
Air Liquide
Decarbonizing industry:
H2, CCUS and Renewable
G. De Smedt - Deputy VP Sustainability
Conference CORIOLIS
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SPEAKER INTRODUCTION

Guillaume DE SMEDT

Deputy VP Sustainability
Group Sustainable Development

1995-1998	Ecole Polytechnique
1998-1999	DEA Theoretical Physics
1999-2002	PhD Theoretical Stat. Physics

Air Liquide

2003-2006	R&D - CCS project leader
2007-2011	Energy Management Europe
2011-2015	Large Industry World Business Line (Energy)
2016-2020	Hydrogen Energy Strategy & Marketing
2020-Today	Deputy VP Group Sustainability

Expert in Climate & Energy

Outline of presentation

I. **Introduction to Air Liquide**
   A. Business model & key figures
   B. Sustainability strategy

II. **Global CO2 emissions: focus on industry**

III. **Air Liquide's solutions to support industry decarbonization**
   A. Technology pathways
   B. Achievements

01

Air Liquide in brief

A world leader in gases, technologies, and services for…

INDUSTRY

Sustainable solutions for a wide range of industrial processes for customers (energy, metals, food, chemicals, automotive, pharmaceuticals, etc.) **and for transportation**

HEALTH

Patients at home
Hospitals
Specialty ingredients

©Adrien Daste

Air Liquide

A world leader in industrial gases and related services

A unique model

Our profile

~66,300(*) committed employees in **60**(*) countries

Extensive scientific & technical expertise in industrial gases (oxygen, nitrogen, hydrogen, etc.)

> 4 million customers & patients

3,900 employees dedicated to innovation

6 Innovation and Technologies Campuses

14,800 patents

2 industrial gases production models
>Centralized production
>On-site production at customers'

3 industrial gases distribution networks
>9,700 km of pipelines for large quantities

~ 20 million cylinders for small quantities

~ 10,000 trucks for medium quantities

Our business model

Long-term vision and sustainable growth strategy

A wide range of customers and applications

Major ability to innovate

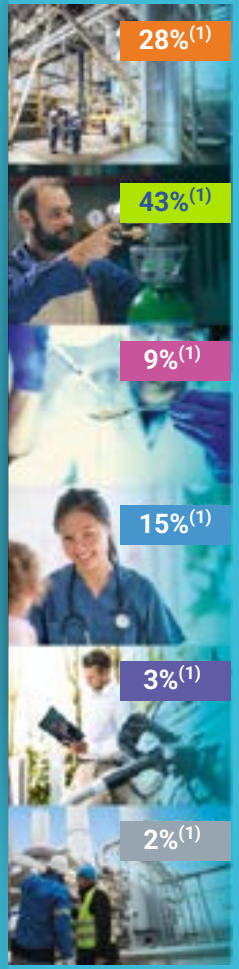
Long-term customer contracts, indexed to energy prices

Management and optimization of production and distribution chain

Active involvement in new markets

Global presence and local activity

Our activities



Serving almost all economic sectors

LARGE INDUSTRIES
Industrial gases in large quantities in the framework of long-term partnerships
> Chemicals, Refining, Metals

INDUSTRIAL MERCHANT
Industrial gases in small and medium quantities, application technologies, small equipment and related services serving a wide range of customers
> Materials & energy, Automotive & fabrication, Food & pharmaceuticals, Technology & research, Entrepreneurs & distributors

ELECTRONICS
Ultra-pure gases in large quantities and development of new molecules
> Semiconductors, Photovoltaic, Flat panels

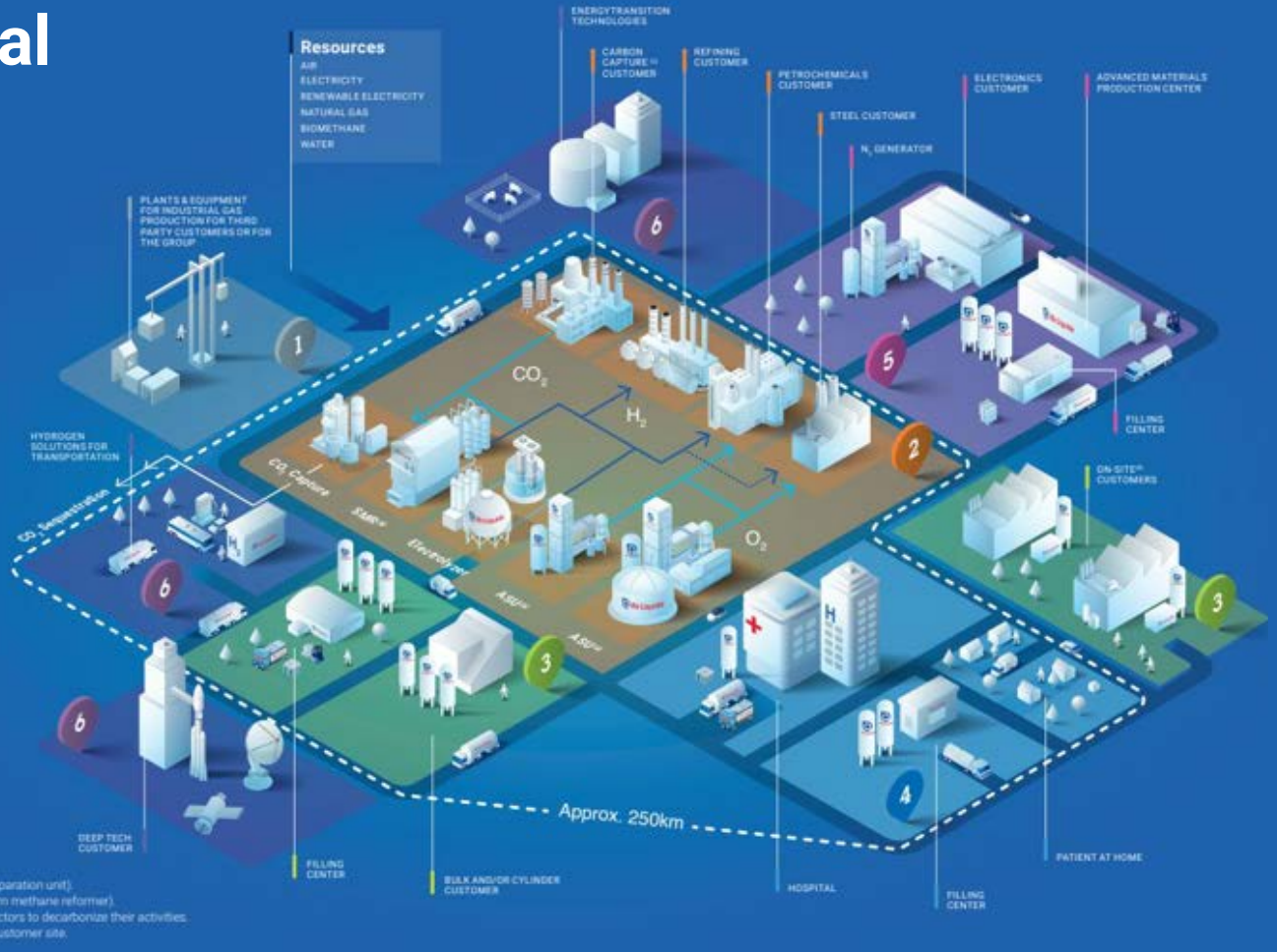
HEALTHCARE
Medical gases, products and services to support patients and customers in hospital and at home
> Hospitals, Home healthcare, Specialty ingredients

GLOBAL MARKETS & TECHNOLOGIES
Molecules, equipment and services to support of energy transition and deep tech(2)
> Energy transition, Deep tech(2)

ENGINEERING & CONSTRUCTION
Plants and equipment for industrial gas production
> Customers choosing to insource their industrial gas needs

(*) Figures as of July 23, 2024
(1) Percentage of 2023 Group revenue.
(2) Disruptive technologies based on scientific breakthroughs that can fundamentally change design and production methods.

