



CCS

Captura, Transporte y almacenamiento de CO₂

Taller con Oficemen 22.11.2022

Agenda

- Apertura
- Concepto de Hub - Martín Raventos
 - Preguntas/respuestas
- Transporte de CO2 - Gonzalo Navarro
 - Preguntas/respuestas
- CO2 sequestration - Fabrice del Corso
 - Preguntas/respuestas
- Cierre

Transporte y almacenamiento de CO2

WEBINAR

Te invitamos al tercero de los webinars que realizamos dentro del acuerdo de colaboración firmado por **Oficemen** y Air Liquide; y que tiene como principal objetivo agilizar la descarbonización de la industria cementera.

Fecha y horario:

- 22 de noviembre de 12:00 a 14:00 horas.

Ponentes:

- Martín Raventos, Gerente de Propuestas - Captura y Liquefacción de CO2 en Air Liquide E&C.
- Gonzalo Navarro, Desarrollador de Negocio - Grandes Industrias en Air Liquide Ibérica de Gases.
- Fabrice del Corso, Experto senior internacional Procesos de gases industriales, tecnologías y evaluación del ciclo de vida (LCA).

Moderador:

- Pedro Mora, Director Técnico de **Oficemen**.

PROGRAMA

1. Apertura:

- Bénédicte Levinson, Directora General de Air Liquide Iberia.
- Teresa Rasero, Presidenta del Consejo Air Liquide España.

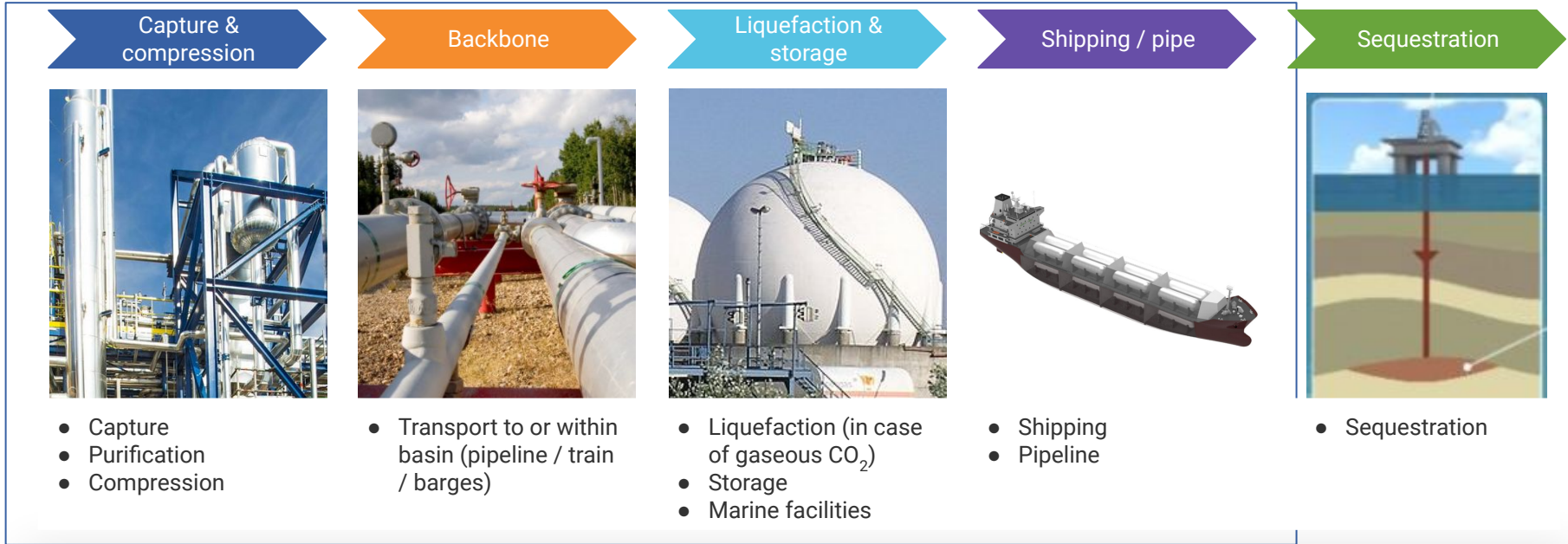
2. Contenidos del seminario:

- Concepto de hub.
- Transporte de CO2.
- Almacenamiento de CO2.

3. Conclusiones:

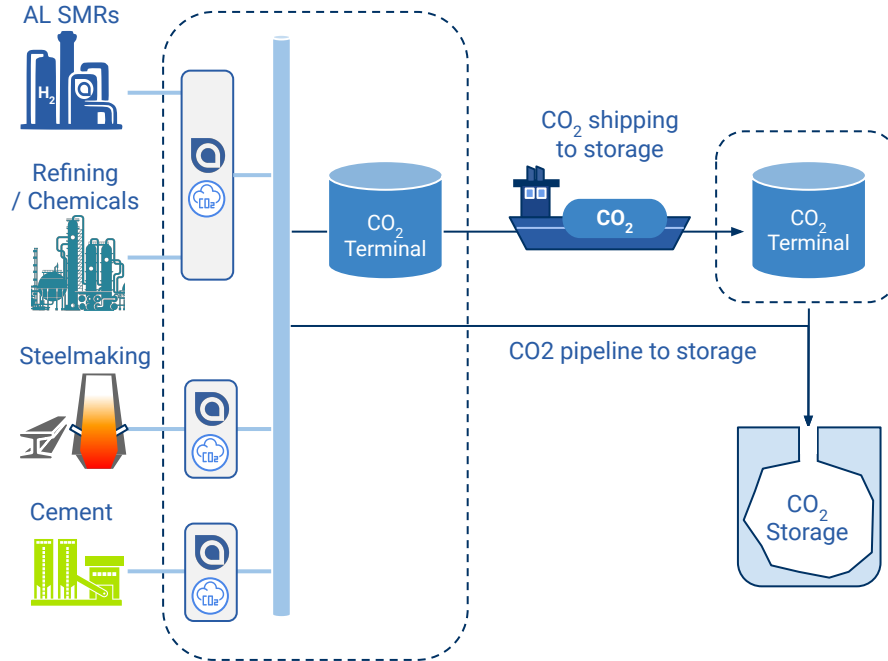
- Aniceto Zaragoza, Director General de **Oficemen**.

