

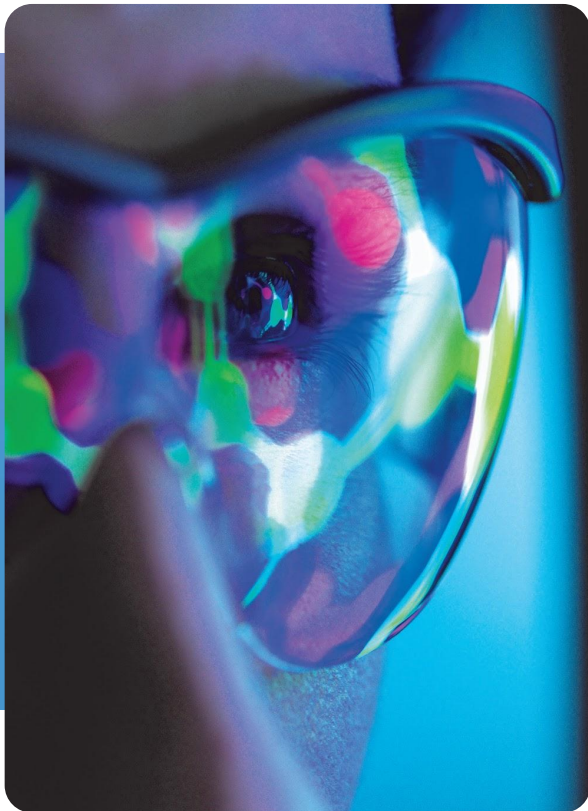


# Innovation and Technologies Enabling Energy Transition

*to deliver the ADVANCE strategic plan*

May 31, 2023





# Innovation and Technologies Enabling Energy Transition

---

*Emilie Mouren-Renouard – Vice President, Innovation and Development*



# ADVANCE



**Financial performance**

**And beyond,**



**Decarbonizing the planet**



**Unlocking progress via technologies**



**Acting for all**

# Decarbonizing Air Liquide Assets, Commitment to Carbon Neutrality

## Air Liquide Commitments



CO<sub>2</sub> emissions **start decreasing** in absolute value

~2025

**-30%**  
Carbon intensity  
in kg CO<sub>2</sub>/€ EBITDA<sup>(a)</sup>  
vs 2015



2035

Decrease scope 1 & 2  
CO<sub>2</sub>eq emissions in  
**absolute value** by  
**-33%**<sup>(b)</sup>

Reach **Carbon  
Neutrality** by 2050

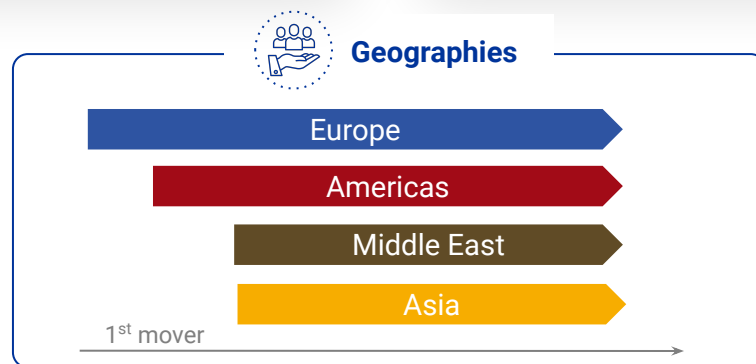
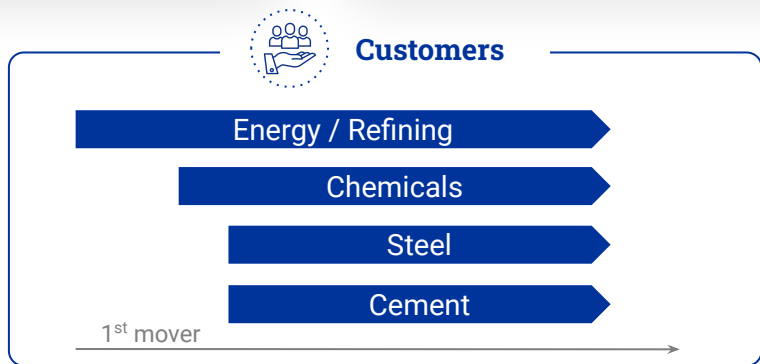
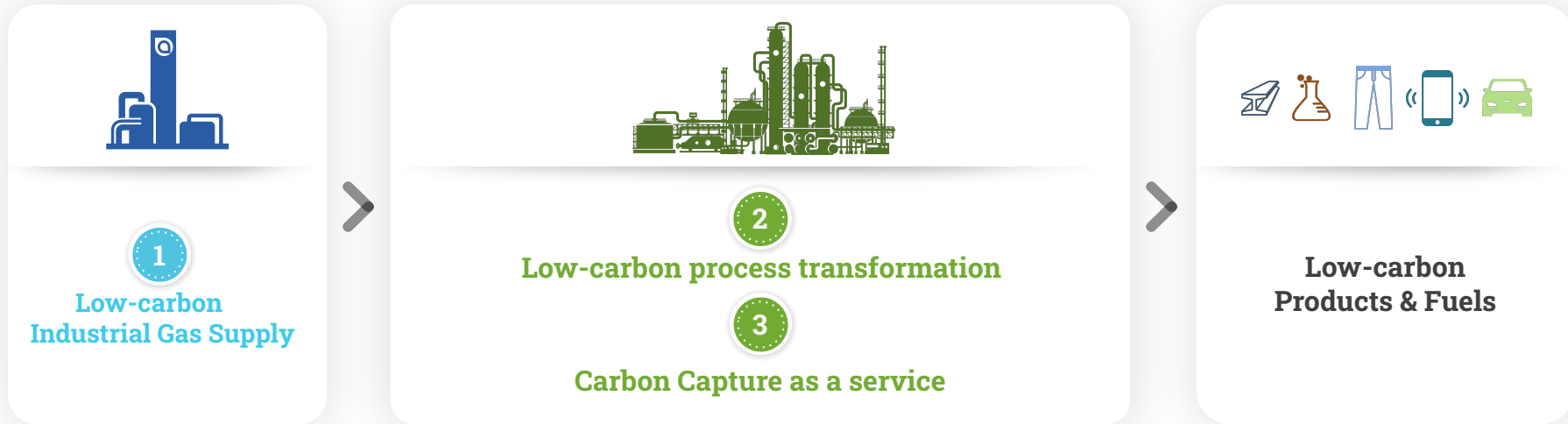
2050