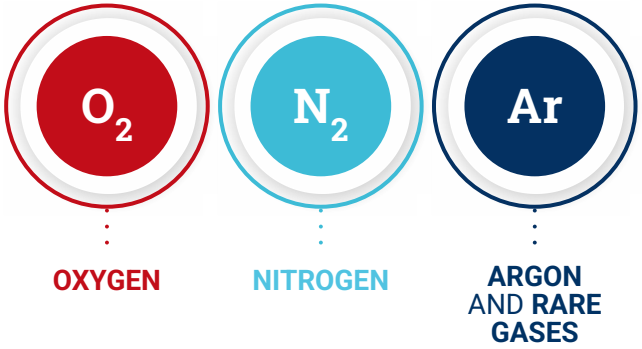
Industrial model



Our scientific territory: Essential small molecules

Oxygen, nitrogen and hydrogen are essential small molecules for life, matter and energy.
They embody Air Liquide's scientific territory and have been at the core of the company's activities.

Separating the components of **air** to take advantage of their properties



Producing and managing molecules from the **natural resources** of the planet

2023 Key Figures

~66,300
EMPLOYEES(1)

PRESENT IN
60 COUNTRIES(1)

MORE THAN
4 MILLION
CUSTOMERS & PATIENTS

REVENUE
€27.6bn

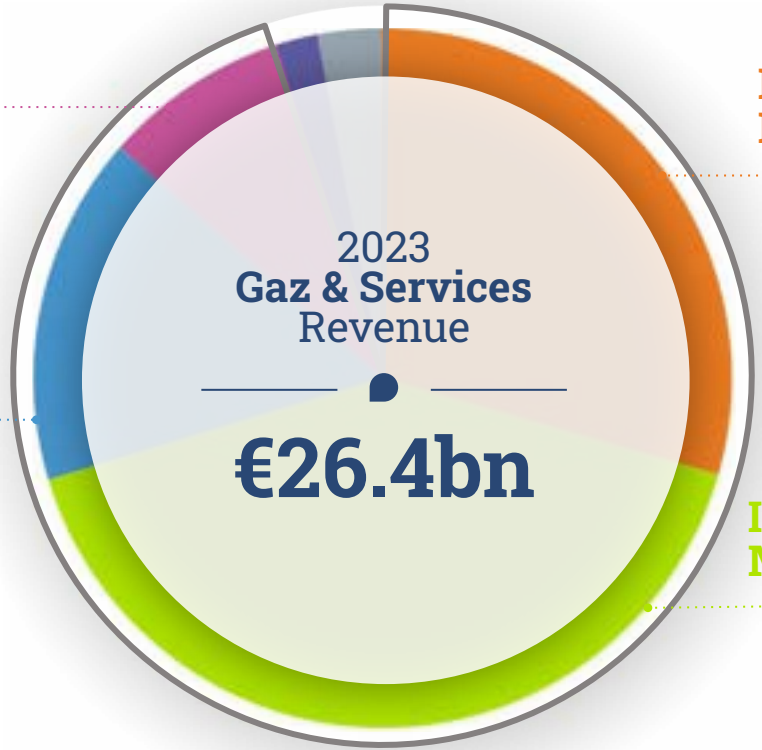
NET PROFIT (GROUP SHARE)
€3.1bn

INVESTMENT DECISIONS
~€4.3bn

(1) Figures as of July 23, 2024

Gas & Services revenue

2023 figures



9% ELECTRONICS

Carrier Gases
Advanced Materials
Equipment & Installations
Services

15% HEALTHCARE

Home Healthcare
Hospitals
Specialty Ingredients

LARGE INDUSTRIES 28%

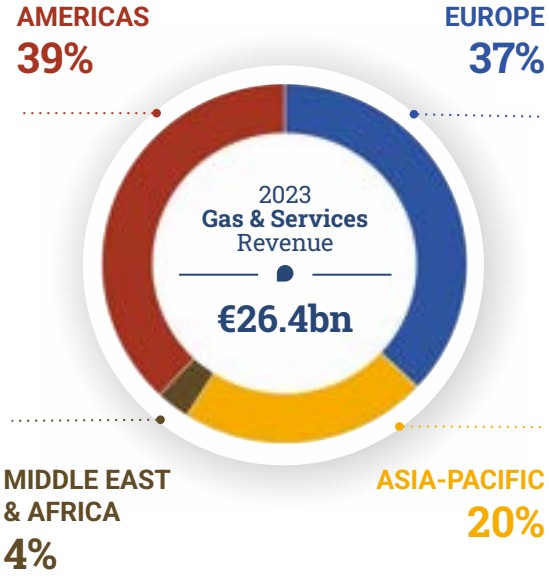
Air gases, hydrogen and CO
15-year or more contracts
Pipeline networks
Industrial basins

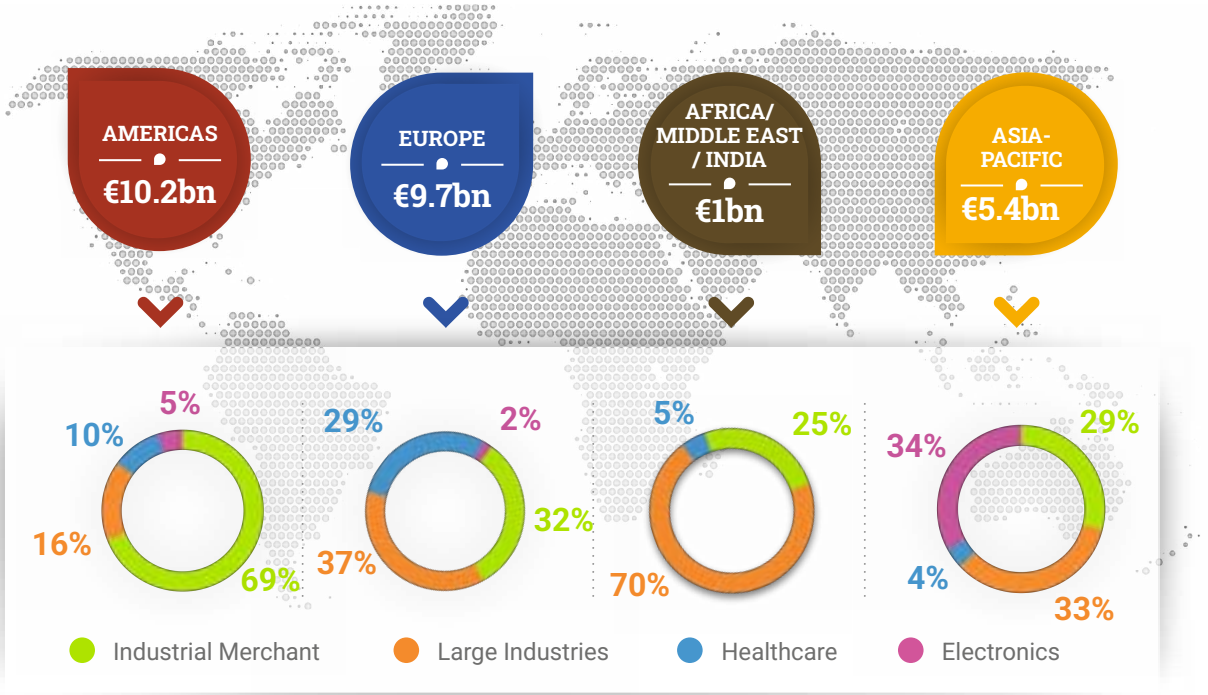
INDUSTRIAL MERCHANT 43%

Bulk and cylinder gases
Hardgoods
for a wide variety of sectors
and customer sizes

Gas & Services revenue breakdown by region

2023 figures





Our commitments to Sustainability

Pillars of our ESG strategy

Our sustainability priorities

For the environment

Contribute to a low-carbon society and to the protection of the environment

- Reducing CO_2 emissions
- Preserving water
- Protecting biodiversity

For health

Improve the quality of life of patients and the access to medical oxygen

- Improving the quality of life of patients with chronic diseases at home in mature economies
- Facilitating access to medical oxygen in low- and middle-income countries