AL is providing services to its customer along the full CCS chain from basin to sink



- Proprietary technologies for capturing CO₂
- Mutualisation of CO₂ volumes and infrastructures along the chain for enhanced competitiveness
- Long term partnerships for CO₂ storages
- Business model that can be similar to “classical” Industrial Gases

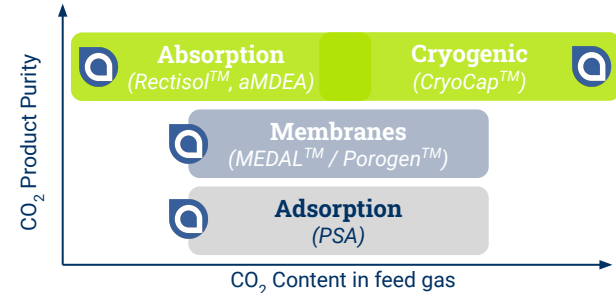
Carbon Capture as a service



Up to 90% capture rate with AL CryoCap™ solutions.
Overall CCS economics depends on CO₂ storage costs & complexity.

CO₂ capture as a service

- **Proprietary purification technologies** to address a wide range of CO₂ streams
- **Model can be similar to 'classical' IG**
- **Mutualize CO₂ capture infrastructure**
- **Long-term partnership** for CO₂ storage



Air Liquide's involvement in CCS projects & sink developments

Northern Lights Starvenger

Project: Northern Lights consortium project focuses on transport, reception and permanent storage of CO₂ in a reservoir in the northern part of the North Sea.

Role AL: evaluating CO₂ capture and transport



Porthos Rotterdam

Project: Open access CO₂ transport and storage system through a public-private initiative by PoR.

Role AL: evaluating CO₂ capture, aggregation and transport



Antwerp@C Antwerp

Project: Consortium of industrial players to develop- feasibility study of building CO₂ infrastructure for CCS(U)

