3D PROJECT : FROM CO2 CAPTURE IN DUNKIRK TO STORAGE IN THE NORTH SEA.

WEBINAR : “CO2 CAPTURE AND UTILIZATION: FROM FUNDAMENTALS TO DEMONSTRATION PLANTS”

H2020 PROJECT LEADER : VANIA SANTOS-MOREAU

05/05/2022

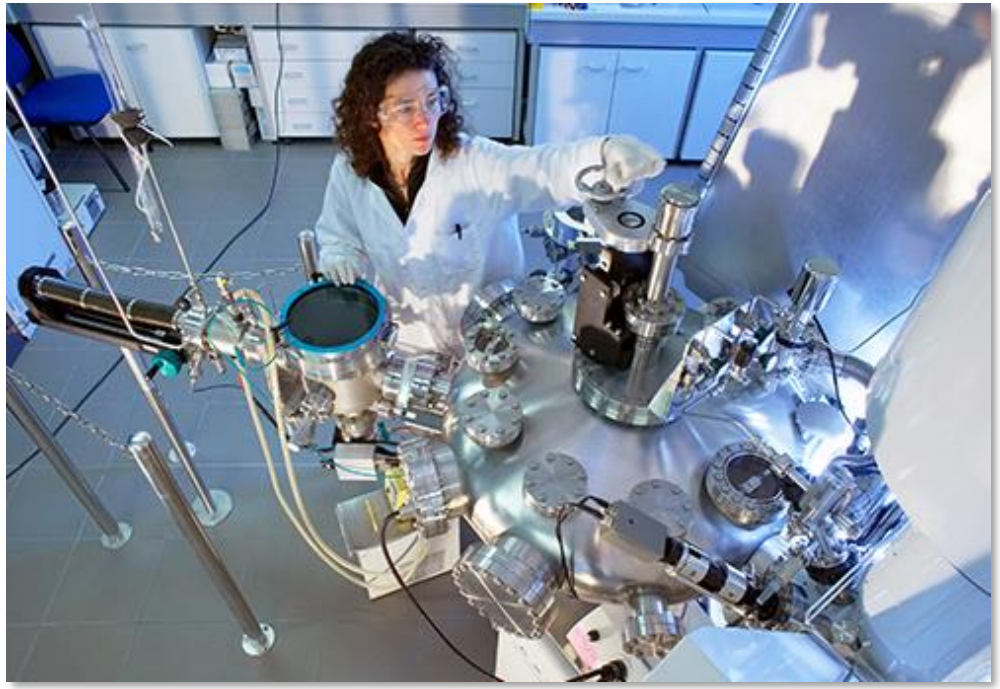
ME

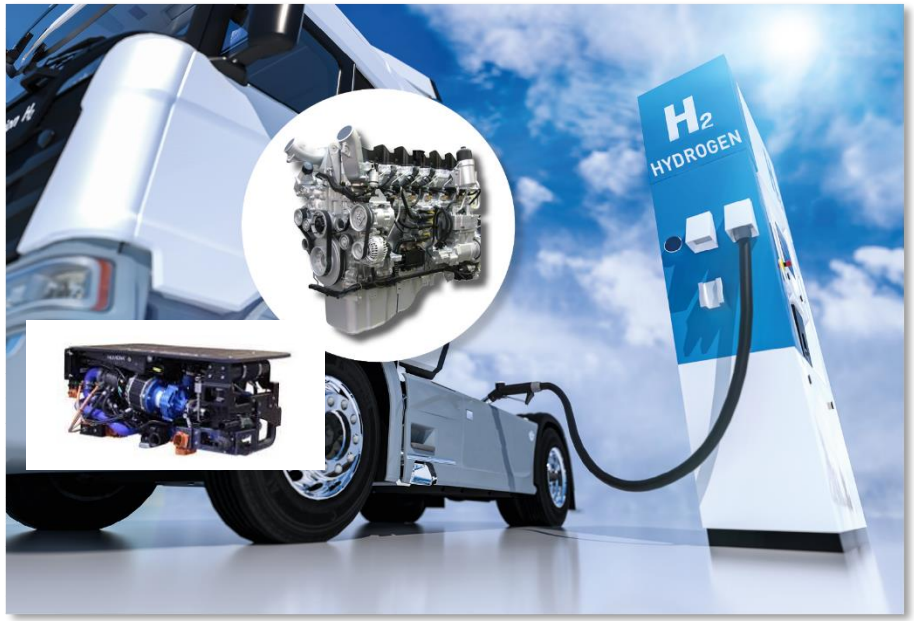
Me

- Vania Santos- Moreau
- I am 40 years old
- I am a Portuguese woman working in France

Career Progression

- 2000- 2005 : Master Degree in Chemical Engineering
- 2005-2008 : PhD in Chemistry : Adsorption processes
- 2008-2017 : Experimentation Engineer and Project Leader (1M€)
- 2017-2018 : HR responsible
- 2018-2019 : Process Design Engineer
- 2019-Now : Project Leader : H2020 European Project (24 M€) and UCL Visiting Professor





IFPEN

2021

ABOUT US

A public sector **R&I** body

A **training** center

An industrial **group**

An international scope in the fields of energy, transport and the environment

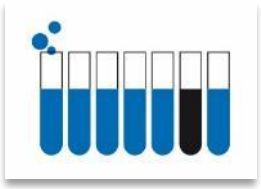
1,635 people

1,190 engineers and technicians dedicated to research

€120.5m budget allocation In 2020

€146.5m own resources In 2020

OUR RESEARCH IN FIGURES



10,205 active patents

175 basic patents filed in 2020

13th ranking patent filer in France (Inpi 2020)

3rd ranking public research centre

More than **200** articles per year published in international scientific journals

Over **50** job fields, from geologists to engine technicians

135 doctoral students and post-doctoral researchers

OUR AREAS OF EXPERTISE

Climate, environment and circular economy

- Plastics recycling
- CO_2 capture, use and storage
- Air quality
- Environmental monitoring
- Climate/soil interactions and the water cycle
- Circular economy / LCA

Renewable energies

- Biofuels
- Biobased chemistry
- Biogas
- Offshore wind and ocean energies
- Geothermal energy
- Hydrogen
- Energy storage

Sustainable mobility

- Hybridization and electrification
- Electricity storage
- Connected vehicles
- Thermal engines
- Low-carbon fuels

Responsible oil and gas

- Fuels
- Petrochemicals
- Gas sweetening and conversion
- Basin modeling
- Reservoir simulation
- Enhanced oil recovery (EOR)
- Offshore production

SUBSIDIARIES AND SHAREHOLDINGS (*)
THE IFP GROUP: €952M TURNOVER IN 2020 - 4,500 PEOPLE

Energy transition

- 23.6% DRIVE QUANT
- 23% GALANCK
- 23% easyLi advanced battery systems
- 20% la Cie des Mobilités
- 14.6% K-Ryole carry on