For all

Strive to act as a trusted partner with all our stakeholders

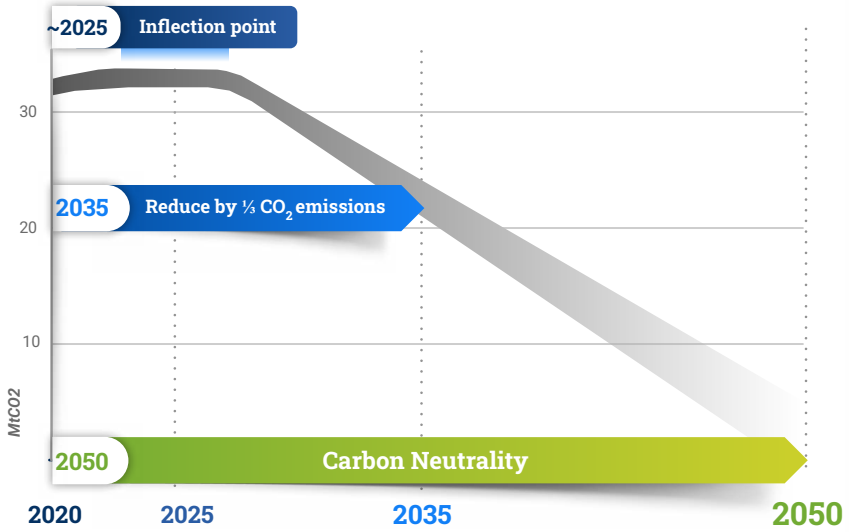
- Safety
- Engaging with our employees: creating a safer, more collaborative and inclusive work environment
- Supporting local communities
- Building a best-in-class governance to nourish close relationships with stakeholders

March 2021: First Complete Set of ESG Commitments

	2025	2035	2050
 **A**batement of CO_2 Emissions	• Inflection in absolute emissions • <30%> reduction in carbon intensity vs. 2015	• <33%> reduction in absolute emissions vs. 2020	• Carbon Neutrality
 **C**are for patients	• In Mature economies - increase personalized care for patients • In Low & Middle Income Countries : Facilitate access to O_2		
 **T**rust as the base to engage with employees & to build best-in-class governance	• 35% Women among M&P • 100% of employees to have common basis of care coverage • All employees to have access to local volunteering initiatives		

…With CO2 Emissions Reduction Becoming One of the 3 Strategic Objectives

Absolute Scope 1+2 emissions



SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

2035 objectives submitted to SBTi were recognized as "Well Below 2°"

ADVANCE
Performance Objectives

Sales growth
+5-6% CAGR(1)

ROCE
>10%
by 2023(2)
and forward

Air Liquide

CO_2 emissions inflection
around 2025

Subject to favorable long-term policy and regulatory frameworks, and availability of new low-carbon energy infrastructure
(1) Group comparable growth 2021-2025 CAGR (2) Recurring ROCE based on Recurring Net Profit

Beyond fighting climate change: preserving water resources and biodiversity

Our commitments and associated progress

Water management

Implement a **water management plan by 2025** for high water use sites in high water stress areas.

- ☑ Priority sites identified
- **Under implementation**

Define a **Group standard** for all operations related to the quality of discharged water.

- ☑ Group Standard defined
- **Under implementation**

Over **90%** of water returned to source.

Biodiversity preservation

Air Liquide biodiversity Commitments validated by act4nature international

- Reinforce **biodiversity assessment criteria** in the **investment process** for all new projects by 2024.
- Develop and implement an **aggregated biodiversity indicator** by 2025.
- Raise **awareness** amongst employees on biodiversity
- Reaffirm the Group's **climate and water ambition.**

2023 Scope 1+2 Emissions

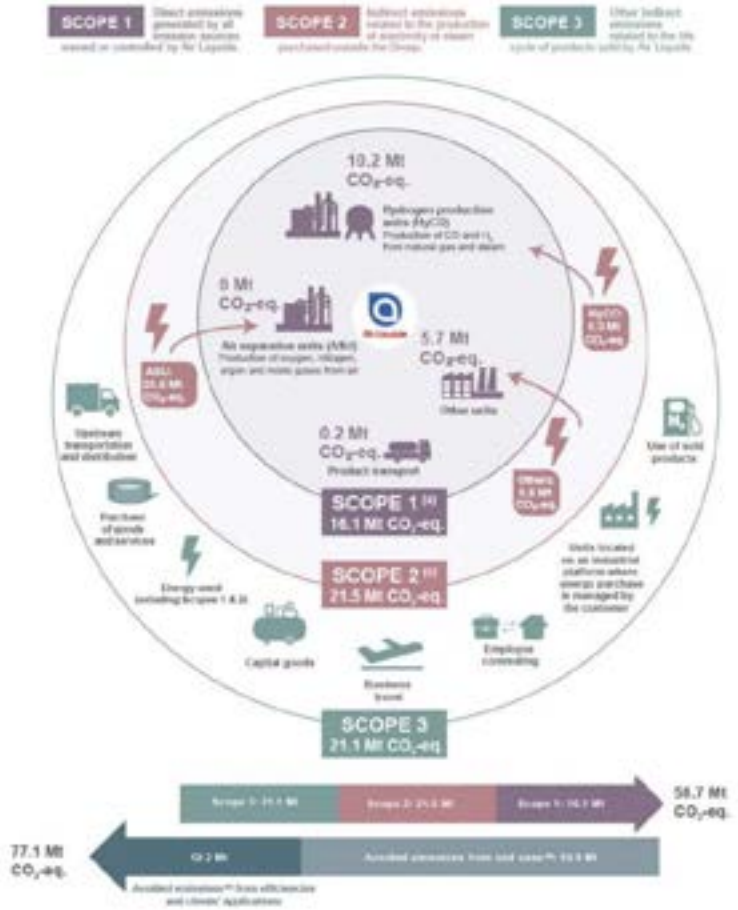
- **Direct emissions** (Scope 1)
  coming mostly from ~ 20 large plants

  ⇒ in particular Hydrogen production units

- **Indirect emissions**
  from power consumption coming from less than 10 countries

  ⇒ dependent upon local Grid Mix and low carbon power availability

- **Other indirect emissions** (Scope 3)
  - Upstream: procured goods, services, energy, feedstocks
  - Downstream: use of very specific products