Role AL: evaluating CO₂ capture, aggregation and transport

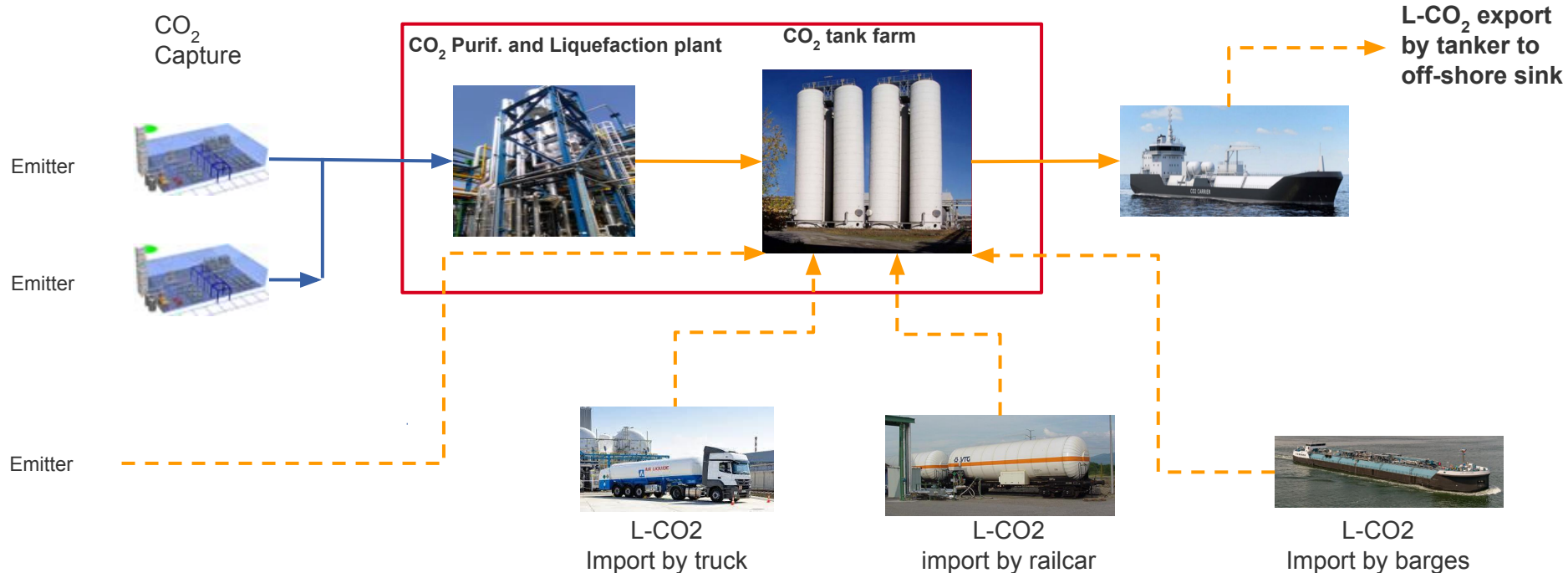


1 Hub

General concept of a liquid CO₂ Hub

— Liquid CO₂
— Gaseous CO₂

L-CO₂ Export-Import Terminal Shared Terminal



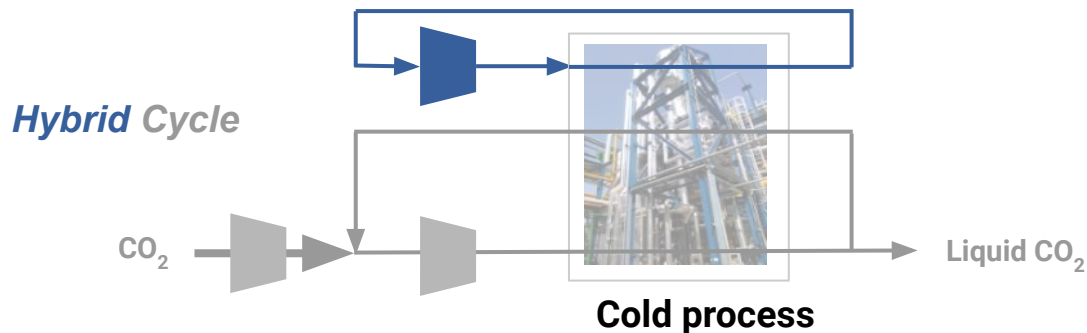
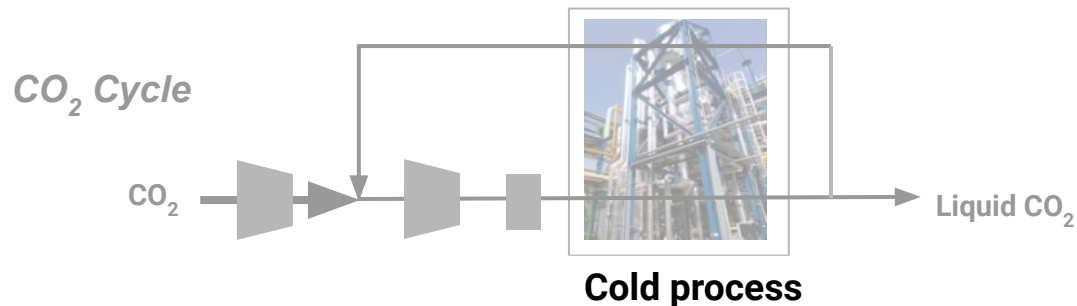
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AIR LIQUIDE, A WORLD LEADER IN GASES, TECHNOLOGIES AND SERVICES FOR INDUSTRY AND HEALTH

Marín Raventos, Gonzalo Navarro, Fabrice dei Corso

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Focus on Cryocap™ XLL



❑ Technical highlights:

- ❑ 800 - 10,000 tpd+
- ❑ Custom plant: flexible design
- ❑ Compact footprint
- ❑ Liquefies CO₂ at ambient temperature
- ❑ Very low OPEX
- ❑ HSE friendly (CO₂ cycle)
- ❑ Includes dehydration and removal of other impurities
- ❑ Can use external cold heat (e.g. LNG)

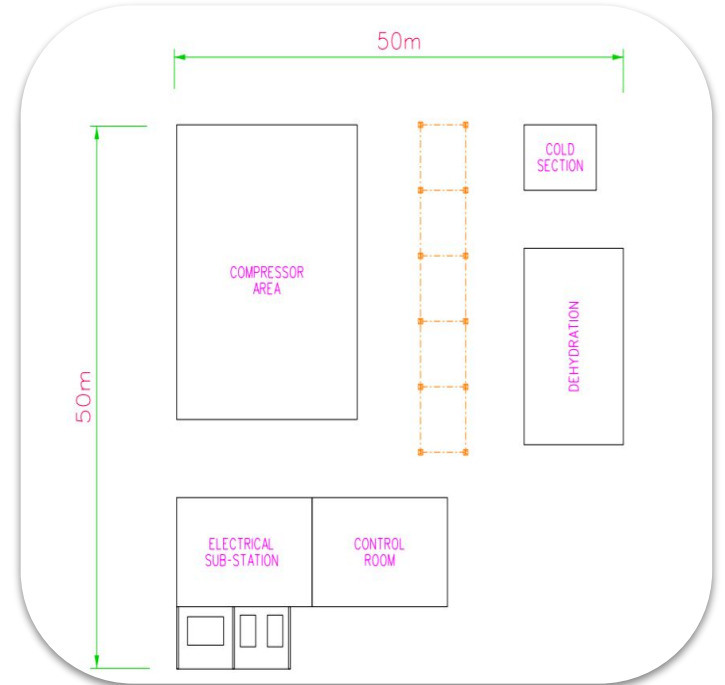
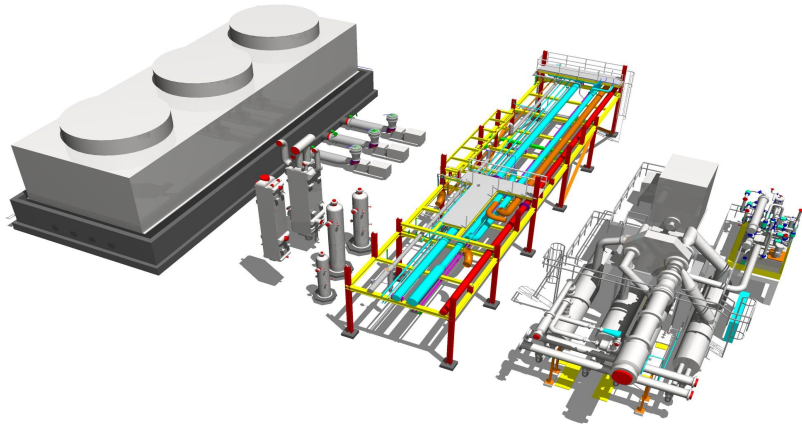
❑ Europe from 800 to 10,000+ tpd

Compared to existing CO₂ liquefiers, paradigm around large scale to be changed for lower TCO & footprint

Focus on Cryocap™ XLL

Various ongoing studies / offers in progress

- Very large size liquefiers for sources aggregation (even above 10,000 tpd)
- Stand-alone liquefiers



CO₂ tanks : main design options, AL experience

Spheres



Typical size 2,500 m³ each
Up to 10,000 m³ each

Standard Cylindrical tanks



Size: 300 m³ each

Cylindrical tanks large Capacity



Size: 750-1,000 m³

Focus on Antwerp@C



- **CO₂ liquefaction hub in Antwerp fed by backbone**
- Selected technology = Cryocap XLL (Large CO₂ liquefier)
- **Main characteristics:**
 - Phased project
 - Size ~ 4 x 7,000 tpd
 - AL proprietary high efficiency CO₂ cycle
 - CO₂ sequestration in offshore sinks (North Sea)
- EU CEF funding awarded in 2020 / EU IF awarded in 2021 for ph 1
- FEED finalized Sept'22 / FID expected the end of 2022