(a) at 2015 exchange rate and excluding IFRS16 for greenhouse gas emissions scopes 1 and 2

(b) from 2020 Market based emissions of 32.5 million tonnes CO<sub>2</sub>eq (Scope 1+2)

# Decarbonizing Customers, Air Liquide Solutions Along the Low-Carbon Chain



# Leveraging our Technologies, Focus on Solutions for Energy Transition

Technos



## Innovative Air Gases Solutions

- Renewable Electricity intermittency management - ALive™
- Ultra low energy ASU
- Oxycombustion



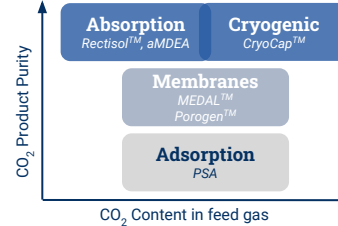
## Low-carbon H<sub>2</sub>

- ATR\* / POX\* with Carbon Capture for large H<sub>2</sub> volumes
- H<sub>2</sub> Liquefaction
- Other E&C technologies such as NH<sub>3</sub> cracking



## Carbon Capture

- The most complete Carbon Capture offer



## Electrolysis

- PEM\* partnership with **SIEMENS ENERGY**
- Active innovation in all technologies

Combined with

Digital - AI

Smart Innovative Operations - Integrated Bulk Operations

Human expertise

Technical and innovation experts  
Skilled operational teams

4,000  
TCL<sup>(1)</sup>

3,000  
inventors

(1) Technical Community Leaders

# Leading in Innovation to Support Business and Operations

## Climate solutions

~33%

Others  
(industrial security, air gases...)