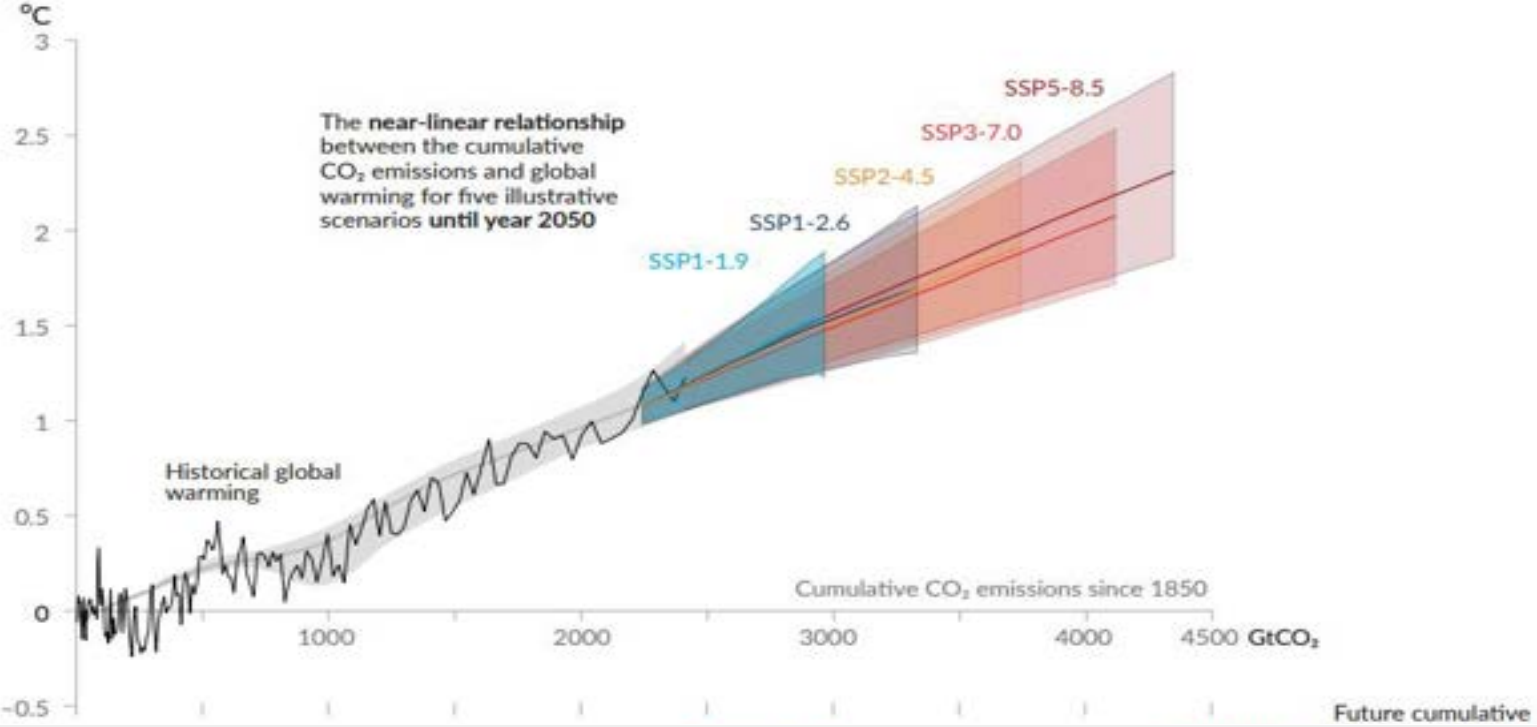
02

Setting the stage: CO2 emissions

Setting the Scene: What science says - Carbon Budget drives T°

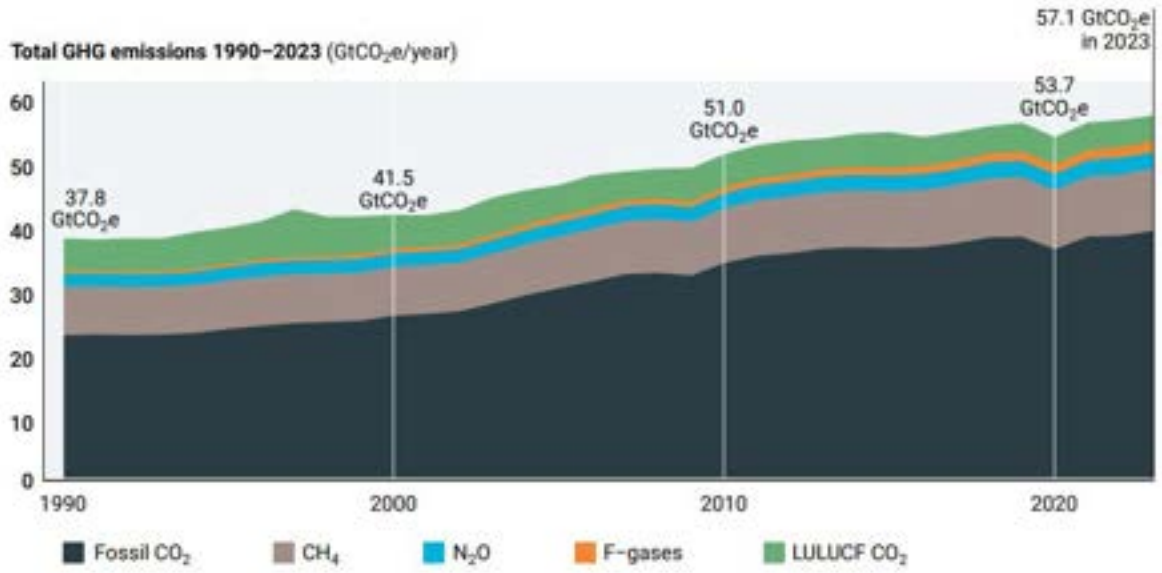
Every tonne of CO_2 emissions adds to global warming

Global surface temperature increase since 1850–1900 (°C) as a function of cumulative CO_2 emissions ($GtCO_2$)



Setting the Scene: GHG emissions

Figure 2.1 **Total net anthropogenic GHG emissions, 1990–2023**

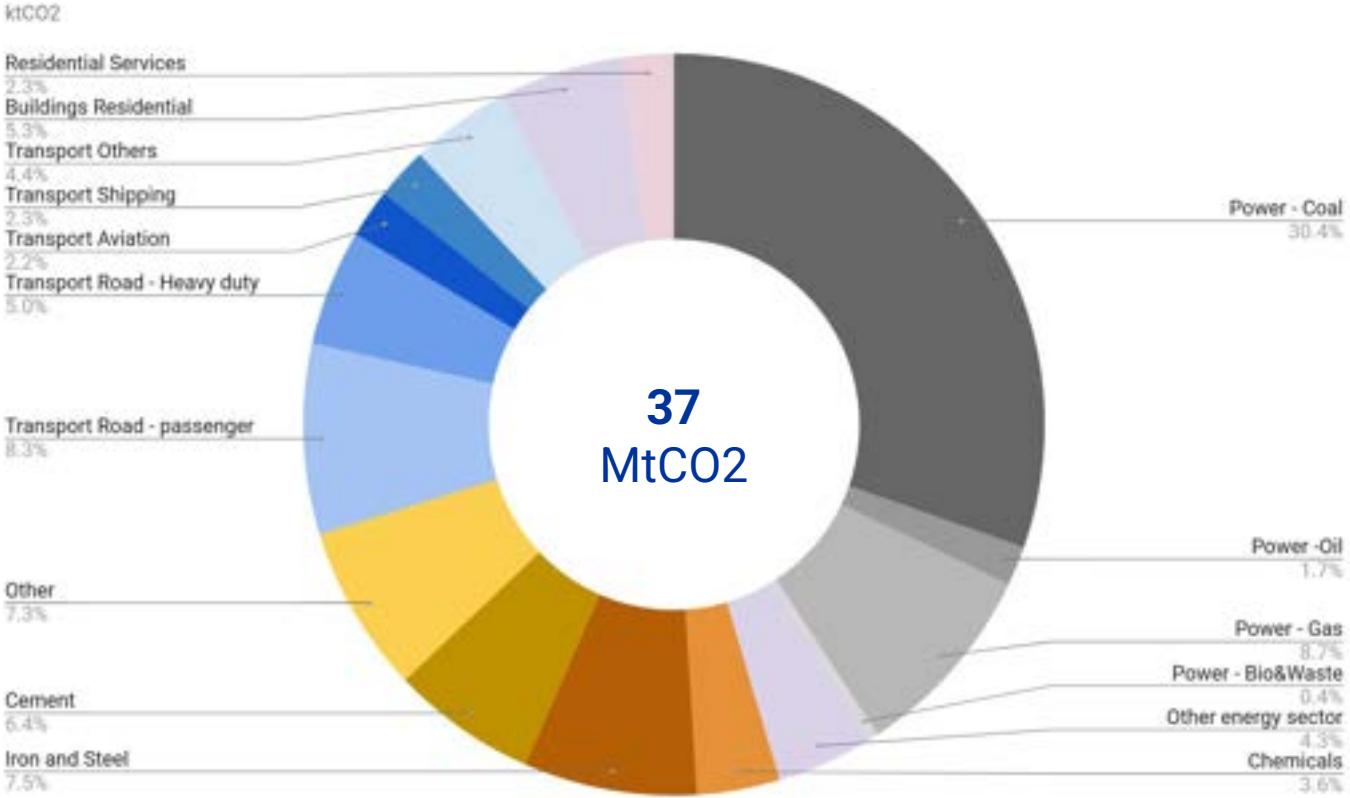


Note: Non-CO_2 GHGs are converted to CO_2e using global warming potentials with a 100-year time horizon from the IPCC WGI AR6 (Forster *et al.* 2021).

Sources: Crippa *et al.* (2024); Friedlingstein *et al.* (2023).