BASF
We create chemistry

BOREALIS
Keep Discovering

ExxonMobil 

INEOS

TOTAL

Air Liquide

fluxys 

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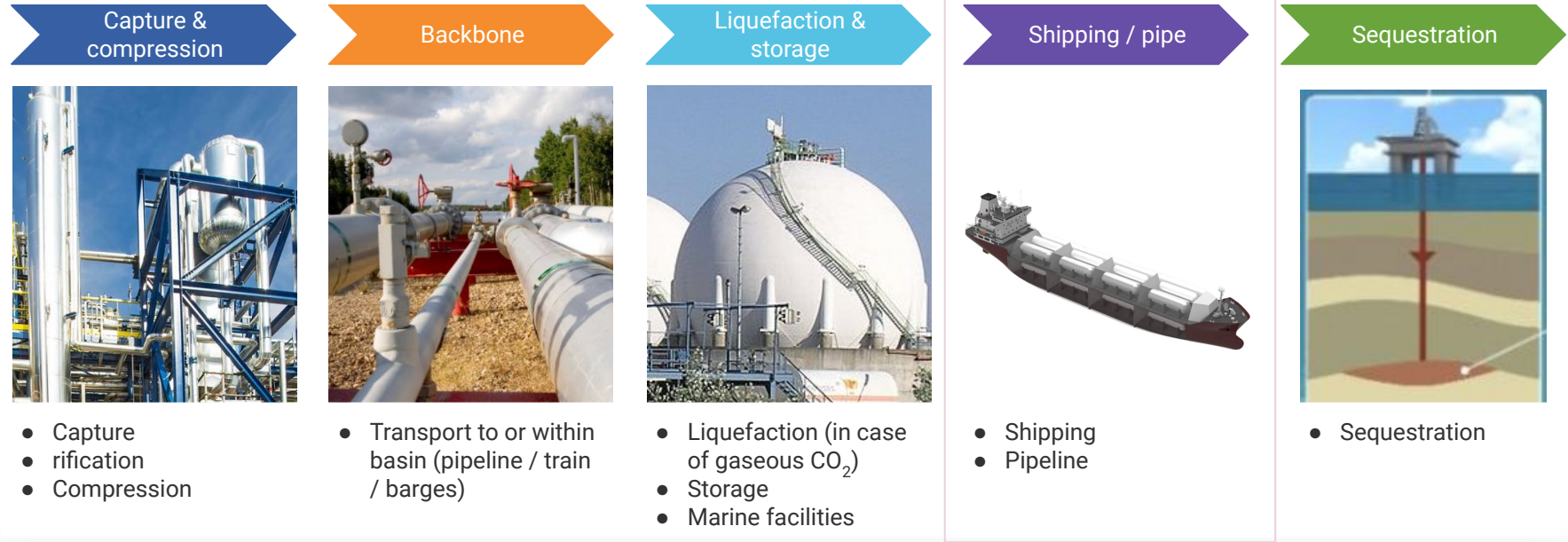
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2

Transporte

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CO2 Transport - by pipeline, barges, train, bulk - AL offers

Increasing
volume



- **Small Bulk Cryo Ships or river/canal Barges**
between 1000 and 8000 tons @
~15 bar
- **Rail 50-60t/wagon**
- **20 ft cryo ISO container** for multimodal transport:
road+sea+train (~20tons)
- **10 ft cryo ISO container** for offshore use (~7tons)

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NEWS

Paris, September 13, 2022

Air Liquide and Sogestran form the joint venture OCEOS for CO₂ shipping and barging

Air Liquide and Sogestran have established a Joint Venture company called OCEOS (Cf April 05, 2022 press release). It will provide large-scale liquid CO₂ shipping and barging solutions tailored to the needs of future Carbon Capture and Storage (CCS) projects in Europe. This joint venture will strengthen Air Liquide's offering on the carbon management value chain, which includes capture, aggregation, processing and transport to permanent storage locations.

Air Liquide and Sogestran form the joint venture OCEOS for CO₂ shipping and barging

September 12, 2022



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CCS represents one of the fundamental tools in the decarbonization process, in particular for the most carbon-intensive industrial sectors. However, many industrial sites are far from geological storage locations. In this context, shipping will be essential to transport CO₂ from industrial plants with major CO₂ emissions, where carbon is captured, to sequestration sites, where it will be permanently stored.

Building on a joint development and combining Air Liquide's expertise in CO₂ with Sogestran's experience in high value-added transportation of goods, the joint venture will transport CO₂ in its liquid form thanks to newly-designed shipping and barging solutions, invested and operated through this collaboration.

OCEOS is being considered as a potential shipping provider for Air Liquide's CO₂ volumes in the Kairos@C CCS project. The Kairos@C project has received support from the EU's Innovation Fund. The Innovation Fund is 100% funded by the EU Emissions Trading System.

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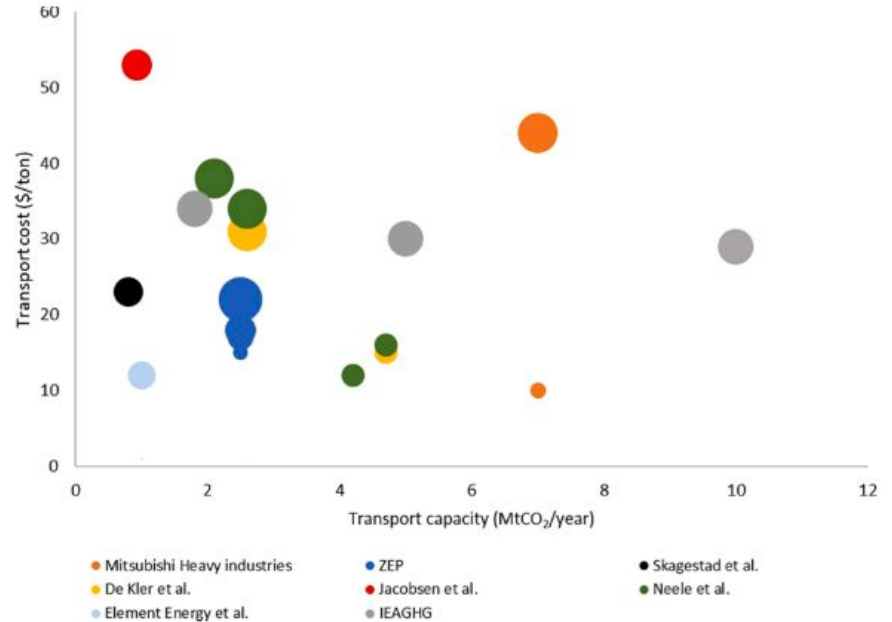
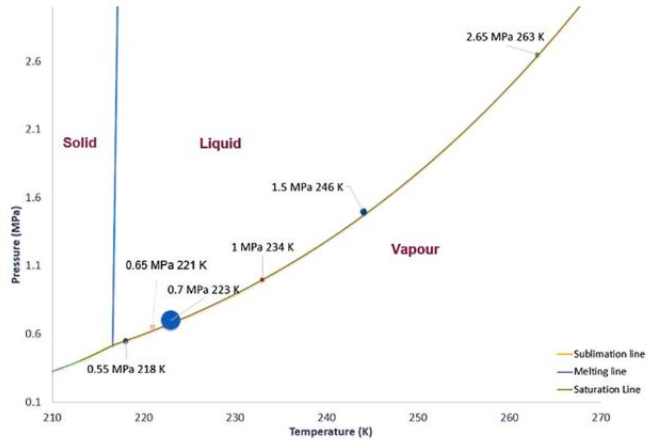