Geoscience consulting and software

- 100% BeicipFranlab
- 100% TECHadvantage

Alternative and renewable energies, refining, petrochemicals, gas, water

- 100% Axens — Powering integrated solutions — An IFP Group company
- EURECAT

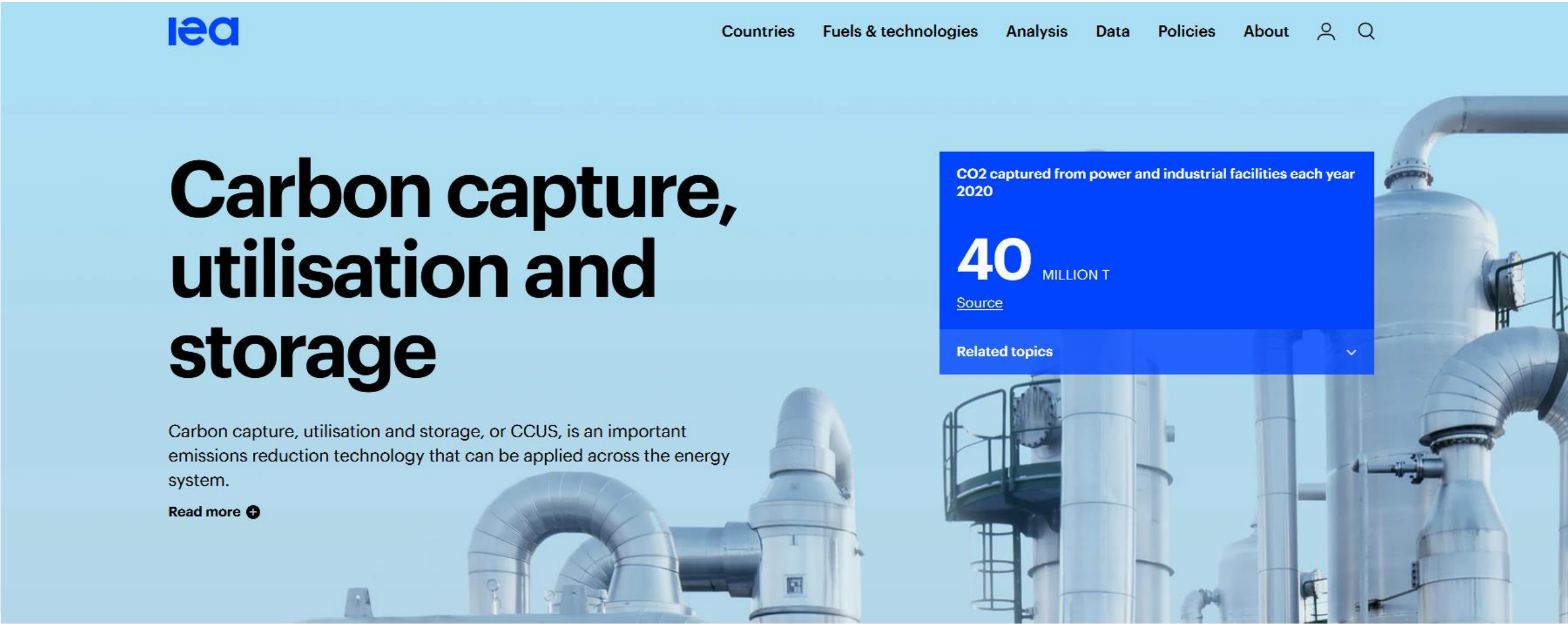
Training

- 62% IFP Training

** As of 14 April 2021*

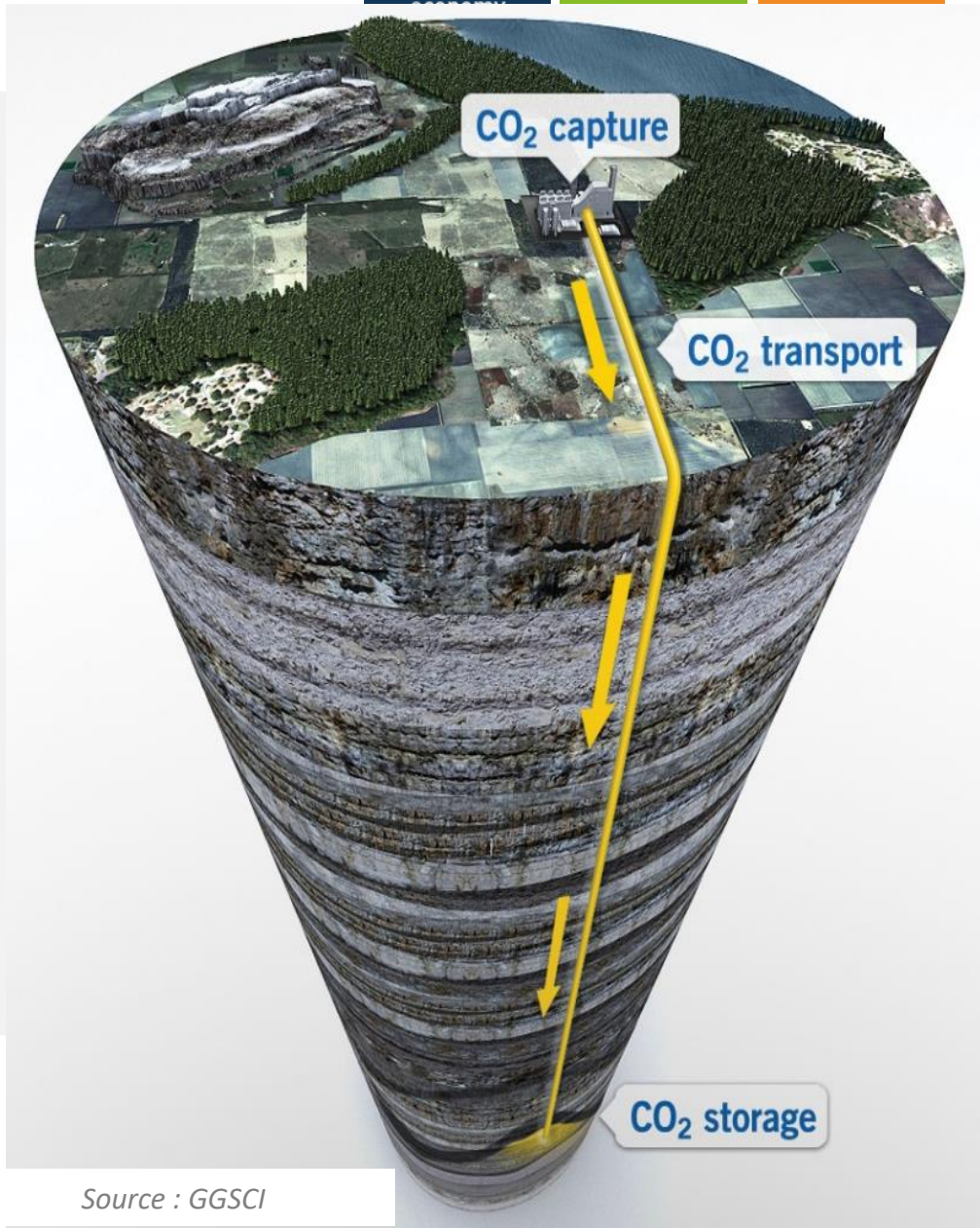
New Business for Industry : CCUS

Climate, environment and circular economy | Renewable energies | Responsible oil and gas



CARBON CAPTURE, UTILISATION AND STORAGE

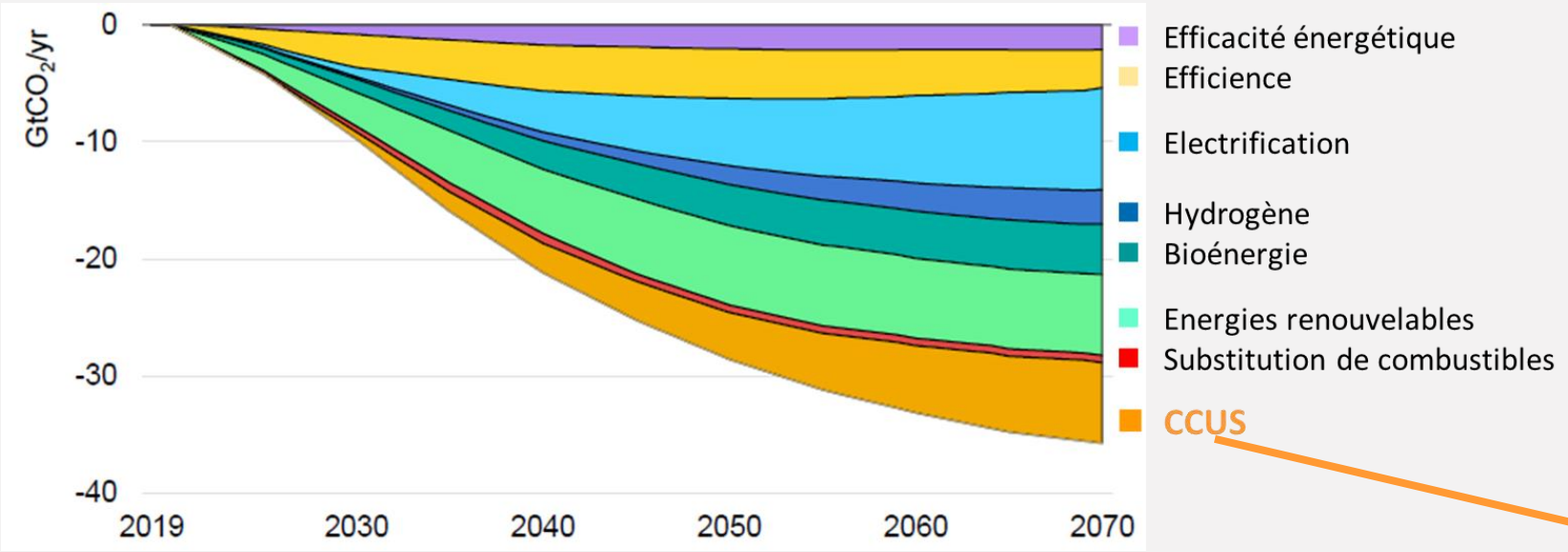
- **Capture** CO_2 from flue gas and industrial gas
  - Thermal power station
  - Industrial plants
- **Transport** the CO_2 (boat and pipes)
- **Store** the CO_2 in geological structures
  - Old oil or gas reservoirs
  - Deep aquifers
- **Utilisation** of the CO_2 captured to product valuable products
  - Chemical Products
  - Materials
  - Carburants



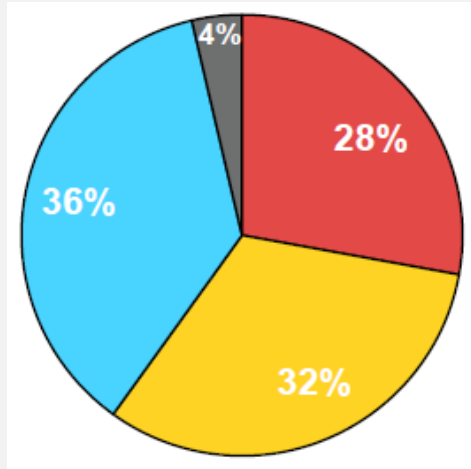
Source : GGSCI

New Business for Industry : CCUS

Climate, environment and circular economy | Renewable energies | Responsible oil and gas



CO_2 capture by sector 2020-20270



➔ **CCUS : 15% decrease of the CO_2 emissions in 2070**

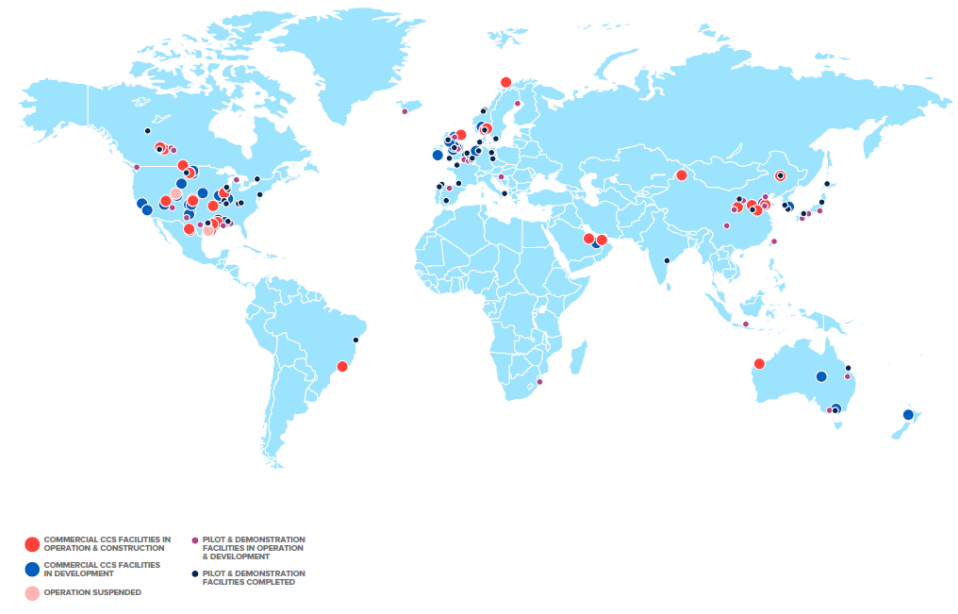
- ✓ Decarbonation of the energy production and industry
- ✓ Synergy with hydrogen
- ✓ One solution of negative emissions

Industry need CCUS to reduce CO2 emissions!