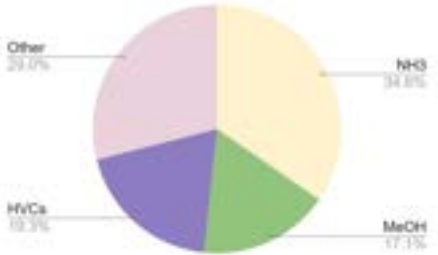
Source: UNFCCC

Setting the Scene: Global CO2 2023 Emissions(*)



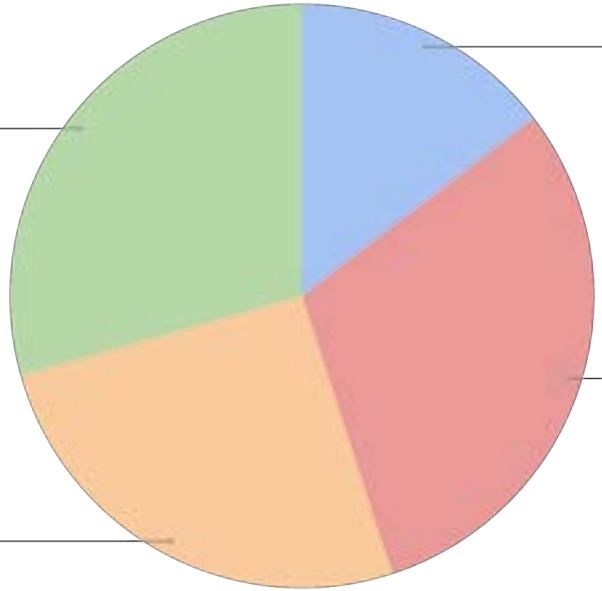
(*) combustion and industrial processes ; excludes non CO2 GHG, agriculture and LULUCF (Land-Use, Land Use Change and Forestry

Focus: Industrial sector emissions



Industry ~ 9.2 GtCO2 (2023)

(excluding emissions from imported power)



Chemicals
14.6%

- High Value Chemicals from steam crackers
- Ammonia (NH3)
- Methanol
- Other base chemicals, specialty chemicals, pharmaceuticals, ...

Other
29.4%

- Heat & power
- Process emissions

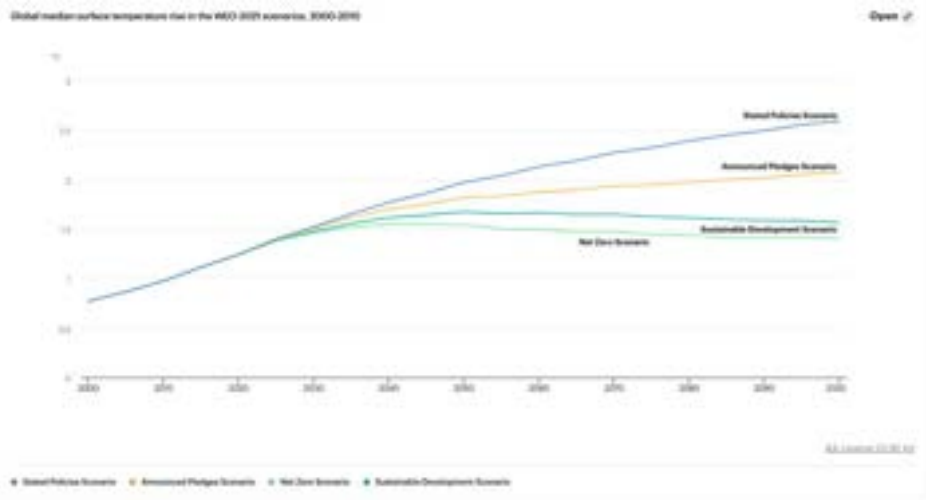
Iron and Steel
30.4%

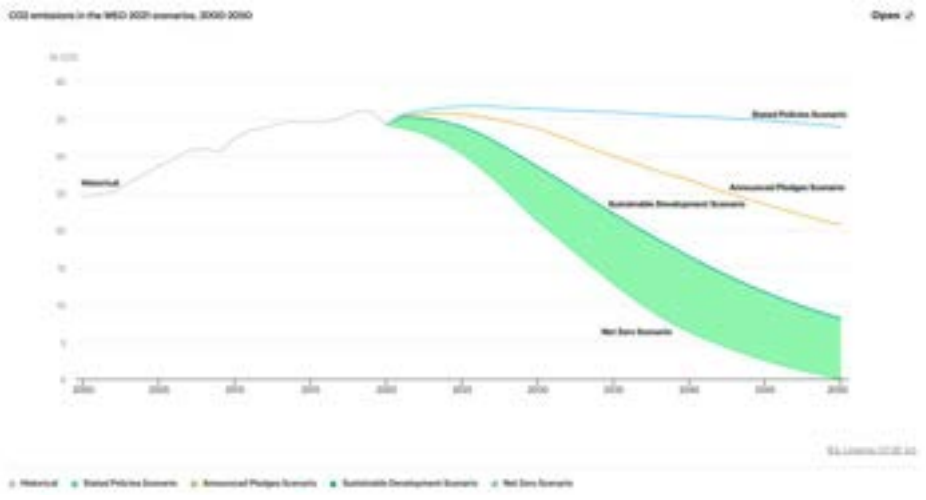
- Blast Furnaces (~70% of emissions)
- Electric Arc furnaces

Cement
25.6%

- Clinker production $CaCO_3 \Rightarrow CaO$ (lime) + CO_2 (~90% of emissions)
- Heat requirements

A word on Scenario

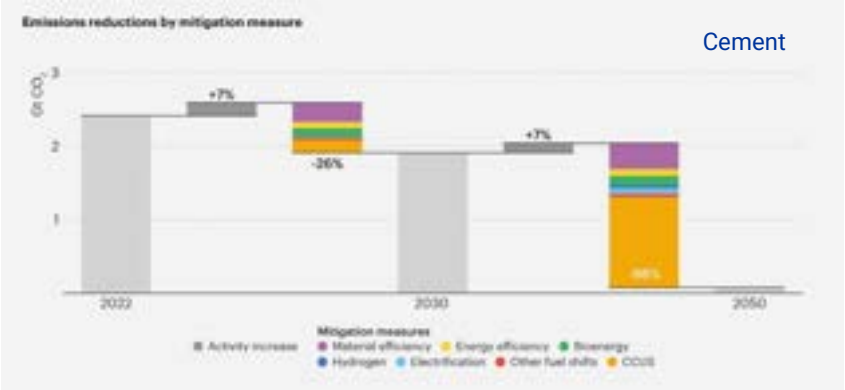


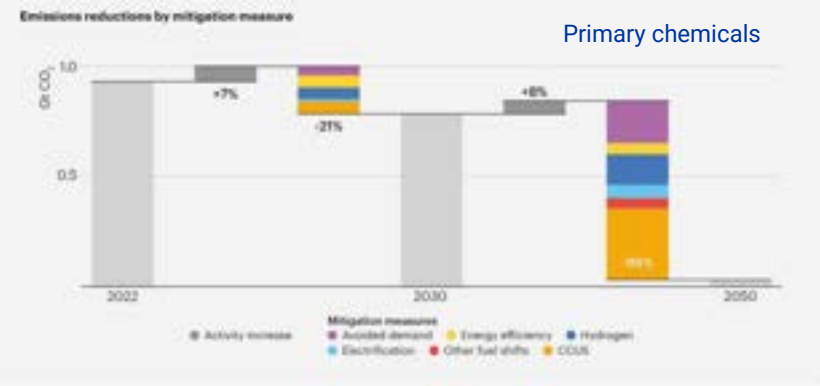


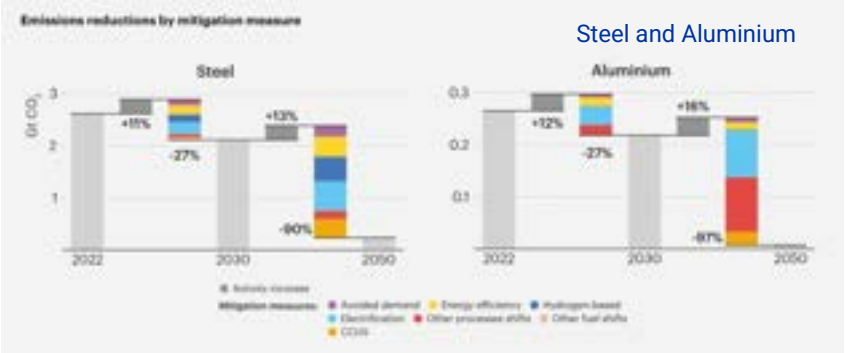
- Scenarios are **not** forecasts: understanding of how levers play out

- Don’t confuse
  - Scenarios assessing impacts of policies and regulations on trajectory (STEPS, APS)
  - Normative trajectory defined by the landing point (SDS, NZ)

Decarbonizing industry in a Net Zero scenario: Electrification + clean electricity, CCUS and hydrogen needed







