industrial customer demand 24/7.

The remote operation and optimization center

Its missions :

- control and drive production 24/7,
- in parallel, adjust energy consumption in real time,
- conduct predictive maintenance actions.

Control production to respond to customer demand 24/7

Like a control tower, the center's teams monitor on-screen all the oxygen, nitrogen, argon and hydrogen needs of customers in France. They adjust the production of all units in real time to meet customer demand, whether they are continuously supplied by pipeline or delivered by a fleet of 400 trucks. Production instructions are transmitted remotely via secure networks, enabling teams to start up a unit, set production levels, or stop production.

Optimize energy consumption

Thanks to this technology, Air Liquide is improving the energy efficiency of its own installations by reducing CO₂ emissions as much as possible. Using big data analysis, the operating center teams identify the most efficient settings for each production unit in a bid to save energy. When electricity consumption peaks in France, the operation center adjusts the various production volumes of each unit to meet the demand of industrial customers, achieving the best energy efficiency depending on the geographic area concerned.

Ensuring continuous facility runtime

Thanks to the automation of industrial and health gas production processes over 30 years ago, the onsite technical teams are focused on the maintenance and repair of the installations. The day-to-day work of technicians involves safety, regulatory control, and optimal operation of equipment.





Using big data to optimize energy consumption and develop predictive maintenance

For nearly 15 years, Air Liquide has been making constant measurements of production information at **450,000 points** in its **400 production facilities** worldwide. Air Liquide collects **a billion bits of data every day from around the world**. As an illustration, nearly 5,000 measurement points are recorded every second at a hydrogen production unit. To take advantage of this mass of data, Air Liquide engineers have created a data analysis program based on new statistical processing algorithms.

Experts from the Group's Large Industries, Information Technologies, digital transformation, and Research & Development teams have developed a new analytic system applicable to all the Group's production sites around the world, which models the energy consumption profiles of each unit.

For each level of production, the analytics tool searches the saved history for all similar configurations. It compares all energy consumption in order to offer the most efficient settings and equipment that consume the least energy possible.

This new analysis program, used by the operating center teams in Lyon, enables us to define the most efficient and energy-smart operation for each plant on a daily basis and to further improve the energy efficiency of the Group's production units.

Moreover, the analysis of mass data also enables Air Liquide to develop the predictive maintenance of its plants. Through the analysis of statistical and historical data, weak signals that precede a malfunction are identified. The necessary technical interventions can thus be carried out under the best conditions before an unexpected shutdown occurs. These tools help to ensure that customers get reliable service and also provide efficiency gains for the Group.



New digital tools at production sites in France

As part of its open innovation approach, Air Liquide worked with several start-ups to develop new digital technologies adapted to the occupations and practices of its onsite production teams.

Training tutorial videos

In collaboration with the start-up SpeechMe

"A picture is worth a thousand words": certain technical processes and procedures are easier to understand and share by video. Technicians now use a connected camera or glasses and software to film and comment on a specific intervention. The video tutorial is then saved in a database and accessible to everyone via a computer, a smartphone, or a tablet. Employees are filmed explaining how to change a valve for example, a new way of learning. Every video pertaining to troubleshooting, tracking, training, or checking is shot in real-life situations.

<http://www.speech.me/>

Tablet: consulting and entering data anywhere on the production site

In collaboration with the start-up Wedo Studios

Using a tablet, the operator enters or accesses information in real time, anywhere, without having to go to his or her office to consult or input data. To meet the needs of teams in the field, the development has focused on putting the operator at the center, with several test iterations and the close involvement of "experience designers". The configuration of this process, the video tutorials, and the technical documentation required for inspection rounds, truck audits, or CAMM (computer-assisted maintenance management) are available on the tablet to save time on the job.

<http://www.wedostudios.fr/>

3D scanning: 3D blueprints for all production units

In collaboration with the start-up Imag'ing

Thanks to 3D scanning, very precise three-dimensional installations blueprints can be drawn up very quickly. The entire floor area of the site (the grounds and facilities) are scanned at the same time. During maintenance shutdowns, technicians can opt to scan the inside of the installation in three dimensions. All of the technical developments involving the installations are integrated into the 3D plans, which can thus be constantly updated. This facilitates maintenance operations at the oldest units.

<https://www.imag-ing.com/>

Connected glasses: visualizing information in augmented reality

In collaboration with the start-up AMA

Connected glasses allow the technician to visualize the safety of the premises visited, the maintenance procedures, and the workflows in real time. They are equipped with an integrated camera that facilitates remote technical appraisals. Often, it is necessary to both see and hear in order to analyze a situation. Thus equipped, a technician can transmit sound and images from the environment to collaborators located remotely. From his or her computer screen, the Air Liquide expert observes the situation and can give visual indications by pointing to an area using the mouse. The image appears instantly in the technician's eyeglasses onsite. Connected eyewear technology is being deployed at production sites.