CCUS, a reality

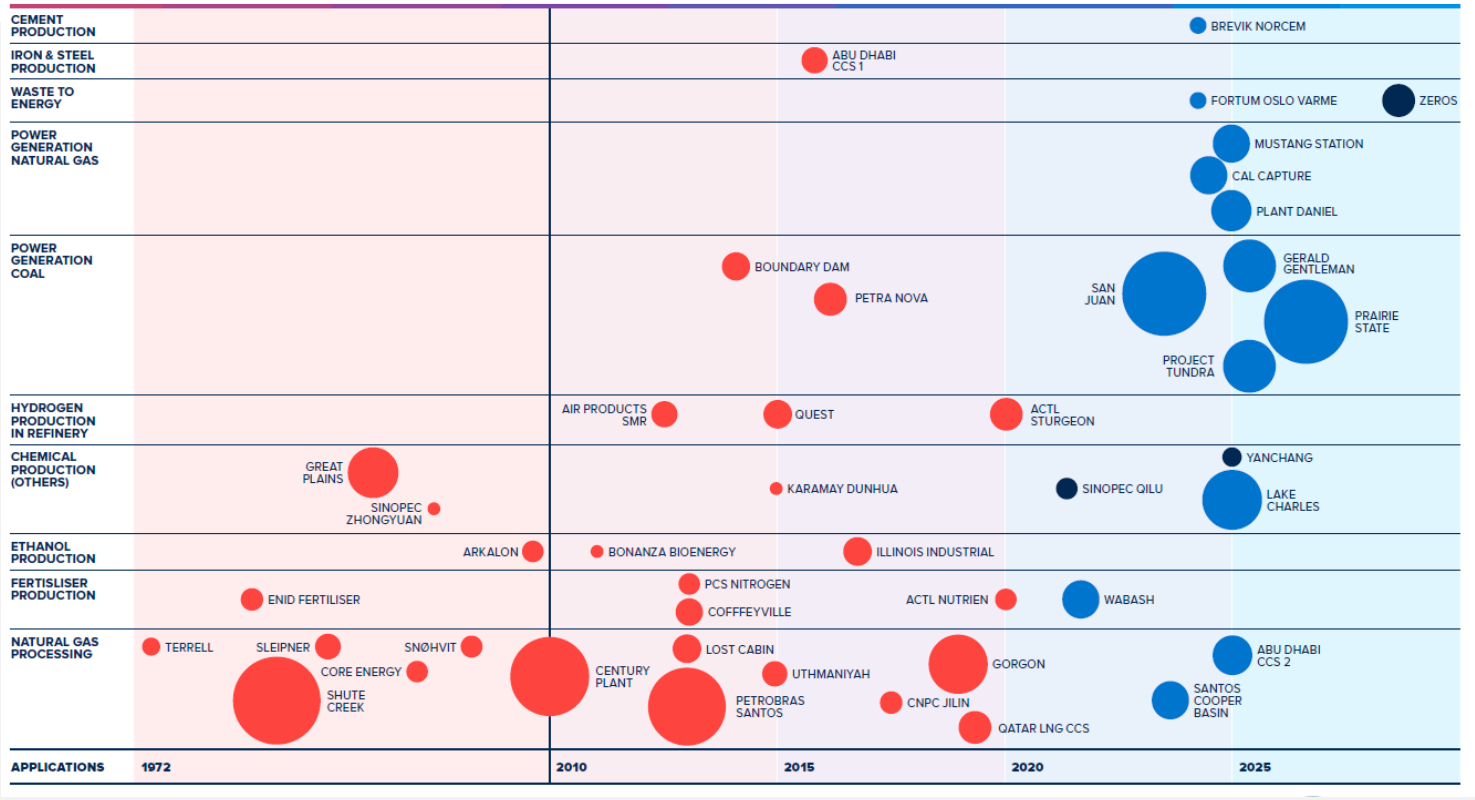
Climate, environment and circular economy | Renewable energies | Responsible oil and gas

40 Mt CO_2
Capture and stored /Y



65 large scale projects in 2020

- 26 on operation
- 2 on stand by
- 3 on construction
- 13 advanced stage of development
- 21 on study

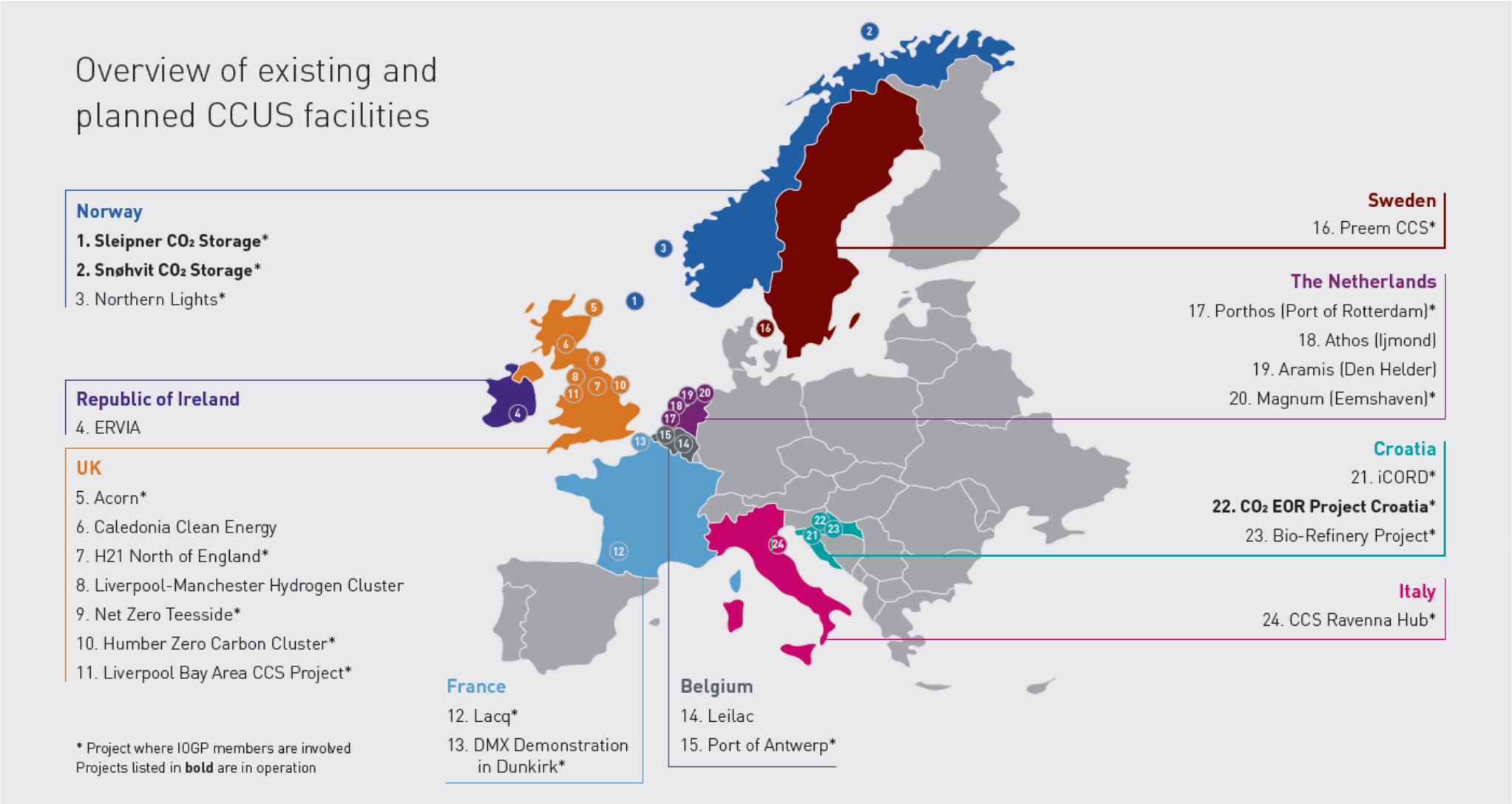


34 Pilot units & demonstrators

Source : GCCSI, 2020

CCUS, a reality

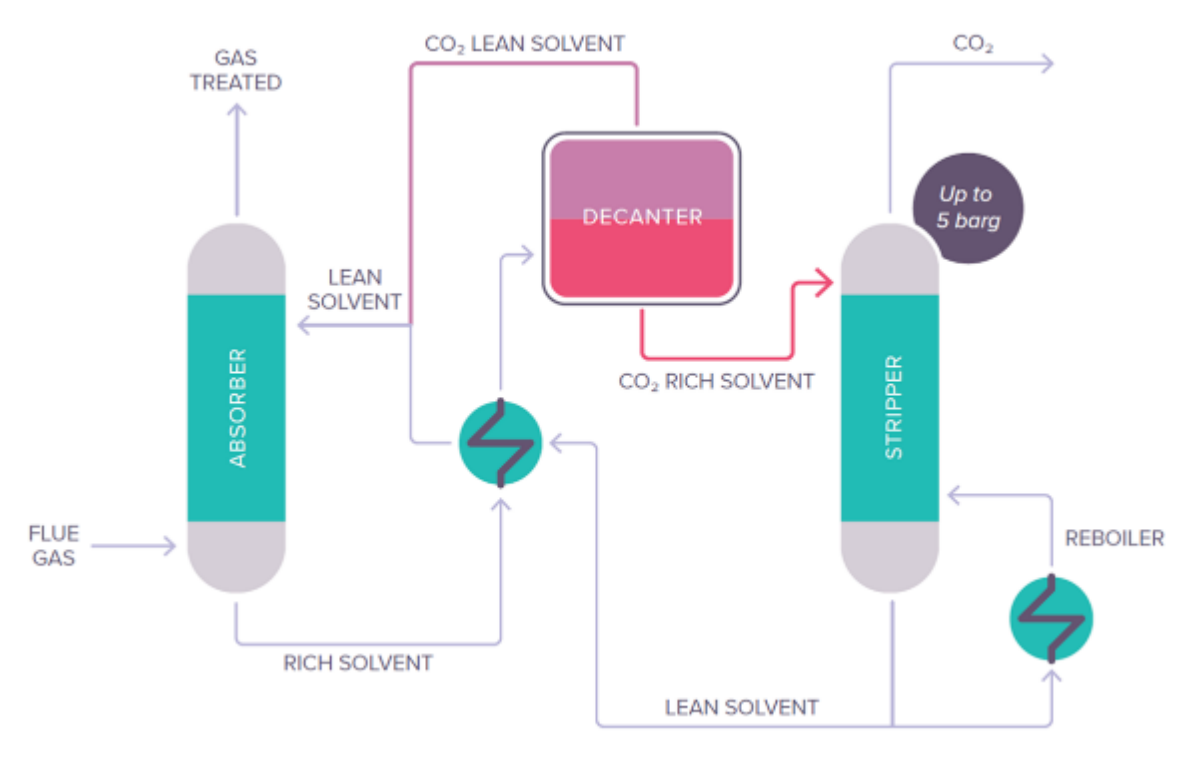
Climate, environment and circular economy | Renewable energies | Responsible oil and gas