~22%



## Digital

~15%

## Advanced Materials

~11%

## Healthcare

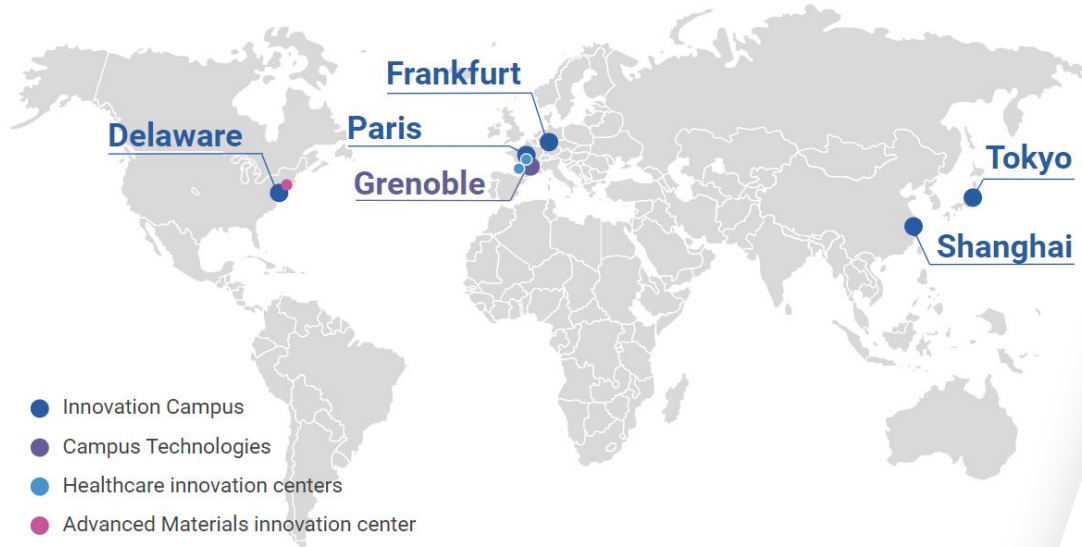
~19%

# #1

applicant of new patents in Industrial Gases

(1) Innovation expenses

# Innovation Contributing to Short Term Profitable Growth While Preparing the Group's Future



**400+**  
partners





# E&C Capabilities Enabling Innovation Delivery

7

**Main Engineering Centers worldwide**

3

**Manufacturing centers**

>€1bn

**Order Intake**

~50%

**of Group's patents filed**

## Proprietary core business technologies

Air gases, low-C H<sub>2</sub>, H<sub>2</sub> liquefaction, carbon capture

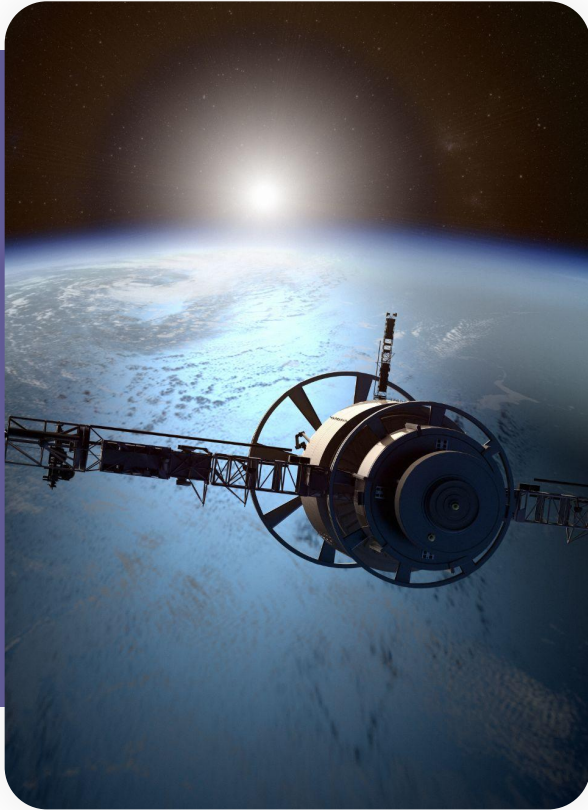
References in **large projects**

Closeness to **plant operations**

operated by LI, EL, IM

Allowing continuous operational feedback, creating a virtuous circle for **fast continuous improvement**

➤ **Key differentiating factors** enabling **innovation DELIVERY**



# Air Liquide Global Markets & Technologies

---

*Emilie Mouren-Renouard – Vice President, Innovation and Development*

# Support the Deployment of Sustainable Solutions, Invent the Future

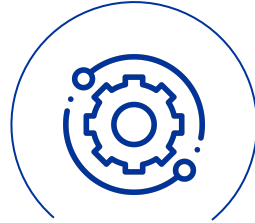


## Delivering **solutions**

Technologies, Molecules,  
Equipment, Services

for

- **Energy Transition**
- **Deep Tech**



Through 3 activities:



**Technologies**



**Biomethane  
Solutions**



**Maritime**



- Acting to **decarbonize** industry
- Promoting **progress** through **technological** innovation
- **Acting for all** of our stakeholders

# Strong Growth Dynamic, Disruptive & Entrepreneurial Mindset

## 2022 third party sales<sup>(1)</sup>



### Technologies

- Space
- Big Science & Fusion
- Hydrogen technologies
- Membranes
- Cryogenic equipment