Transporte de CO2 en barco (1/2)



- Licuado
- Carga
- Transporte por barco
- Descarga
 - Onshore: Descarga/Almacenamiento/Gasificación
 - Offshore (directa): Gasificación/Descarga
 - Offshore (con almacenamiento): Descarga/Almacenamiento en plataforma/Gasificación
- Transporte por tubería
- Inyección y almacenamiento

Transporte de CO2 en barco (2/2)

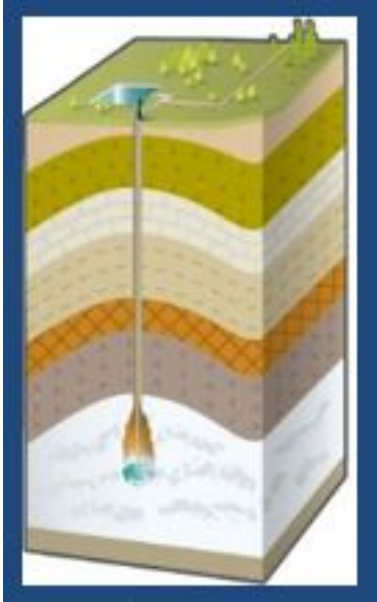


Fuente:
A review of large-scale CO₂ shipping and marine emissions management for carbon capture, utilisation and storage
Hisham Al Baroudi et al

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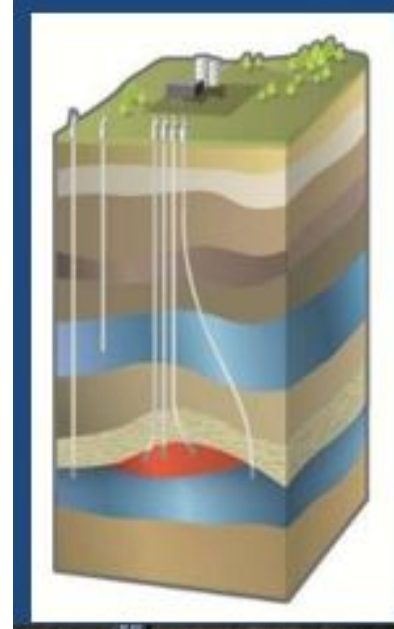
Sequestration

Different massive underground storages



Salt caverns

Natural Gas
Liquid hydrocarbons
Liquefied hydrocarbons
Compressed air
Ethylene, Propylene
Hydrogen
Helium
CO₂



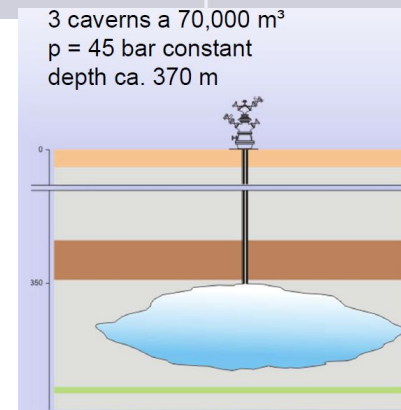
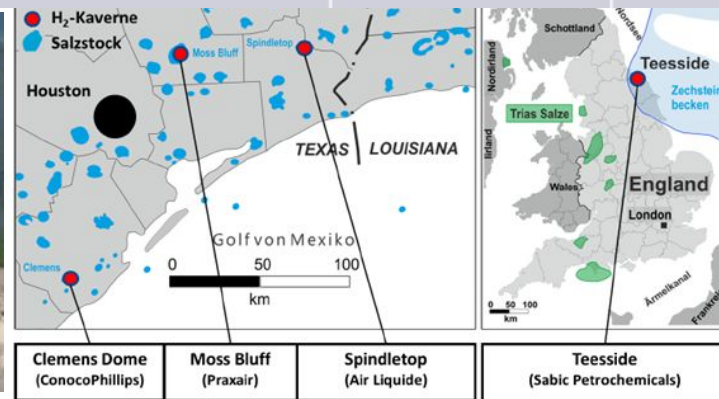
Depleted Gas Field

and aquifers

Natural Gas
CO₂ for CCS

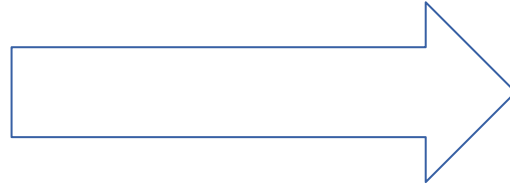
Existing Hydrogen Underground Storages in Salt Caverns

Location	Clemens Dome	Moss Bluff	Spindletop	Teeside (UK)
Operator	Conoco Philips	Praxair	Air Liquide	Sabic
Start up	1983	2007	2014	1972
Geo Volume k(m ³)	580	566	906	3 * 70
P Range (bar)	70 – 137	55 – 152	68 - 202	45
Capacity (GWh)	81	123	274	27



CO₂ uses today

CO₂ used within CO₂ Market
~ 80 MTPy (million tons per year)