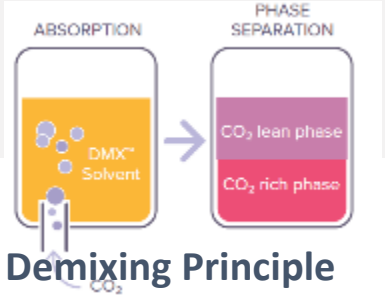


New Business for Industry : CCUS

An IFPEN solution to CO_2 capture, the DMX™ process

Climate, environment and circular economy | Renewable energies | Responsible oil and gas





Demixing Principle

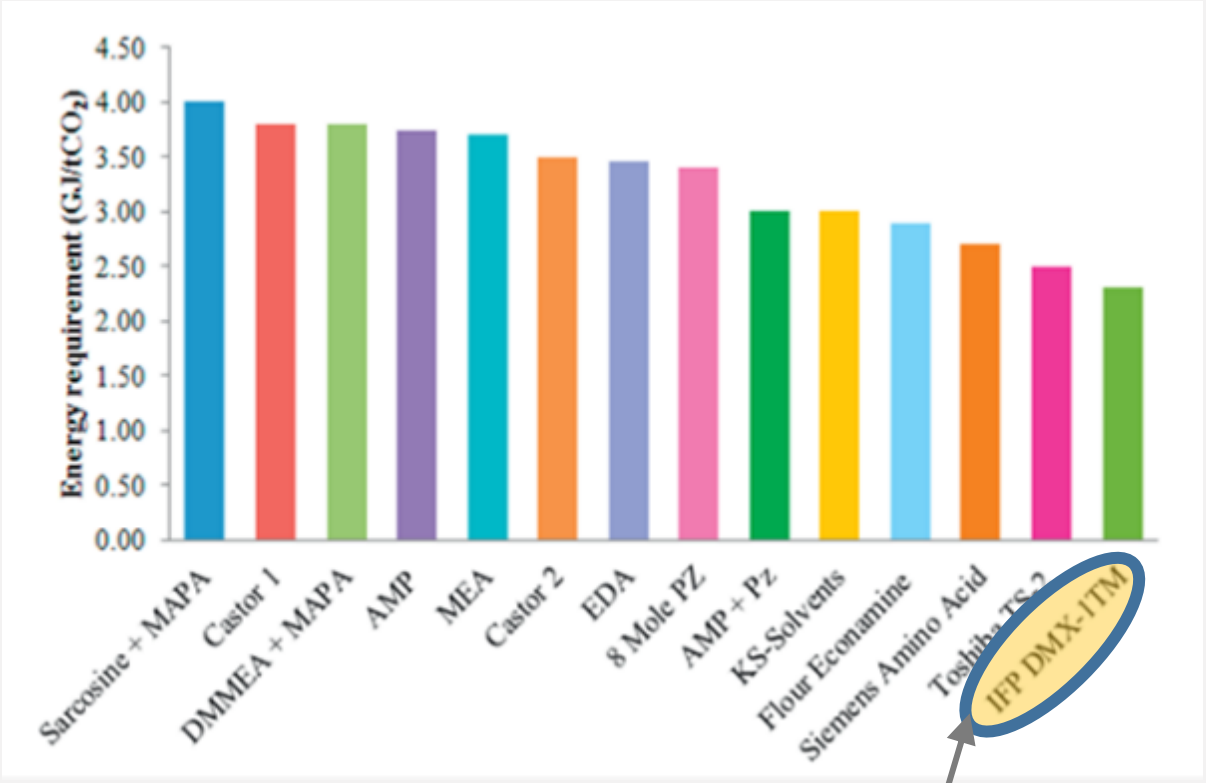
BENEFITS

- Low steam energy consumption: from 2.3 to 2.9 GJ/tCO_2 depending on application and capture rate
- Thermally stable solvent with low degradation rate
- CO_2 produced readily under pressure up to 5 barg for significant compression cost savings
- High capture rate achievable (>90%) and high purity of produced CO_2 (>99%)
- -30% of CO_2 capture costs

DMX™ PROCESS - PERFORMANCES

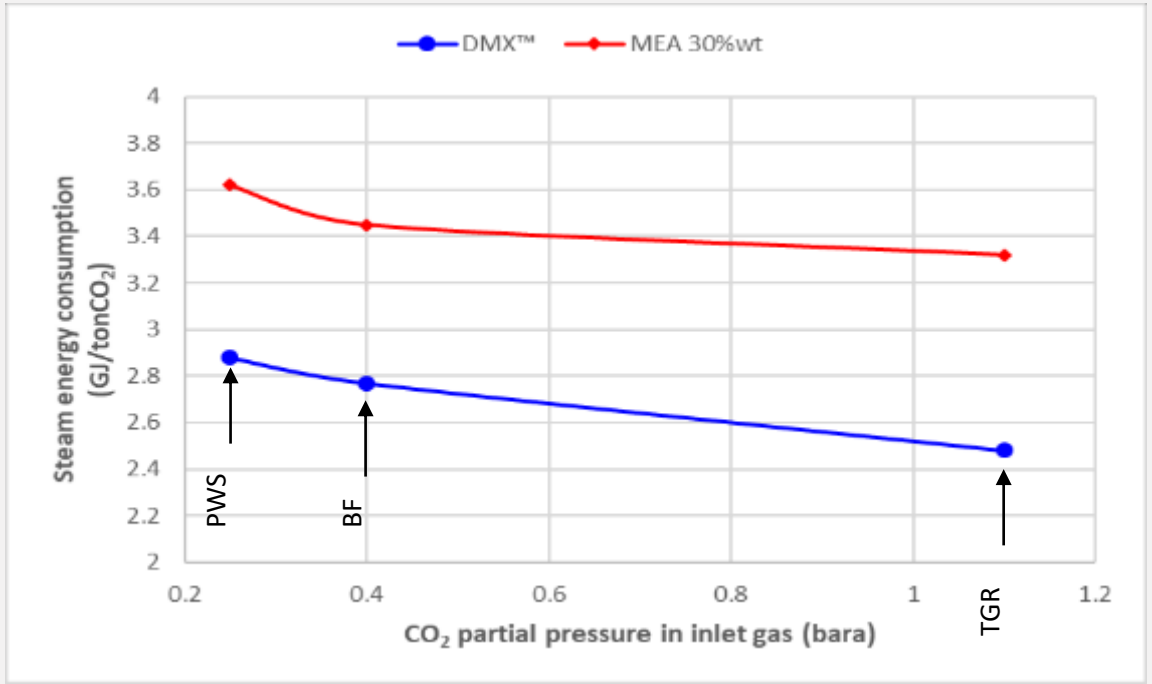
Climate, environment and circular economy | Renewable energies | Responsible oil and gas

Low Energy for solvent regeneration (< 2.3 GJ/tCO2 @ 90 % capture rate / without any integration)



Source: Singh P. (IEAGHG), et al., Energy Procedia 37 (2013) 2021-2046, Oral présentation , GHGT-11, Kyoto, 2012.

- 30% OPEX (vs MEA)



- Steam Energy Consumption:
  - **3.7 → 2.9 GJ/tCO$_2$ for Power Station Case**

DMX TECHNOLOGY DEVELOPMENT

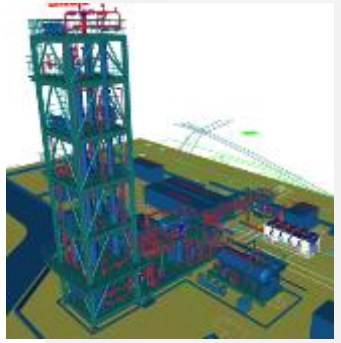
Renewable energies

Responsible oil and gas

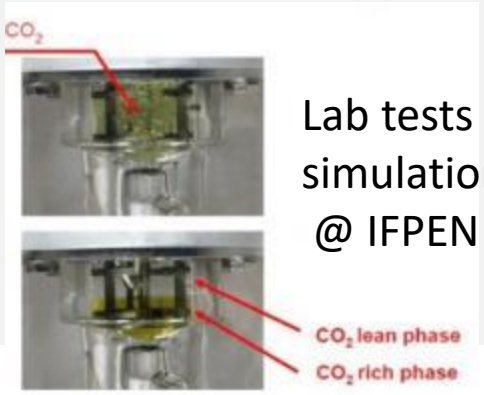
OCTAVIUS (coal case)

VALORCO project (steel mill case)