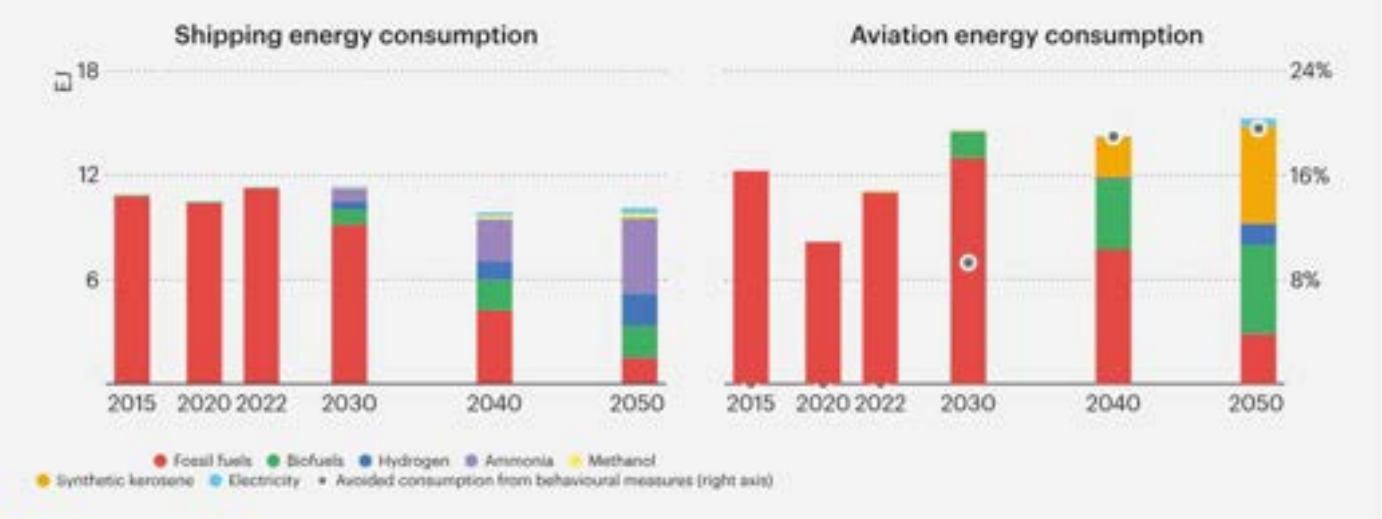
Electrification + Clean electricity

CO2 Capture & Usage/Storage

Hydrogen & related-fuels

Source: IEA Net Zero scenario

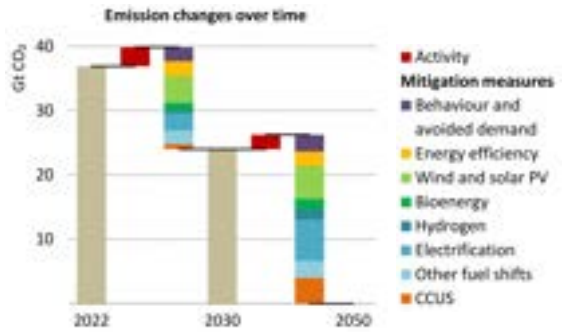
In addition to industry, transport sector will require hydrogen-derived fuel, including some CCUS routes



Making the Net Zero scenario happen:
Key Prerequisites of a 1.5 °C world that industrial Transition Plans rely upon

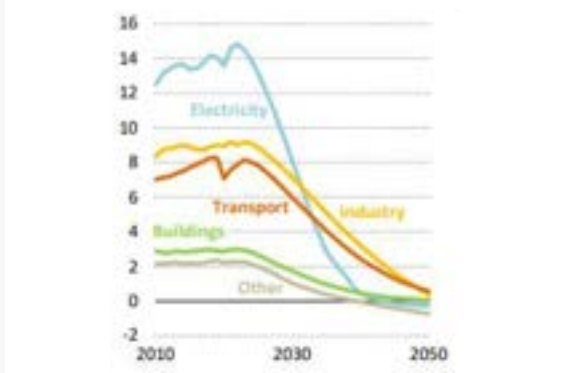
For the world to succeed on a 1.5 °C pathway.....

1 Renewables, CCS, Hydrogen.. will need to accelerate and will be critical



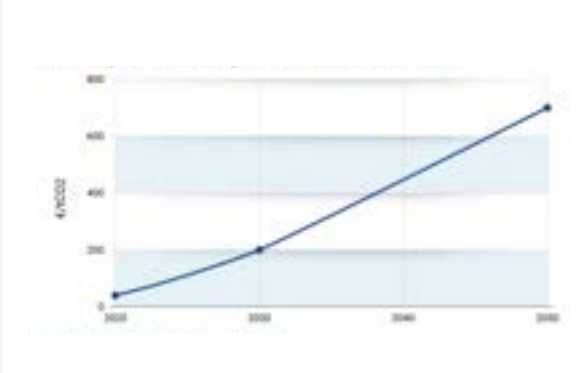
Source: International Energy Agency, Net Zero Roadmap, 2023 Update

2 Pace of decarbonization will vary across industries and geographies



Source: International Energy Agency, Net Zero Roadmap, 2023 Update

3 The implicit price of CO2 will need to evolve to drive decarbonization



Source: IPCC SR-15, Chapter 2

→ Therefore, a 1.5 °C aligned Climate Transition Plan is contingent upon these prerequisites to evolve at the pace shown above

03

Air Liquide’s Solutions to decarbonize industry

Two major challenges:
Decarbonization of hard-to-abate industries and mobility

Our key markets

- Refining
- Metals
- Chemicals

Our key markets

- Heavy-duty trucks
- Intensive fleets
- Maritime
- Aviation

Our 4 pillars to move fast

- Focus on key basins
- Best-in-class technologies
- Operational excellence
- Ambitious partnerships