CO₂ used directly by their producers (mainly for urea and sodium carbonate)
~ 100 - 200 MTPy

CO₂ emissions from human activities
~ 40,000 MTPy CO_{2,eq} (average 2009 - 2017)

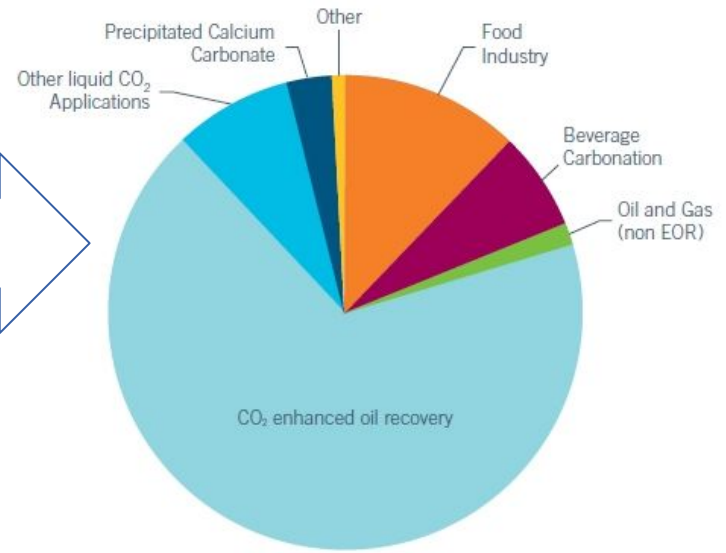
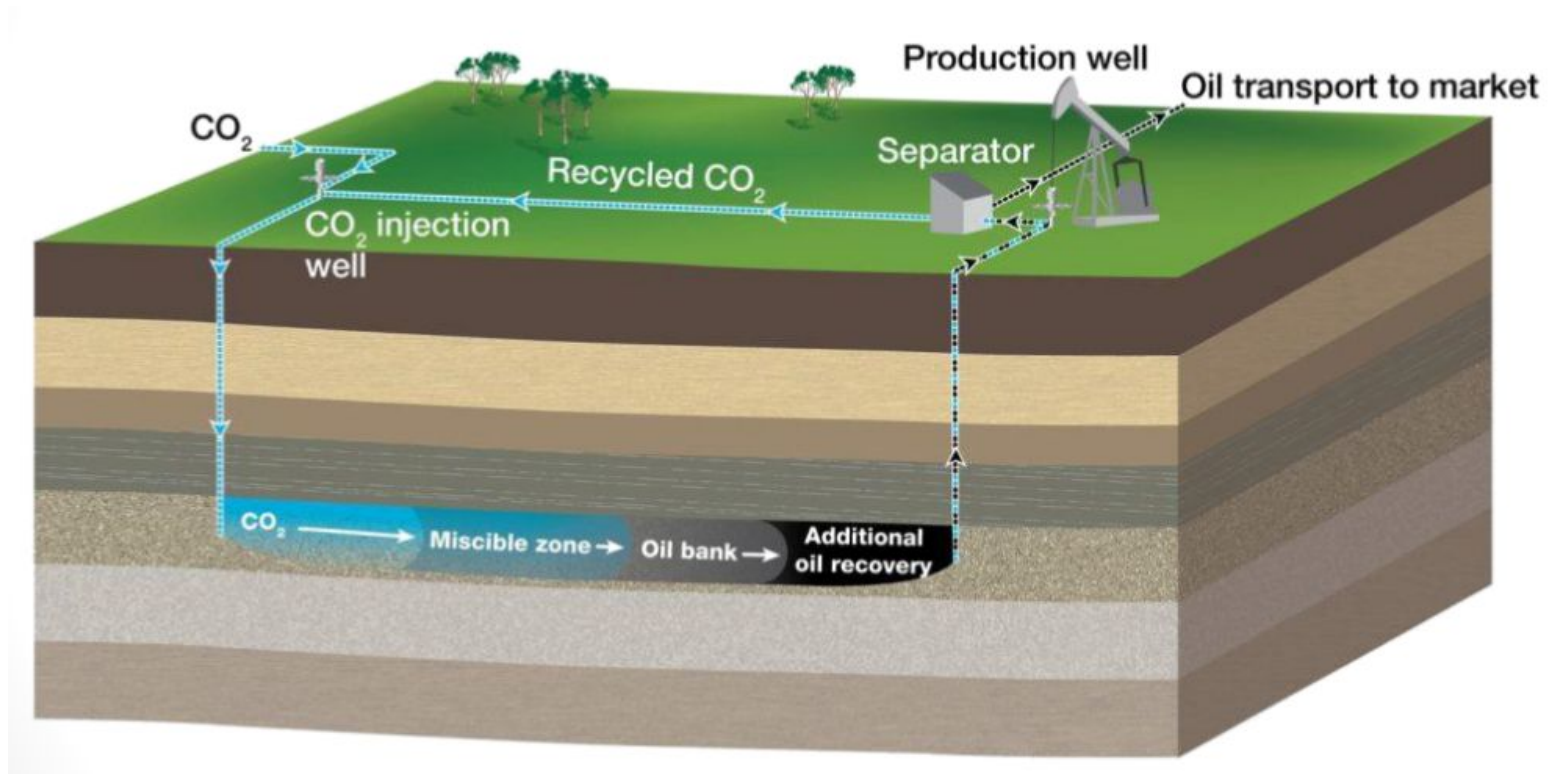


Figure 2.1 Approximate proportion of current CO₂ demand by end use

Principle of CCU for « Enhanced Oil Recovery » (EOR)