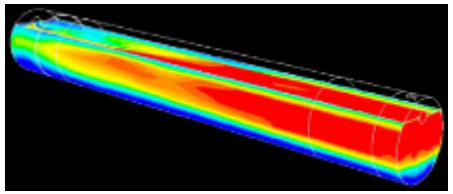
3D project

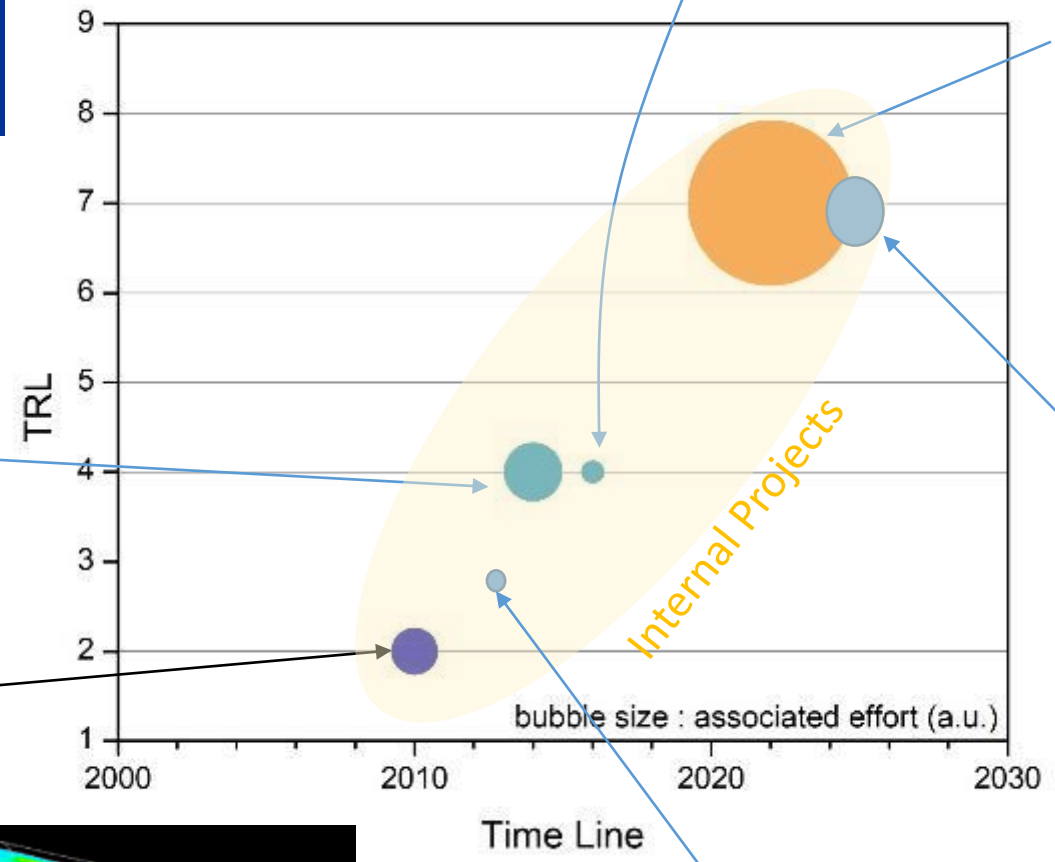


DINAMX project

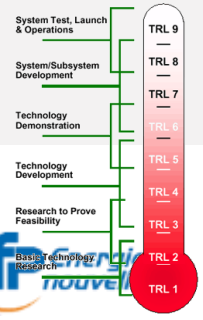


Lab tests and simulation tests @ IFPEN

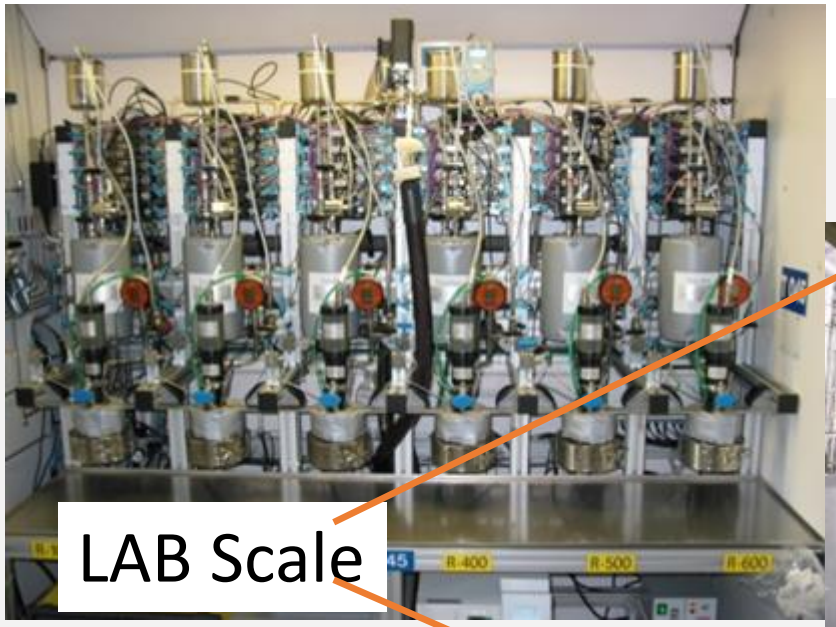




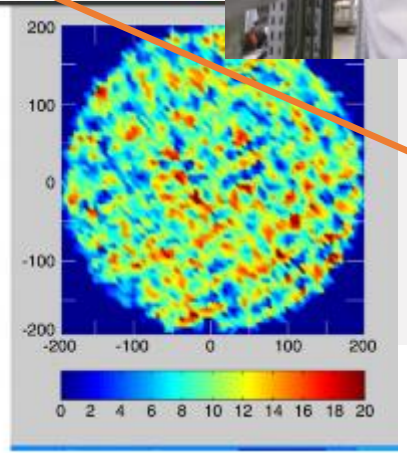
ACACIA FUI+ANR (DMX vs MEA)