### Biomethane solutions

- Production & purification



### Maritime

## GM&T solutions provider to the Group



### Technologies:

Equipment for EL & IM



### Maritime :

global sourcing of molecules (helium, rare gases) to IM & EL

**+19%** 5 years CAGR<sup>(2)</sup>

(1) Consolidated revenue (2) 2017-2022



# The Campus Technologies Grenoble

*Benoît Hilbert, Managing Director ALAT*

# A Unique Technology Campus within the Innovation Network



Created in **1962**



Around **1,400** employees



**14 hectares** including a **test center** of 3 hectares



~**20,000 m<sup>2</sup>** of production workshops



**Low environmental impact** tertiary buildings



# More than 60 Years of Innovation



# An Exceptional Local Ecosystem with Strong International Reputation



**30,000**

**jobs in research**

Within a radius of  
20km



**#1**

**In France** for  
concentration of  
**R&D jobs (7.6%)**  
(ex: glass, steel)



**670**

**Startups  
launched**  
since 2000



**High  
concentration of  
research  
organisations  
and industry  
leaders**



**5<sup>th</sup>**

**most inventive  
city in the world\***



**40%**

**of people in the  
industry sector  
employed by a  
foreign entity**

(1) Forbes magazine



# Acting for All: Highly Integrated into Local Ecosystem

## With research-oriented ecosystem

### SOLARIMPULSE FOUNDATION

Supporting the **ecological transition** of the territory and businesses

April 25<sup>th</sup>:  
Climate & Solutions Day



Common **research** for **cryogenics & quantum computing**



Common **laboratory** for **space cryogenics and refrigeration for big science**

## With local authorities and public services



Promotion of **scientific culture** through projects of public interest



Professional **insertion & mixity** in **technological industries**



Making commitments for **economic resilience**



Unique **training program** on "Science & Society" debates

# Dynamic Electronics Activity in the Basin



**Huge presence** at customer sites, delivering **carrier gases**, **specialty materials** and **equipment** for semiconductors and flat panels display manufacturing



soitec

Aledia



**Stunning rise** of electronic activities in the 2023-2025 period:

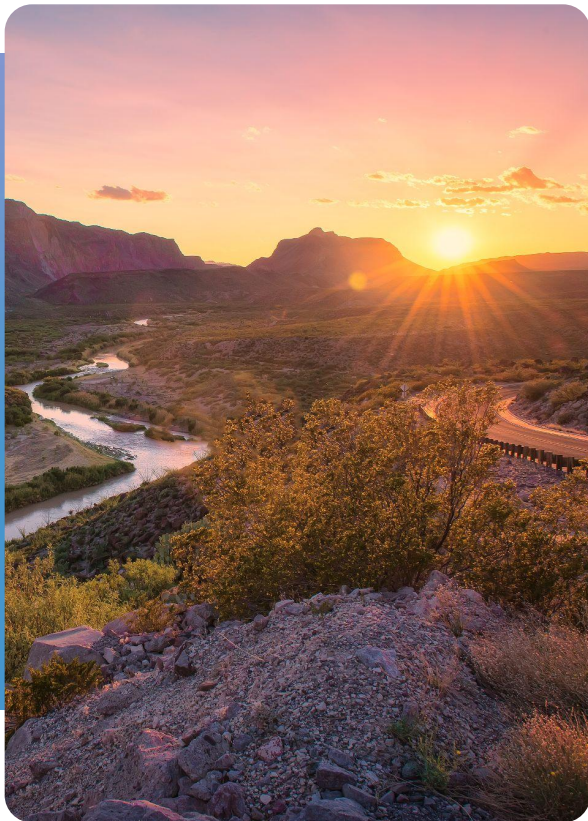
- ~+9,000m<sup>2</sup> new clean rooms
- ~+15,000m<sup>2</sup> new fabs



**Capacity to deliver in less than 18 months.** Planned until 2025:

- 4 new N<sub>2</sub> generators
- 2 new PEM electrolyzers
- >375 gas cabinets and >180 chemical distribution systems





# Key Takeaways

---

*Emilie Mouren-Renouard – Vice President, Innovation and Development*

# Innovation and Technologies, First Enablers of the Energy Transition

## Act as a leader in Energy Transition



Decarbonize **our assets**



Decarbonize **the assets of our customers**



## Innovation as a differentiating factor

- Large portfolio of **proprietary technologies**
- Key **partnerships**
- **Unique position:** ability to innovate, develop, invest, operate

**There will be no Energy Transition without Innovation and Technologies**

# Early Player in Biomethane

- **Proprietary technologies**
- Build, own and operate on a **long term** basis
- **De-risking sourcing of waste by incentivizing feedstock providers** & promoting **circular economy** schemes
- Starting in transportation, now positioning on **high value niche markets** upstream for **industry**:
  - **Decarbonizing industrial customers' processes**, leveraging Air Liquide portfolio
  - Partly **decarbonizing Large Industries SMRs**
  - Offering **renewable H<sub>2</sub>** and **CO** to Large Industries customers
  - **Supplying biogenic CO<sub>2</sub>** to Industrial Merchant
- **Dynamic** market growth



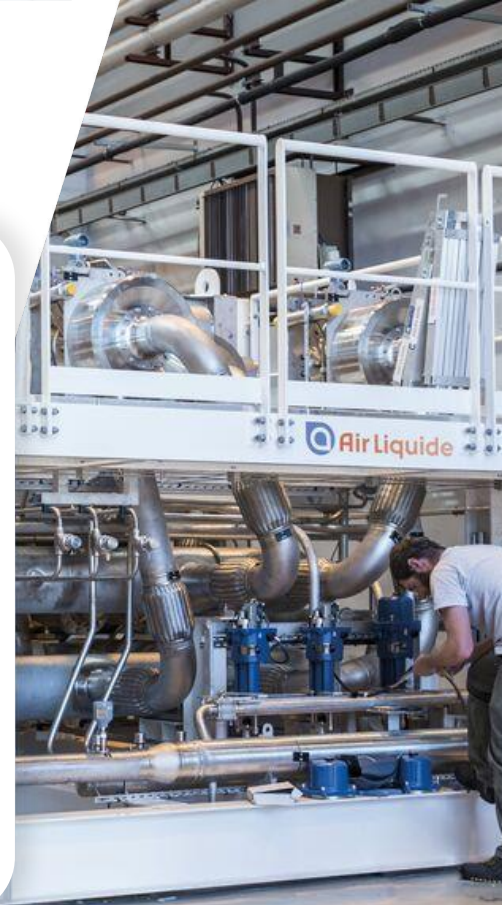
# Innovating in Cryogenics for Growth and Efficiency