Air Liquide Solutions along the Low Carbon value chain

ASSETS

1. **Low Carbon Industrial Gas Supply**
   including decarbonized Takeovers

CUSTOMERS PROCESSES

2. **Low Carbon process transformation**
3. **Carbon Capture as a service**

LOW C PRODUCTS & FUELS

4. **Mobility : H2E**
5. **Low carbon products & Manufacturing**

Customers

- Energy / Refining
- Chemicals
- Cement
- Steel

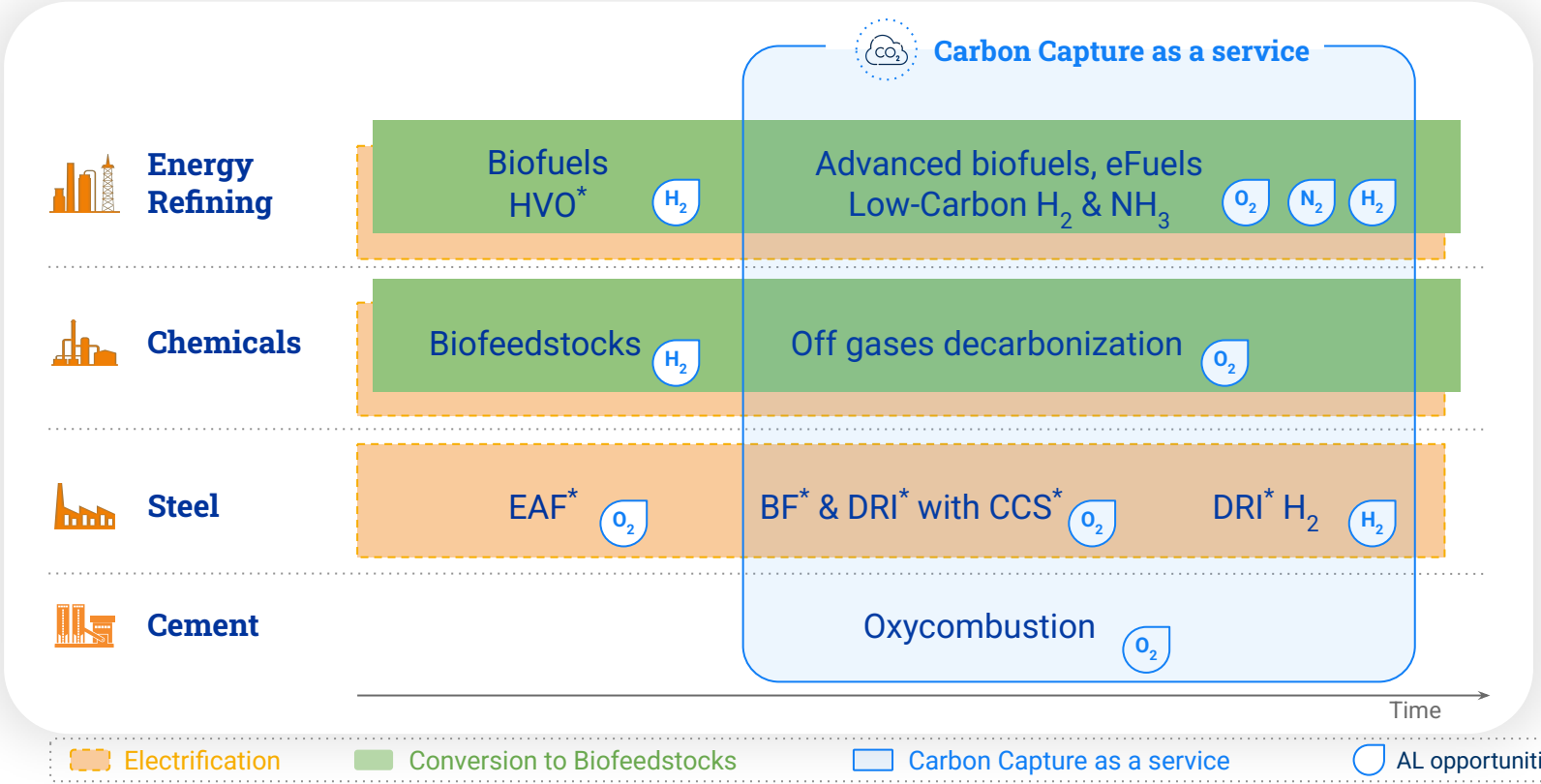
1st mover →

Geographies

- Europe
- Americas
- Middle East
- Asia

1st mover →

A Unique Position to Decarbonize Customers' Processes…



** EAF: Electric Arc Furnace; BF: Blast Furnace; DRI: Direct Reduced Iron; CCS: Carbon Capture Sequestration; HVO: Hydrotreated Vegetable Oil*

…and to Accompany Customers in New Energy Transition Markets

Example **Battery manufacturing**

A rapidly expanding market…

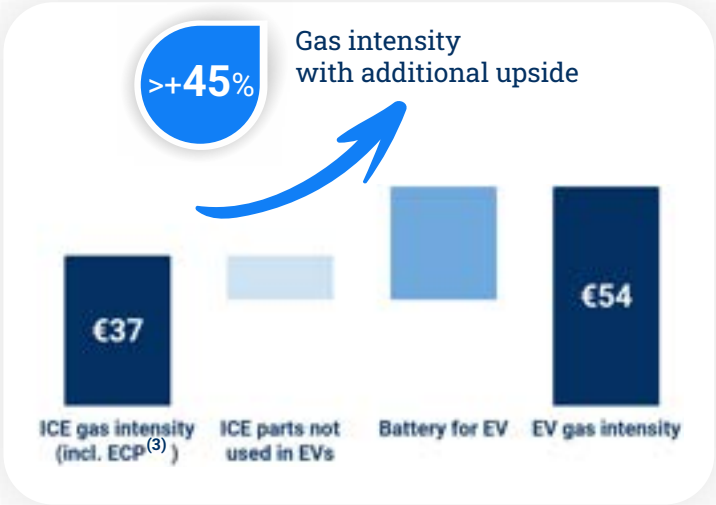
- **+19%** CAGR 2020-30 for **battery production**
- **30** EV battery **gigafactories** planned **in Europe**

… with mid term gases potential

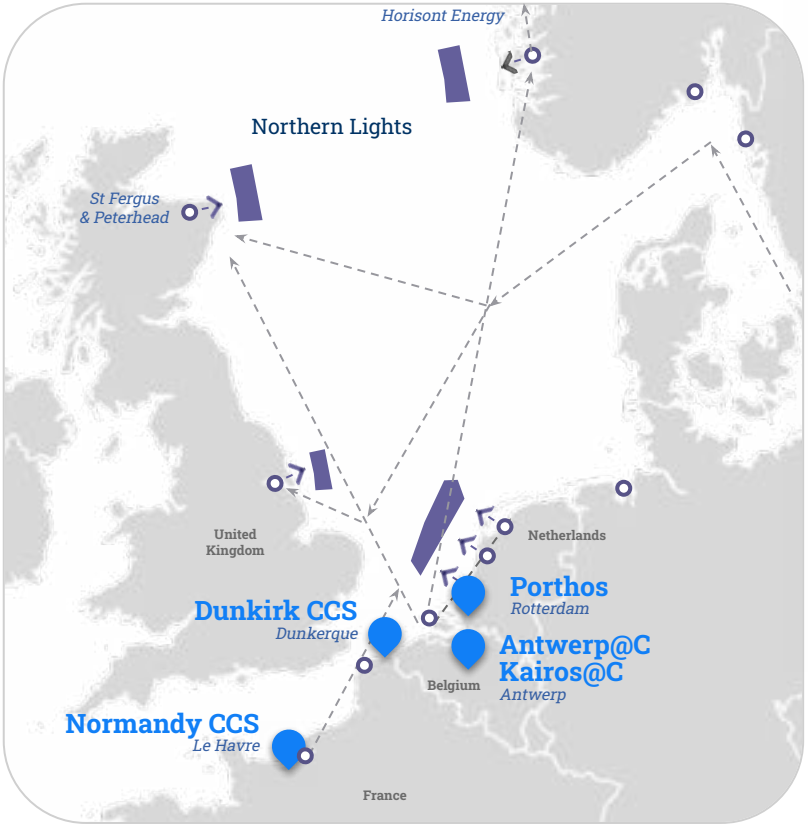
- **>€1bn** potential for **gases** by 2030
  N_2 (inerting), O_2 (oxidation), CO_2, He
- **Advanced Materials** innovation to enhance Battery Performance

EV[(1)] vs. ICE[(2)] gas intensity

in € of gas / car



Carbon Capture as a Service Becoming a Reality



Large-scale Carbon Capture projects in Europe
First mover in flagship Carbon Capture projects

For Air Liquide but also **Customers' assets**

Strongly supported by **European fundings**

Similar dynamics starting in **other geographies**

- U.S.
- Middle-East
- Asia

Import/Export Terminal	Sea route
CO_2 storage	CO_2 pipeline
Air Liquide Carbon Capture Project	Partnership

Subject to Final Investment Decisions

Leveraging our Technologies: the Backbone of Air Liquide Solutions

Technos

Engineering & Construction

Innovative Air Gases Solutions

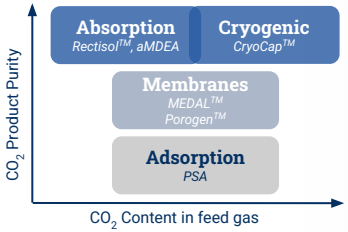
- **Renewable Electricity intermittency** management - ALive™
- **Ultra low energy** ASU

Low-carbon H_2

- **ATR* / POX*** with **Carbon Capture** for **large H_2 volumes**
- E&C technologies for synthesis process, such as Methanol

Carbon Capture

- The **most complete Carbon Capture** offer



Electrolysis

- **PEM*** partnership with SIEMENS energy
- **Active innovation** in all technologies

Combined with

Digital tools — **Smart Innovative Operations**

Human expertise — **Technical and innovation experts, skilled operational teams**

** ATR: AutoThermal Reforming; POX: Partial Oxidation; PEM: Proton Exchange Membrane*

Air Liquide's hydrogen track record

60+ years of expertise

€2.2 bn in sales

1,000 employees

1.2 M tonnes of H2 produced p/y

200+ HRS installed worldwide

Technology leadership

LOW-CARBON & RENEWABLE PRODUCTION

Electrolysis
PEM | ALKALINE

Other technologies
E-METHANOL

Reforming
SMR | ATR

Partial Oxidation (POX)