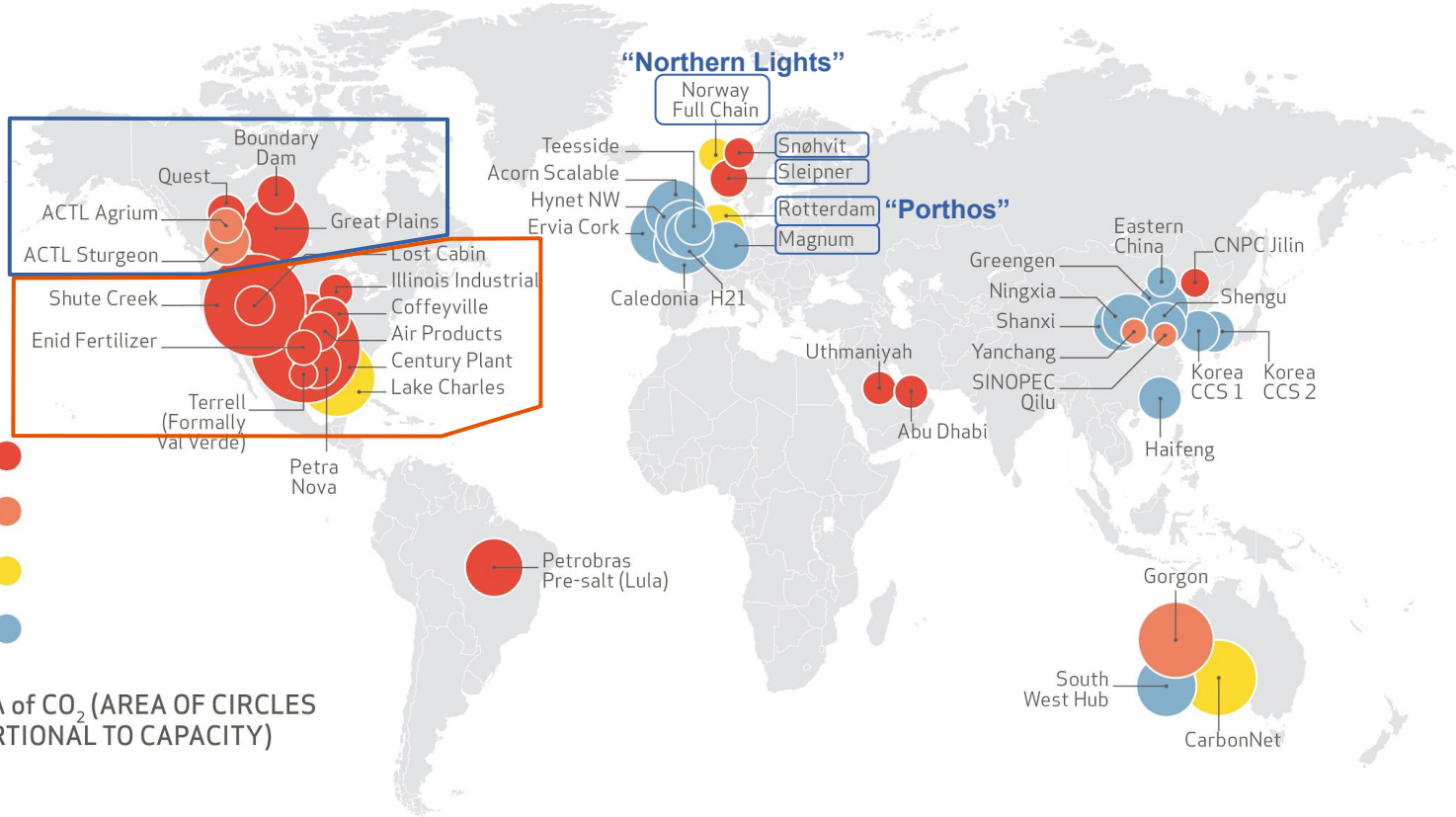
Many CC(U)S projects already ongoing globally

Operating
CCS+EOR in Canada
CO₂ from industrial
sources

Operating EOR in
US 85% "natural" CO₂

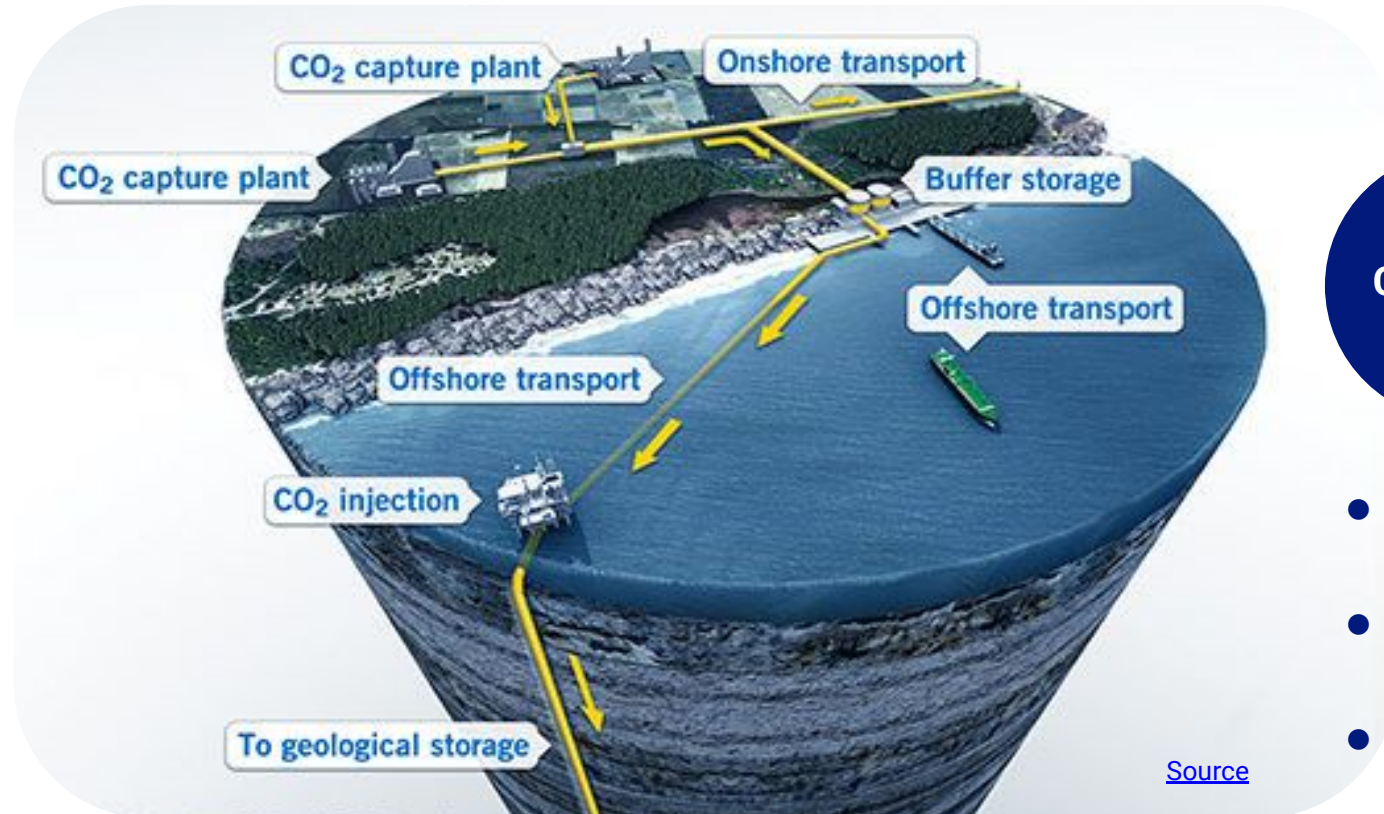
- OPERATING ●
- IN CONSTRUCTION ●
- ADVANCED DEVELOPMENT ●
- EARLY DEVELOPMENT ●