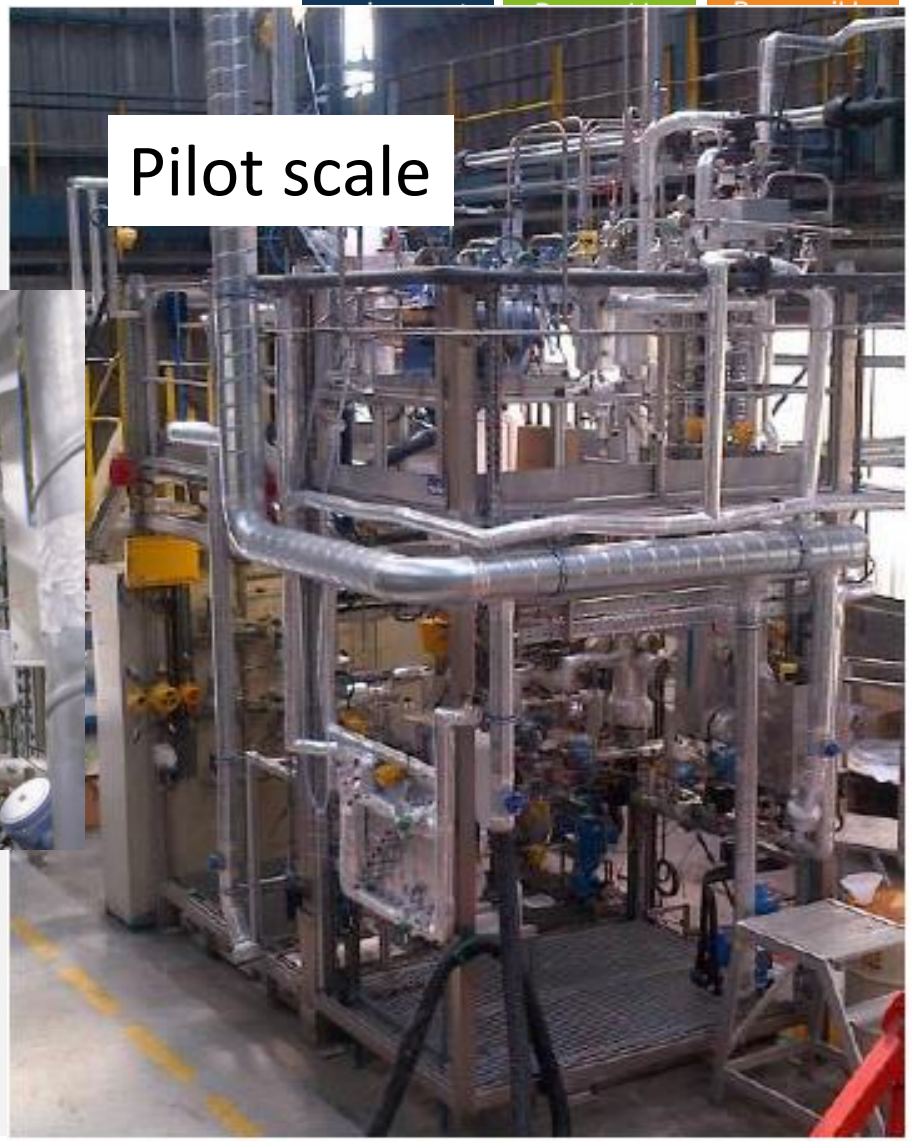


+ DE 10 YEARS OF R&I



LAB Scale





Pilot scale

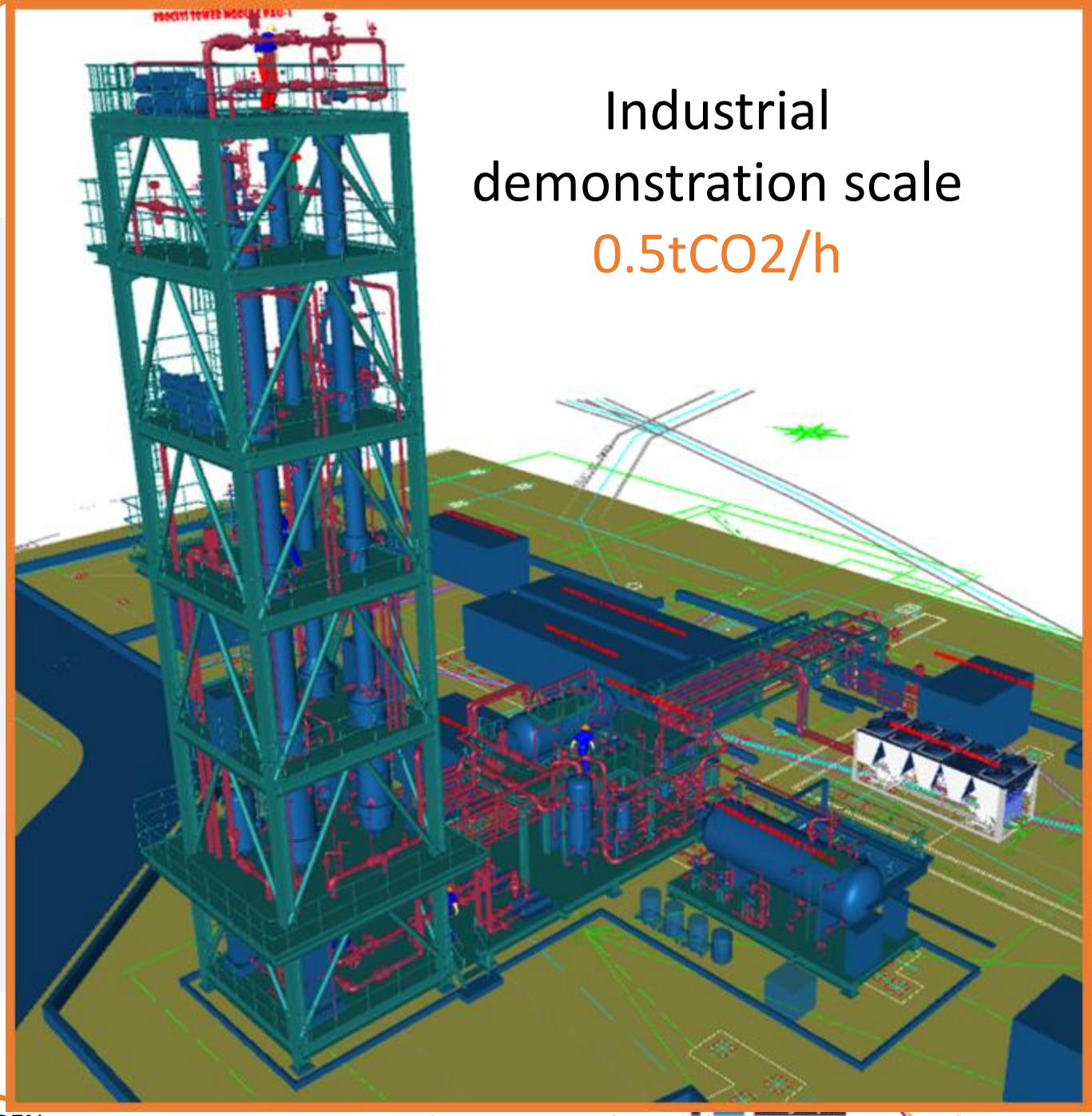
Credits : IFPEN

CHALLENGE

Credits : IFPEN

Pilot scale

0.2kgCO2/h



Industrial demonstration scale

0.5tCO2/h

Credits : Axens & Artelia

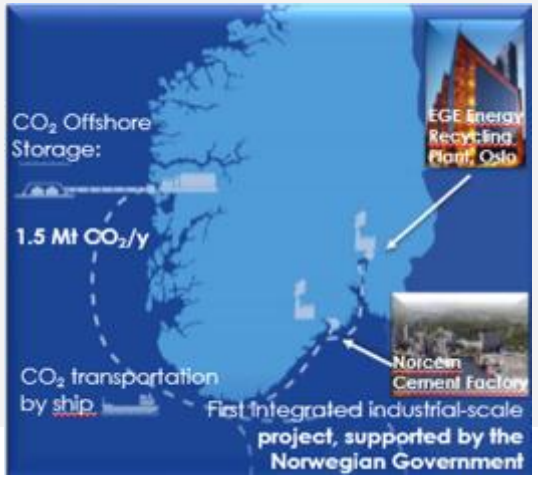
DMX DEMONSTRATION IN DUNKIRK: 3D PROJECT GRANTED BY H2020

ACKNOWLEDGEMENT

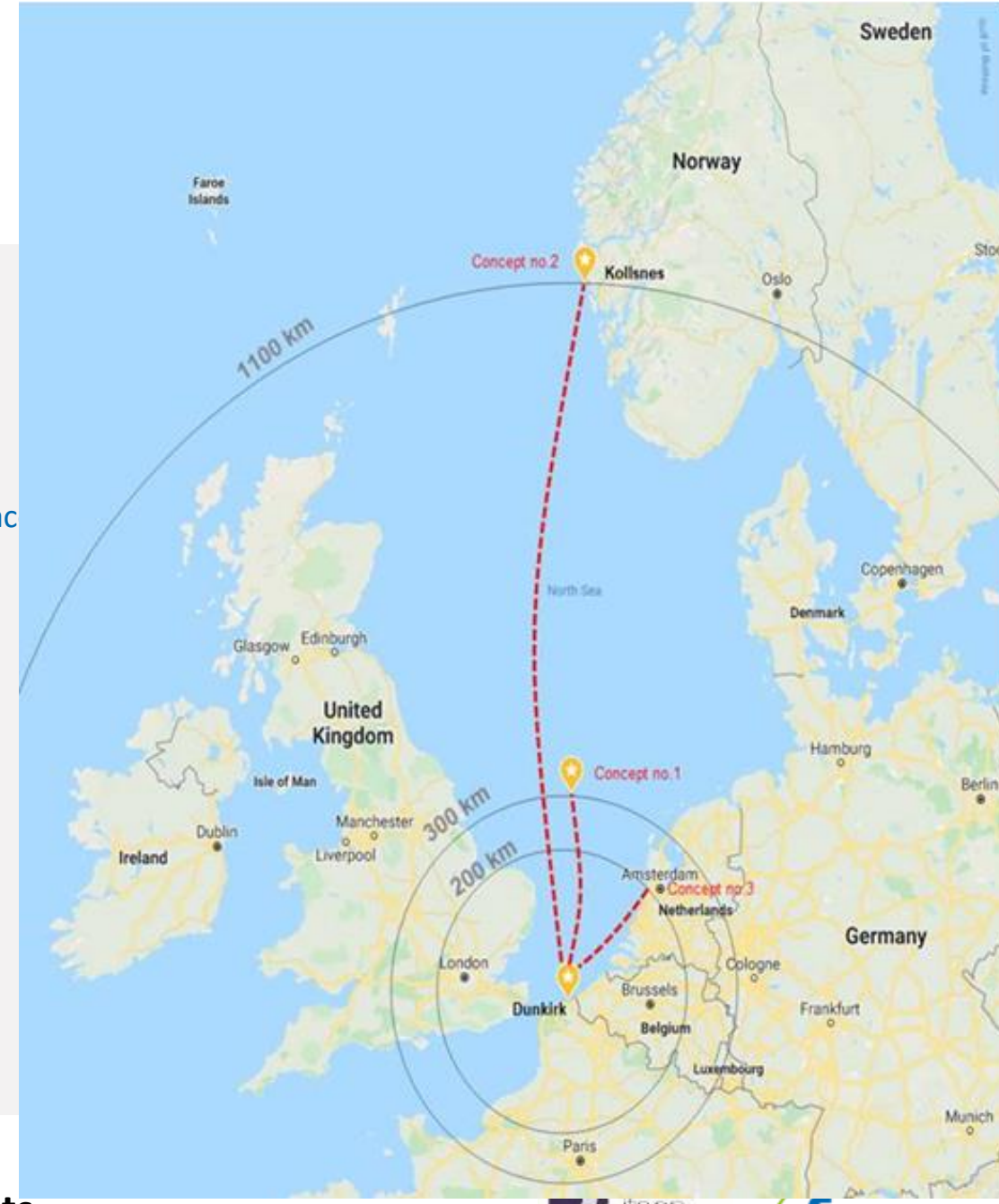
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 838031.

3D IN A NUTSHELL

- H2020 Project (call 2018 / topic LC-SC3-NZE-1)
- Objectives
  - Demonstrate the **DMX™ process** for CO_2 capture
    - Construct a plant for CO_2 capture (0.5 tCO2 capture/h) to treat Blast Furnac gas of Arcelormittal steel plant
  - Prepare a first CCS large-scale demonstrator (> 1M tCO2eq/y)
  - Study the CCS Hub 2035 Dunkirk-North Sea (10 MtCO2eq/y)
- Project start-up: **May 2019**
- Duration: **48 months**
- Estimated eligible costs: **19,2 M€**
- EU funding: **14,7 M€**