<http://www.amaxperteye.com/fr/>



New occupations, new ways of working in collaboration

Two new occupations were created at the remote operation and optimization center: the “analysts” who study the production and optimization of energy consumption and the “real time operators” who are in constant contact with the sites. Production unit skills are also evolving as technicians choose, test, and use new tools (see, for example, the role of the site manager).

The role of the operation center analyst

Before assuming his or her role, the analyst usually occupies various production positions in the plants. His or her in-depth knowledge of processes and experience qualify him or her for the practice of this profession. The analyst defines the medium-term production plans for the production units. He or she uses big data analysis to optimize energy consumption and detect the weak signals that precede a malfunction. The analyst is also responsible for improving digital tools and identifying future efficiency projects.

The center’s analysts have participated in the definition of the operating processes that link the plants and the remote operation and optimization center.

The role of the real-time operator of operation center

As a training engineer, the real-time operator follows a training and empowerment path lasting more than 6 months before assuming the role. The operator adjusts plant production in real time to meet customer demand while ensuring that energy consumption forecasts are met. Ultimately, by 2018, the real-time operators will work 3x8 shifts. In particular, the operator is in contact with customers that are continuously supplied (by pipeline) so that production can be adjusted instantaneously in the event of unforeseen changes. These real-time operators contributed to the design of the man-machine interfaces.

The real-time operators team defined the onscreen displays of the data used daily for the remote operation and optimization center.

The role of the production unit site manager

In charge of several production sites, the site manager is usually trained as an engineer specializing in research and then in production. Leading a team of technicians, his or her priorities are the safety and availability of equipment. Compliance with customer supply commitments means ensuring regulatory controls, maintenance, equipment monitoring, documentation quality, compliance with procedures, regular safety tests and exercises, and proper training and authorizations for onsite teams.

The onsite teams collaborated on Connect by working on the remote start-up and shutdown automation of their units. They also tested the new tools developed to facilitate the operations of technicians.

An open innovation approach

The Connect project is part of the Group’s **open innovation** approach, an essential component of the Group’s innovation. Thanks to the development of numerous collaborations between the teams and customers, scientific partners, technology institutes, SMEs, suppliers and start-ups, this open innovation approach is accelerating the Group’s innovation.

Air Liquide’s teams have been working both internally and externally with the start-up ecosystem to help define solutions. Proofs of concept (POC) have been developed with start-ups in order to validate promising technological avenues and their relevance in terms of uses for the Group. This approach, centered on actual use, makes it possible to identify new levers of efficiency and deploy some innovations more rapidly.

Connect is part of an open innovation approach with the local economic fabric, the French start-up ecosystem and production site teams. It brings together **more than 100 local businesses, including around ten French start-ups.**

Air Liquide and the transformation of its operations through digital tools

With the “Smart and Innovative Operations” (SIO) program, the Group’s Large Industries business line is exploiting data related to the operation of its plants by integrating digital technologies to improve the reliability and efficiency of its operations.

By using the latest digital tools to analyze operating data, this program enables to optimize equipment maintenance, anticipate incidents, and facilitate decision-making to ultimately improve the supply of industrial gases to our customers.

This program, deployed by the Group around the world, is organized around the **automation and centralization of operations, the anticipation of breakdowns, and the optimization of the performances of every production unit.** The goal of the SIO program, which is part of the NEOS corporate program, is to reduce the costs associated with unreliability and to obtain greater efficiency gains for Large Industries by 2020, which will contribute to the Group’s competitiveness.

With the creation of the “Fab SIO”, a collaborative space based in Paris that brings together experts in the relevant areas (Large Industries, Information Technologies, digital transformation, R&D), the program is being rolled out more rapidly on a global scale by delivering a turnkey solution. The Group has already deployed its digital tools for **predictive maintenance** at 15 production sites around the world (China, Japan, Singapore, Germany, Belgium, Russia, Mexico, Argentina, the United States, Egypt, Saudi Arabia, etc.).

The **performance optimization** program was successfully implemented at a plant in the United States in 2016 for units that supply the hydrogen network of the Gulf of Mexico. With the optimization of the operation of the Group’s production units, the SIO program provides customers a more adapted service that offers greater reliability, flexibility, and responsiveness.



FOR FURTHER INFORMATION

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