Carbon Capture
The most comprehensive offering

Ammonia Cracking

CONDITIONING

LIQUID HYDROGEN

Liquefaction
Scaled up capacities
& Optimized payload

GASEOUS HYDROGEN

Conditioning
High-Pressure filling centers

SUPPLY CHAIN

Liquid & gaseous storages

GH2 & LH2 distribution

GH2 & LH2 hydrogen stations

From ambition to reality:
Scaling up our electrolysis capacity

2018

HYBALANCE 1.25 MW PEM

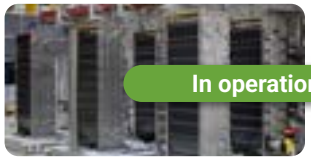
2021

BECANCOUR 20 MW Largest PEM project

In operation

2023

Giga-Factory start-up in 2023



In operation

2024

TRAILBLAZER 20 MW PEM

In operation

2026

ELYgator 200 MW

ELYgator

FEED

2027

AL Green Motion Steel 120 MW

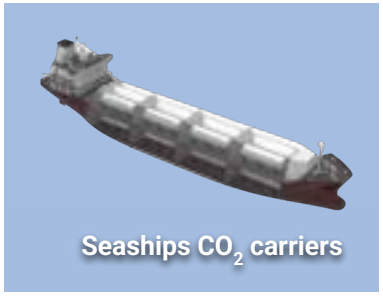
Under conception

2028

Air Liquide Normand'Hy 200 MW Largest ELY project

FID taken
Under execution

Air Liquide Positions along the Supply Chain



CAPTURE & COMPRESSION	Onshore Transport	AGGREGATION, LIQUEFACTION & STORAGE	SHIPPING / PIPE	SEQUESTRATION
• Capture • Purification • Compression • CO_2 storage & loading	• Transport to / within basin via pipeline (incl. compression stations), train, barges, trucks	• Basin CO_2 Aggregation • Liquefaction • CO_2 storage • Multimodal transport	• Sea shipping (liquid) • Offshore pipeline (gas)	• CO_2 Storage • CO_2 Mineralization
CRYOCAP™ & Absorption CRYOCAP™ is operating in Port Jerome (FR)		**CRYOCAP™ XLL**	OCEOS *)	**Multiple Service Partners**

Air Liquide value proposal on CO2 Management as a Service

*) OCEOS is a JV between AL and Sogestran

Walking the talk

Air Liquide and Sasol sign first long-term contract for the supply of renewable energy to the Secunda site

Air Liquide and Sasol sign long-term contracts to supply an additional 110 MW of renewable energy to the Secunda site

Air Liquide to reach 70% renewable energy sourcing in Benelux with new large PPA

Air Liquide signs a long-term power purchase agreement for renewable electricity in Spain

Air Liquide signs long-term supply agreement with GCGV and will build new Air Separation Unit in Texas

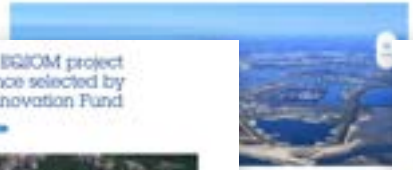
Air Liquide signed record volumes of PPAs in 2024, securing over 2,500 GWh of low-carbon electricity and reducing CO2 emissions by over 1.2 Mt per year

Air Liquide to modernize and lower the carbon footprint of two oxygen production units in Tianjin, China

Air Liquide invests to increase efficiency and reduce CO_2 emissions of its industrial site in Stade, Germany

Air Liquide and Lhoist join forces to launch a first-of-its-kind decarbonization project of lime production in France

Air Liquide to build a world-scale CO_2 capture unit to contribute to Rotterdam's industrial basin decarbonization



Air Liquide and BIGHOM project in Northern France selected by the European Innovation Fund

Air Liquide transforms its network in Germany by connecting a large electrolyzer producing renewable hydrogen

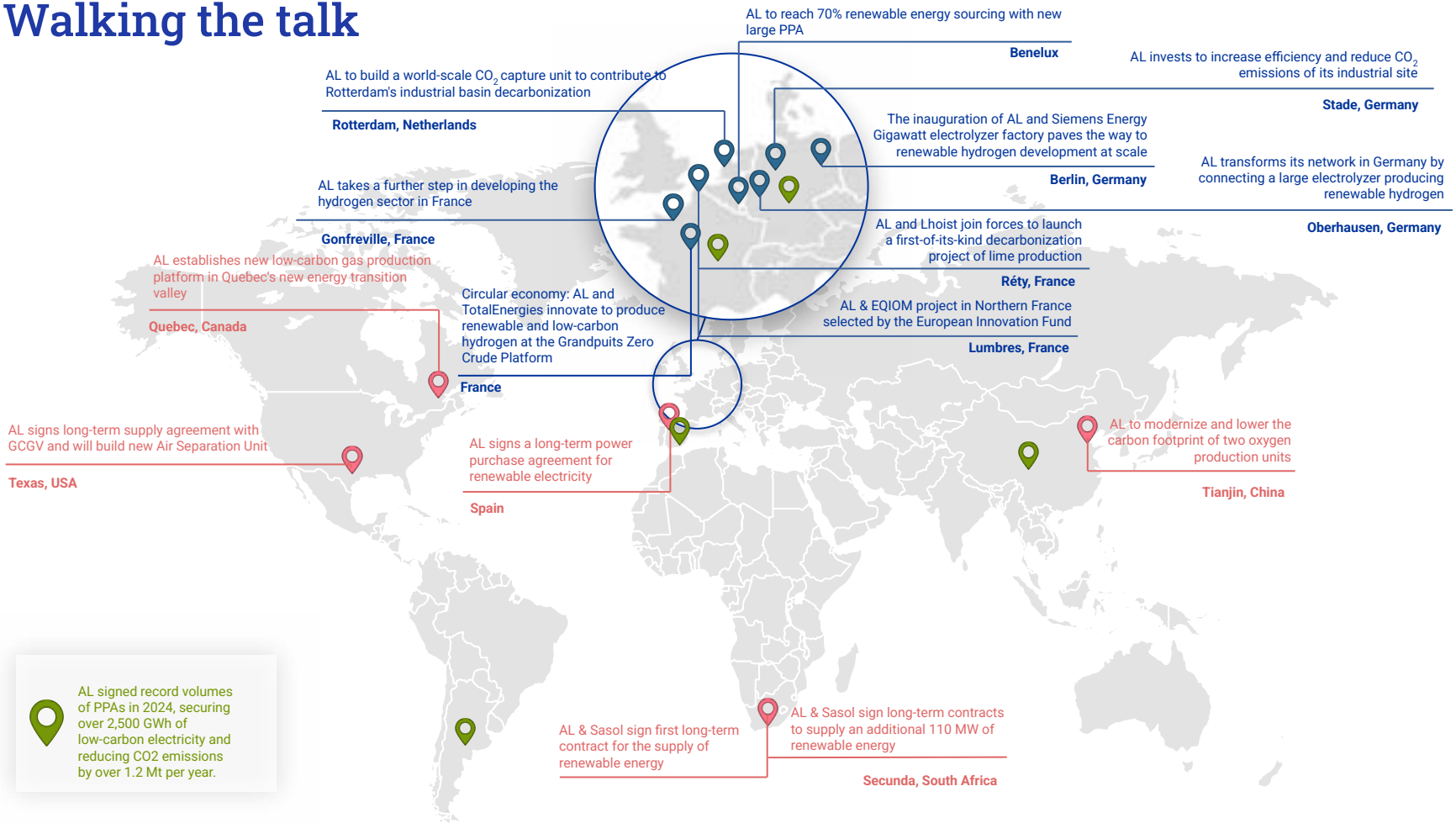
The inauguration of Air Liquide and Siemens Energy Gigawatt electrolyzer factory paves the way to renewable hydrogen development at scale

Air Liquide takes a further step in developing the hydrogen sector in France

Circular economy : Air Liquide and TotalEnergies innovate to produce renewable and low-carbon hydrogen at the Grandpuits Zero Crude Platform

Air Liquide establishes new low-carbon gas production platform in Québec's new energy transition valley

Walking the talk



Decarbonizing industry

Between a rock and a hard place

PRESSURES

- Regulators
- Investors
- NGOs
- General Public
- Talents

CHALLENGES

- Customer willingness to pay Low ROI
- Lack of ambition of climate policies: Less expensive to emit than decarbonize & geographical gaps
- Lack of competitive access to Renewables
- Access to subsidies
- Missing CO_2 infrastructure, CO_2 sinks

Thank you for your attention

Q&A