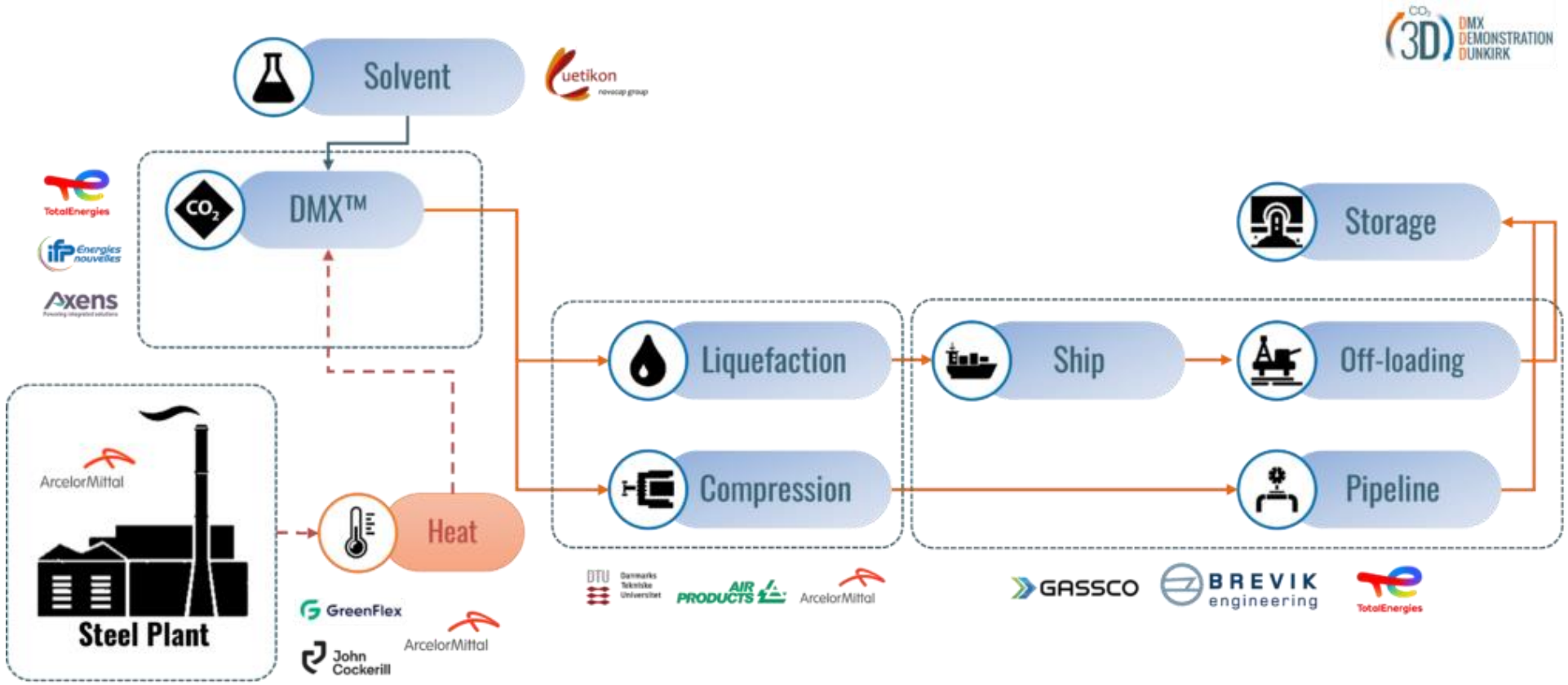


Norwegian project Northern Lights
https://northernlightsccs.com/en/about



https://3d-ccus.com/3d-public-deliverables/

11 PARTNERS WORKING TOGETHER



Social Sciences and Humanities, Life Cycle Analysis and Cost

CCS cluster 2035 in Dunkirk

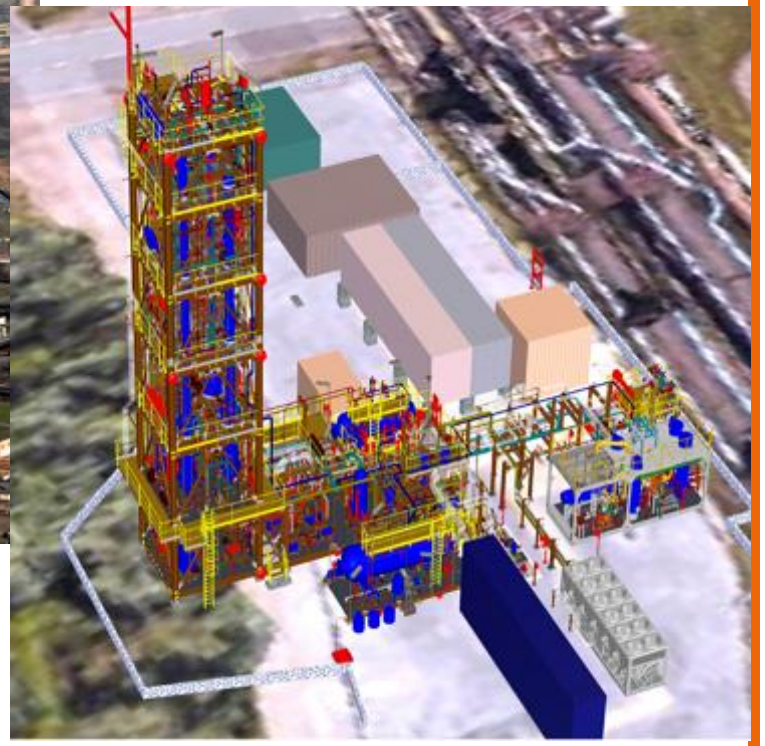
ArcelorMittal DUNKIRK

TO DEMONSTRATE THE DMX™

ArcelorMittal Steel Mill

Dunkirk

The industrial Demonstrator plant



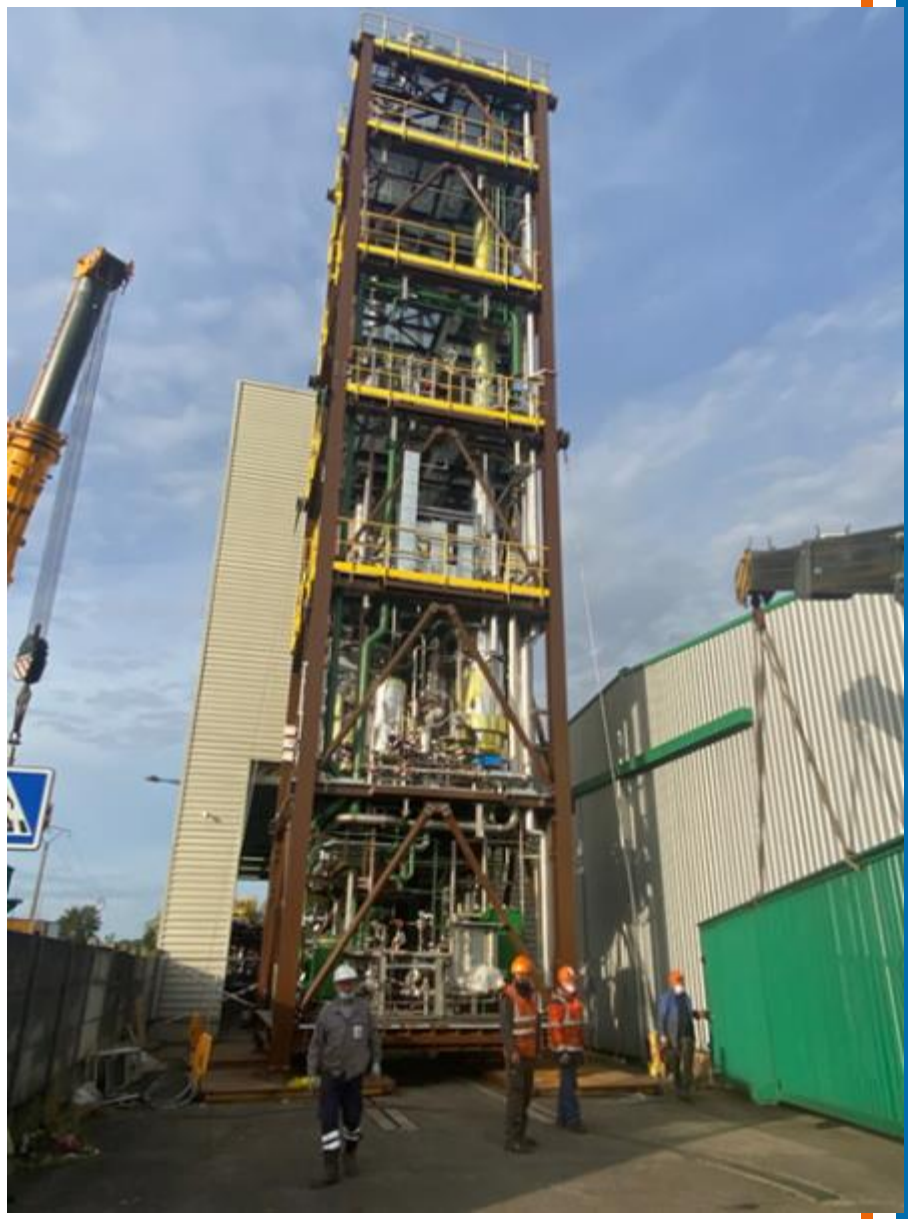
Credits: Artelia&Axens

2021 CONSTRUCTION AT THE YARD, ETCI IN LENS

Credits : ETCI, Axens and AMF

2021 CONSTRUCTION AT THE YARD : LIFTING AND ASSEMBLING

Credits : ETCI, Axens and AMF

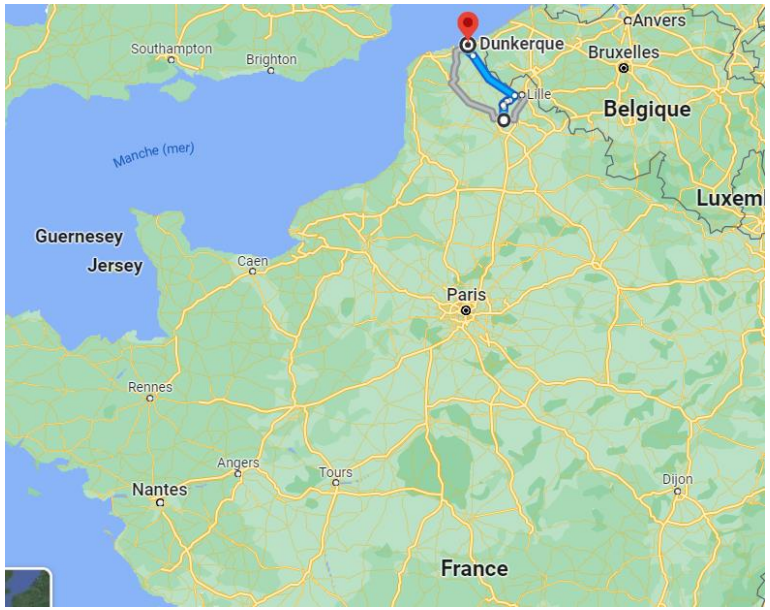


2021 TRANSPORT ON TRUCK FROM LENS TO DUNKIRK : 90 KM

Credits : ETCI, Axens and AMF

2021 TRANSPORT ON BOAT

Credits : ETCI, Axens and AMF



CO_2 3D DMX DEMONSTRATION DUNKIRK

2021 ARRIVAL TO DUNKIRK

Credits : ETCI, Axens and AMF

DMX
DEMONSTRATION
DUNKIRK

Inauguration du pilote

Juillet 2021 – Février 2022

Dunkerque

Credits : AMF

MARCH 2022 : ARRIVAL OF THE TEAM IFPEN/TOTAL ENERGIES ON SITE TO WORK WITH AMF AND AXENS

Credits : IFPEN

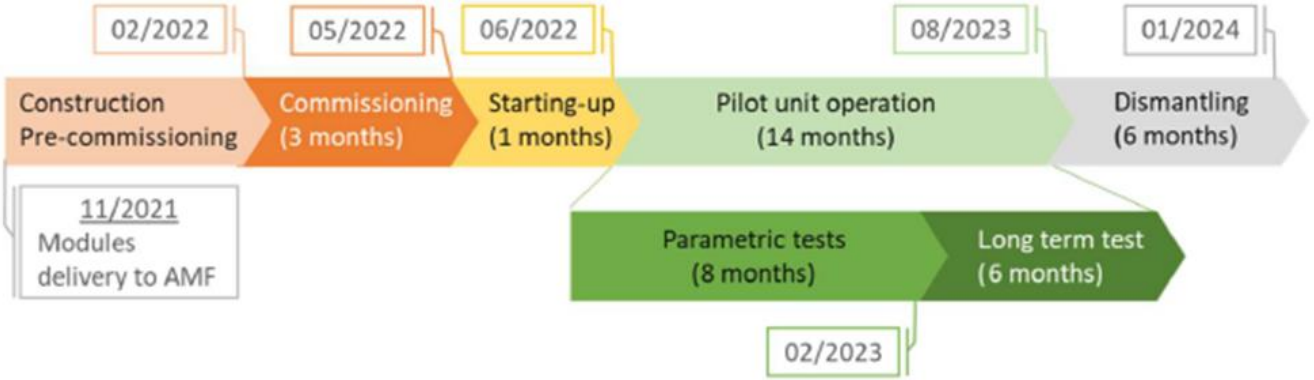
SOLVANT ARRIVAL TO DUNKIRK

Credits : IFPEN