- **Unique cryogenic expertise**
- **Turbomachines at the core of gas liquefaction and refrigeration units, key for Energy Transition**
- **To reach cryogenic temperature (-150°C, 120K)**  
Gas flows through compressor, heat exchanger, expander
- **High expertise in Turboexpander machines**
  - High-speed rotating machines
  - The site produced:
    - >800 turbo expanders over the last 50 years
    - >400 turbo compressors for Turbo Braytons over the last 6 years
  - Unique test bench in cryogenic conditions
- **Recognized performance of AL expanders associated with cryogenic knowledge**
  - ITER nuclear fusion project
  - Major He liquefaction units in Qatar



# Leveraging Turbo Brayton for Liquid H<sub>2</sub>

- **Several steps of development over 20 years**  
Space -> Superconductivity -> Maritime LNG & Biomethane liquefaction -> **Hydrogen liquefaction**
- **Highly competitive in Capex & Opex**
  - Improved **reliability, efficiency & flexibility**
  - Compact & modular system for **easy manufacturing, logistics & installation**
  - **Adapted to intermittent renewable energy** source
- **One of the key techno bricks for the liquefaction of H<sub>2</sub>**



# Liquid Hydrogen, a Key Differentiator for H<sub>2</sub> Mobility Markets

- **H<sub>2</sub> distribution in**
  - **Gaseous** form @300 bar in GH<sub>2</sub> tube trailers
  - **Liquid** form in LH<sub>2</sub> trailers
    - 1 LH<sub>2</sub> trailer **replaces 6 GH<sub>2</sub>** tube trailers
- **AL global Leader in H<sub>2</sub> (and He) liquefaction**

**Unique test platform** with unique cryogenics capabilities  
*LH<sub>2</sub> @-253°C, LHe @-269°C*
- **HRS<sup>(1)</sup>, a key enabler for H<sub>2</sub> mobility markets**
  - **From GH<sub>2</sub> storage to GH<sub>2</sub>** (from 300 to 700 bar; >200 HRS delivered) -> mature technology
  - **From LH<sub>2</sub> storage to GH<sub>2</sub>** (@700 bar, test of the pump) -> less energy intensive, cheaper LH<sub>2</sub> supply chain
  - **From LH<sub>2</sub> storage to LH<sub>2</sub>** into planes, ships, trucks -> developed for Ariane rockets, to be adapted to new markets

(1) HRS: Hydrogen Refueling Stations





# Air Liquide Unique Competencies enabling H<sub>2</sub> Emergence for Aviation

- H<sub>2</sub> central for the decarbonation of aviation with 3 usages:
  - Electricity produced onboard with **fuel cells**
  - H<sub>2</sub> **burned** into a turbine
  - **efuels** (H<sub>2</sub> + CO<sub>2</sub>)
- **Medium-haul aircrafts prime segment for LH<sub>2</sub>**  
<2000 kms, <200 passengers
- **Leveraging on unique competencies to:**
  - Master the **H<sub>2</sub> supply chain**
  - Contribute to the **airport H<sub>2</sub> infrastructure development**
- **Working with partners to move fast**



**AIRBUS**



# Taking a Strong Position in Electrolysis

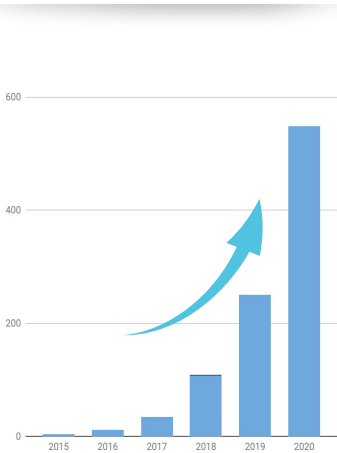
- Secure **access to the most competitive technology** in Capex and Opex
- Ensure **safe, reliable** and **efficient operations**
- **Leveraging** project execution & industrial operation from **PEM<sup>(1)</sup> 20MW electrolyzer in Becancour** since 2021
- **Managing all technologies**
  - **PEM**   **Joint Venture**  
Gigafactory and R&D agreement
  - On-going development on **Alkaline**
  - Promising **AEM<sup>(2)</sup>** - R&D program started with bench tests