○ - 1MTPA of CO₂ (AREA OF CIRCLES PROPORTIONAL TO CAPACITY)



Source: Global CCS Institute 2018

CCUS will represent 8-10% of total est. CO₂ capture by 2050

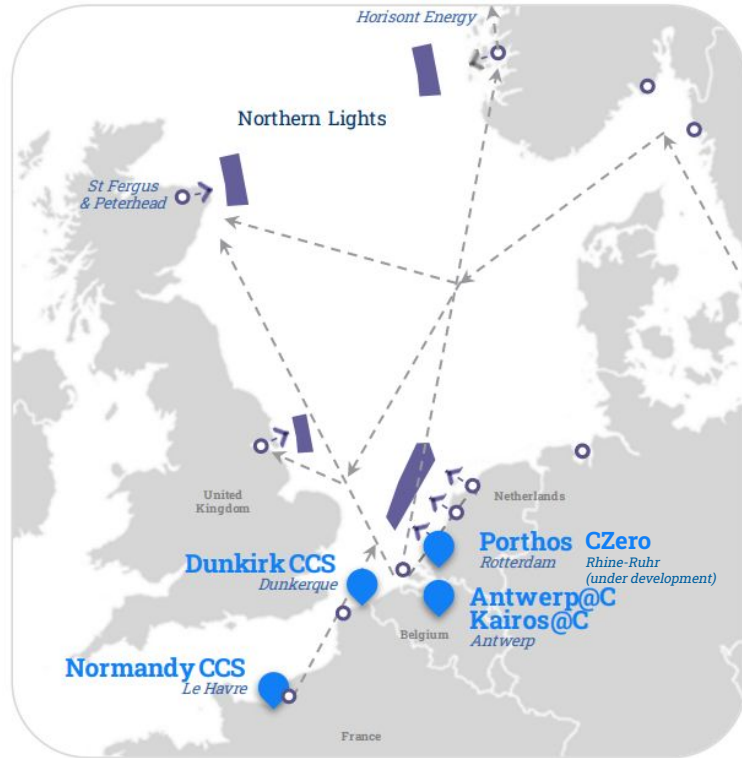


CAPTURE

- Pressurisation/
Liquefaction
- Transport /
Distribution
- Sequestration /
Utilisation

[Source](#)

Carbon capture as a service becoming a reality



Large scale Carbon capture projects in Europe

- Air Liquide is a **first mover** in flagship CCS projects
- For Air Liquide and **customer assets**
- **Approximate start-up dates**
 - Porthos - 2024
 - Kairos@C - 2025
 - Dunkirk - Under review (2027)
 - Normandy CCS - 2030
- **Strongly supported by EU and Member States**
- **Under development**
 - FOS Marseille & Rhône Valley - France
 - Gdansk-Poland
 - C Zero- Germany- Duisburg to Rotterdam
 - Terneuzen - The Netherlands

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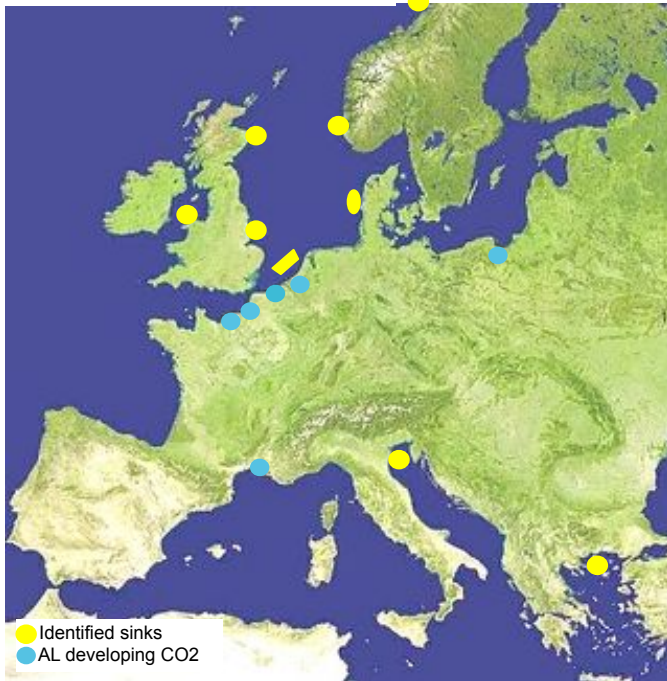
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Sequestration developments

Sequestration is a key block

- There is significant storage capacity available in Europe
- And a strong momentum in certain countries to start CCS

North sea: >1.5Gt storage capacity



But there are challenges to develop

- Open capacity today is **limited** compared to CO₂ projects being developed
- Sink operators hold the key. **Aggregation of large volumes is important**
- Keep industrially acceptable **Terms and Conditions** of the service
- **Regulatory framework** for cross border CO₂ transport is needed
- **Technical** and **permitting timing** needs to be considered



Thank you