(1) Proton Exchange Membrane (2) Anion Exchange Membrane



# Well Positioned to Capture Growth in the Energy Transition

## Growing Customer Needs



+

 **Air Liquide**  
offer

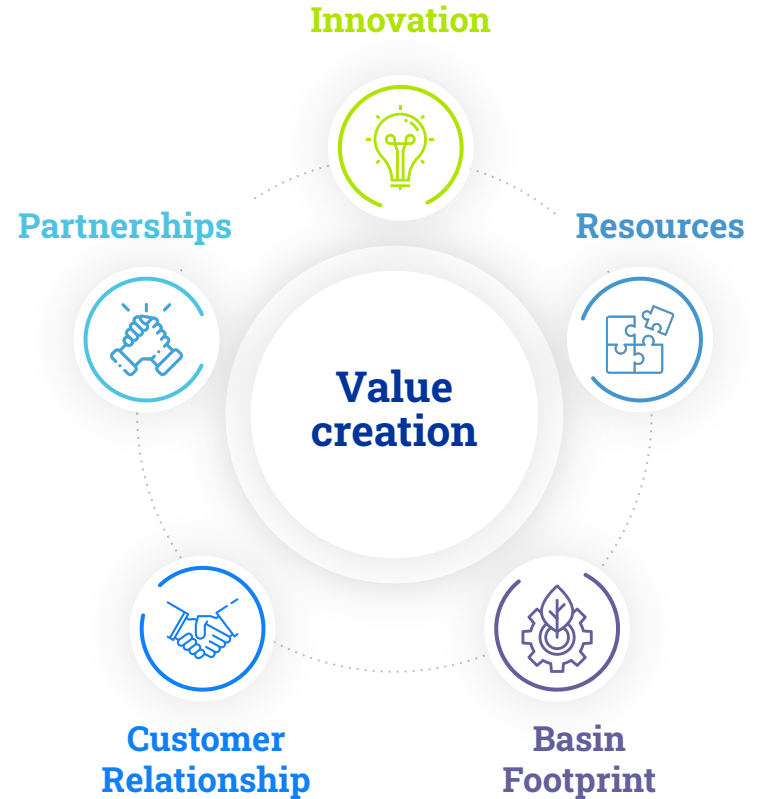
Low Carbon  
Industrial Gas  
Supply

Low Carbon Process  
Transformation

Carbon Capture  
As A Service

New Products &  
Manufacturing Support

+

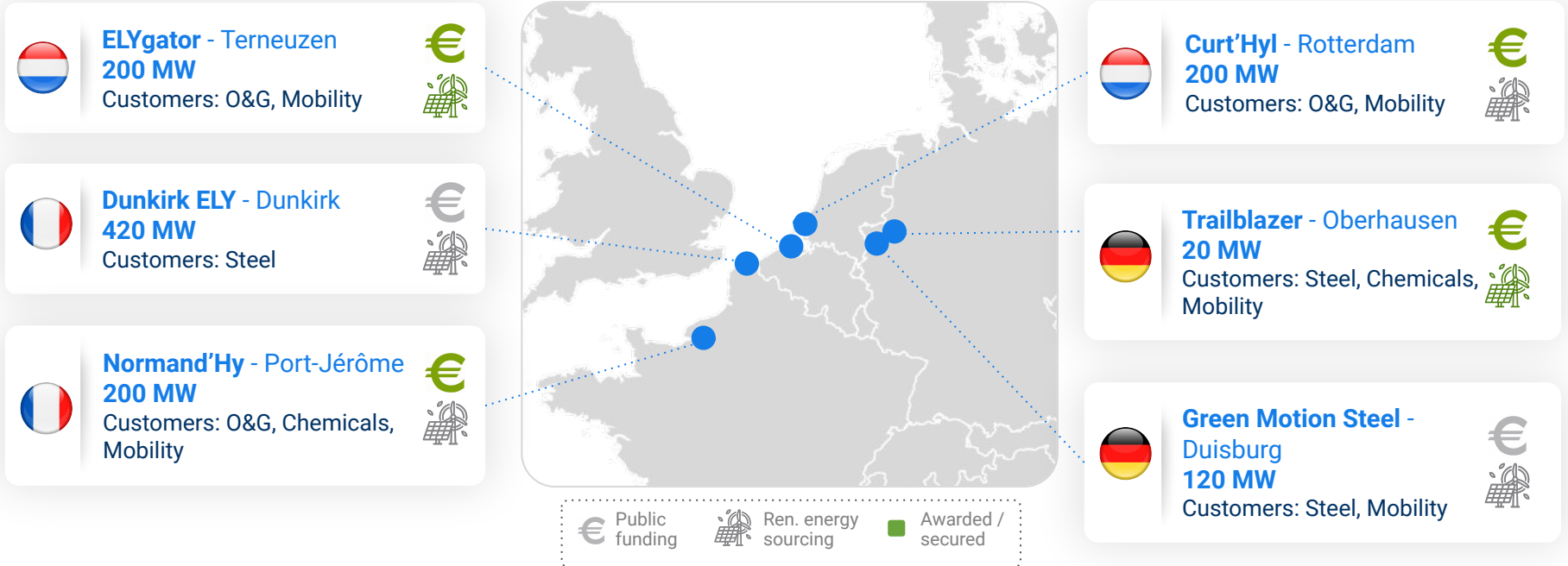




# From Technology to Business Projects

*Pascal Vinet, Senior Vice President in charge of Europe Industries and AME1*  
*Chris Clark, Large Industries Vice President*

# Dynamic Development of Electrolyser Projects in Europe



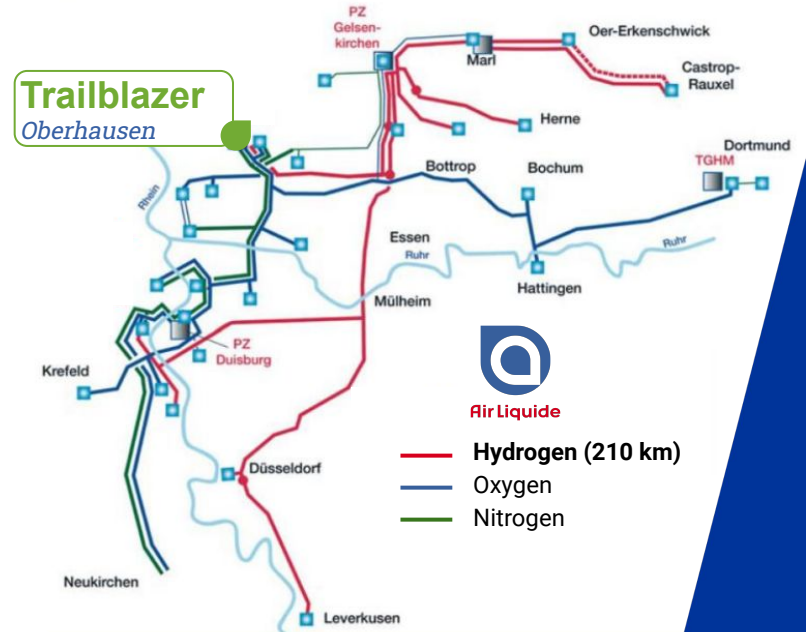
**>1 GW** Electrolyser capacity

# Connecting Electrolyzer and Existing H<sub>2</sub> Pipeline Network

## Example Trailblazer Project, Germany

### 20MW PEM<sup>(1)</sup> electrolyzer

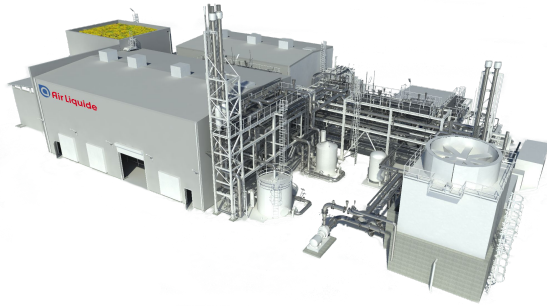
-  **Air Liquide** +  **SIEMENS energy** 1<sup>st</sup> cooperation project
- Startup in **Q4 2023**
- In the **most industrialized basin in Germany**
- Diverse customers: **Steel, Chemicals, Refineries & mobility**
- Supplying  **thyssenkrupp** new **DRI project**
- **Synergies: high purity renewable O<sub>2</sub>** to local premium markets
- **Secured PPA**, wind + solar



(1) Proton Exchange Membrane

# Trailblazer Project: Startup in Q4 2023

*Pictures taken on site, May 5<sup>th</sup>, 2023*



*Visit of German President May 2<sup>nd</sup>, 2023*

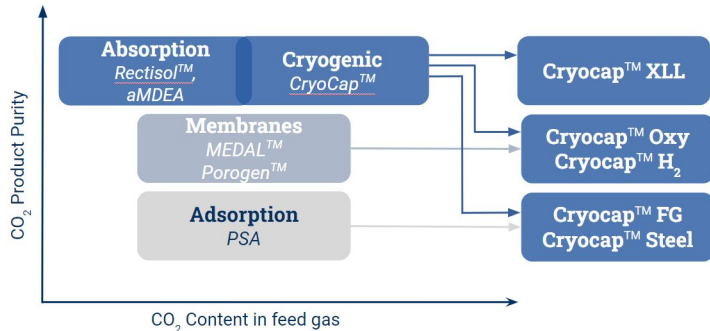


# Carbon Capture, a New Business for Large Industries

## A favourable ecosystem

- Leveraging **major industrial & transportation hubs**
- Strong **national & EU support** for emissions reduction
- Driven by the **hard-to-abate sector**

## Complete portfolio of Proprietary technologies



Cryocap XXL: for large scale CO<sub>2</sub> liquefaction; Cryocap Oxy: for flue gas from oxycombustion; Cryocap H<sub>2</sub>: for H<sub>2</sub> production; Cryocap FG: for low CO<sub>2</sub> concentration flue gas; Cryocap Steel: for steel production

## Involved in flagship projects in European key basins

### Basin

### Projects

#### Belgium-Netherlands

- Porthos [Rotterdam]
- Kairos@C [Antwerp]
- **HOLCIM** cement plant

#### North France

- **Lhoist** lime plant
- K6 **EQUIOM** cement plant

#### Normandy

- CCU/CCS for **TotalEnergies** **ExxonMobil**

#### Paris region

- **TotalEnergies** Grandpuits SMR & CC





# Accelerating Opportunities in the US

## Canada and US Midwest

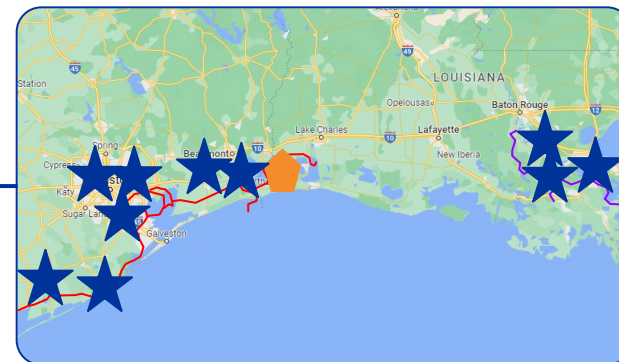


### A favourable ecosystem

- Accelerating opportunities in the **battery market**
- new **O<sub>2</sub>/H<sub>2</sub>** opportunities from Low Carbon **Steel Making**



## US Gulf Coast



## Key project drivers

- **Advancing** decarbonization projects of key chemical and oil/gas facilities to meet **sustainability objectives**
- **IRA legislation** and relatively low energy cost underpinning US gulf coast competitiveness for **energy export markets** (eg low carbon ammonia for northeast Asia)

### Infrastructure legislation:

providing **subsidies for H<sub>2</sub> Hubs** across the US (industry and mobility)



# Delivering ADVANCE Strategic Plan

---

*Jérôme Pelletan, Group Chief Financial Officer*

Innovation and Technologies at the Heart of the Group's Strategy

# ADVANCE



**Financial performance**

**And beyond,**



**Decarbonizing the planet**



**Unlocking progress via technologies**



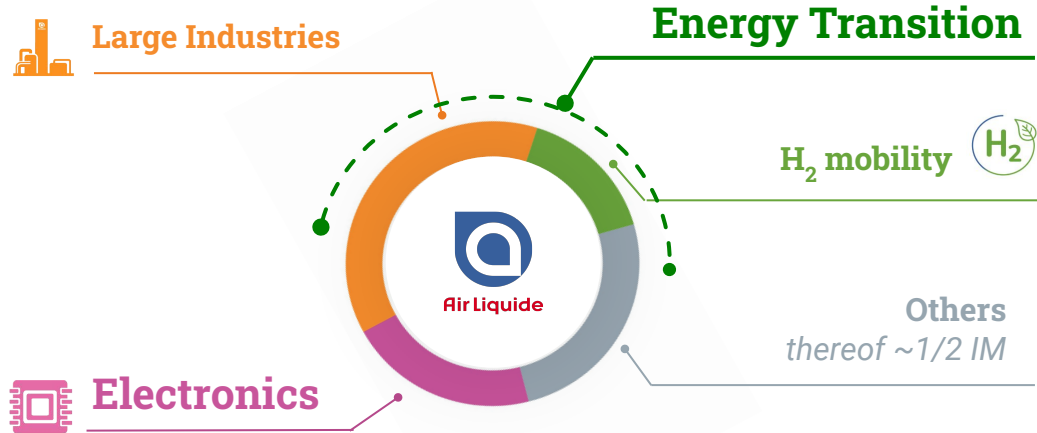
**Acting for all**



# Technologies as a Key Differentiator, Supporting Investments

**ADVANCE**

Industrial Investment Decisions above €5m



> Total investment decisions €16bn<sup>(1)</sup> 2022-2025

(1) Cumulated industrial and financial investments decisions over 4 years 2022-2025

# To Deliver **ADVANCE** Performance Objectives

**Sales growth**  
**+5-6% CAGR<sup>(1)</sup>**

**ROCE**  
**>10%**  
by 2023  
and forward



**CO<sub>2</sub>**  
**emissions**  
**inflection**  
around 2025

(1) Group comparable sales growth 2021-2025 CAGR



# Innovation and Technologies Enabling Energy Transition

*to deliver the ADVANCE strategic plan*

May 31, 2023