MARCH 2022 : CONNEXONS AND COMMISSIONING ACTIVITIES
JUNE 2022 : START OF THE R&I EXPERIMENTATION

Credits : IFPEN

NEXT STEPS

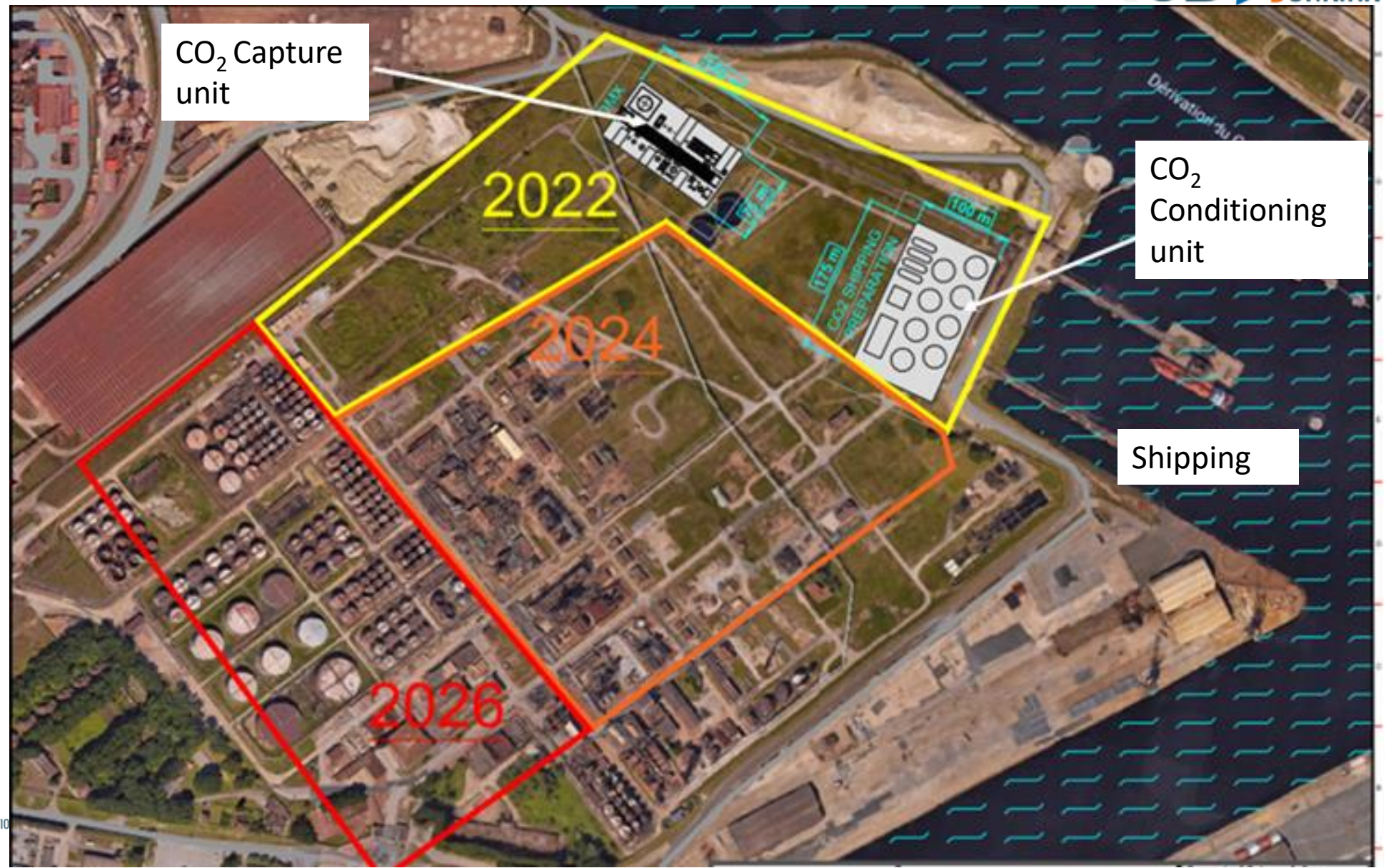


Test Type	Objective
Energy penalty	To optimise the energy consumption of the DMX process for different CO_2 capture applications
Absorber model validation	To validate the transfer phenomena modelling of the absorption process
Unit flexibility Unit capacity	To prove the robustness of the operation to gas flowrate fluctuation (turndown) To confirm the packing capacity provided in the absorption section
Solvent emissions	To optimise the operating parameters allowing to limit solvent emissions

INDUSTRIAL UNIT

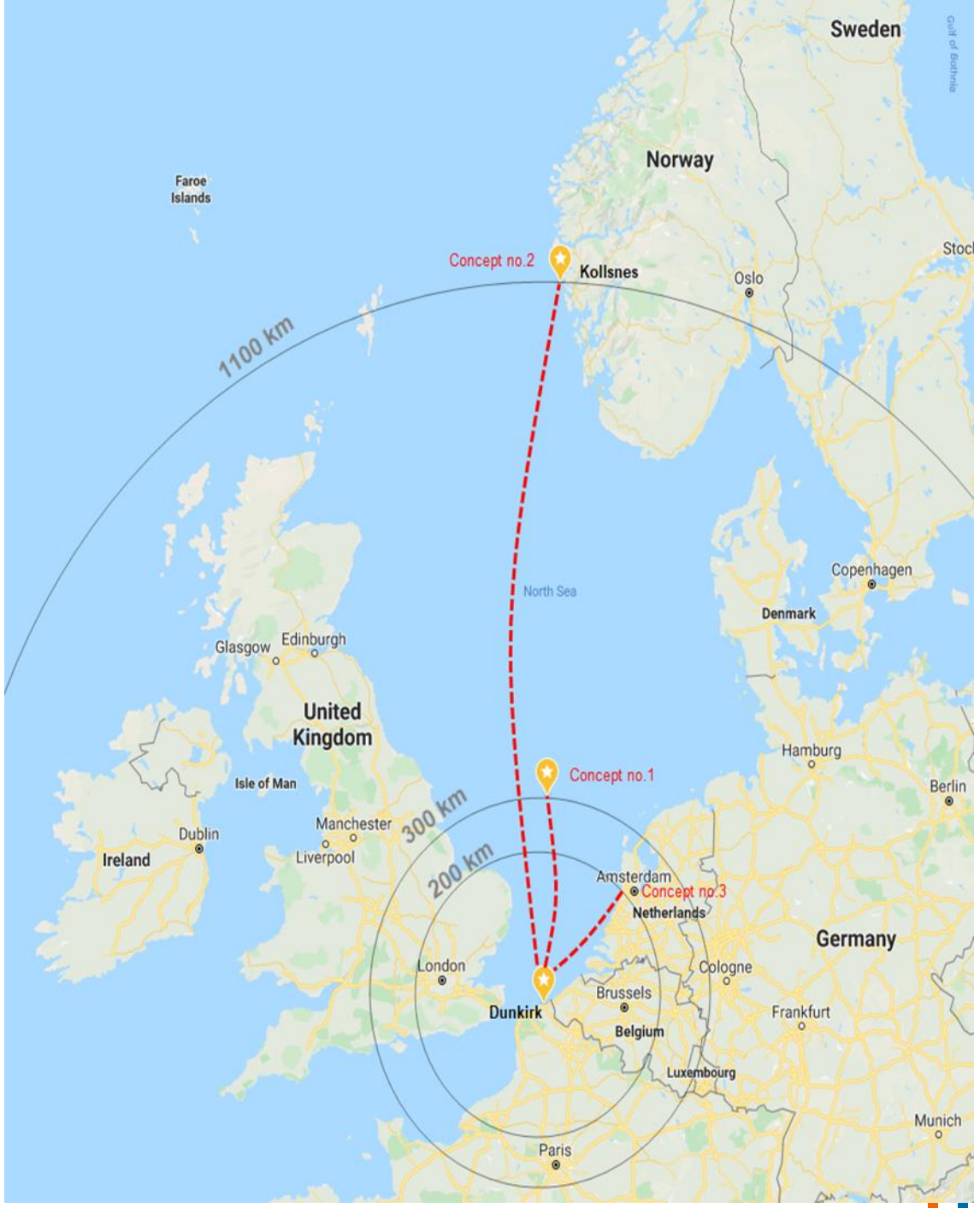
- **1st CCS Demonstrator (1Mton/Y) at 2025+ in Dunkirk**
  - **Technical specifications and CAPEX and OPEX estimations :**
    - **Capture unit : Preliminary study completed-> Final Study after the DMX demonstration**
    - **Heat Recovery : Completed**
    - **Conditioning Plant : Ongoing**
    - **Transport: Ongoing**
    - **Economics and LCA : Ongoing (Feed with the results of the different WP)**
    - **Social Acceptability : Ongoing Stakeholder's identification + Strategic recommendations -> Civil Comity creation**

INDUSTRIAL UNIT



INDUSTRIAL UNIT

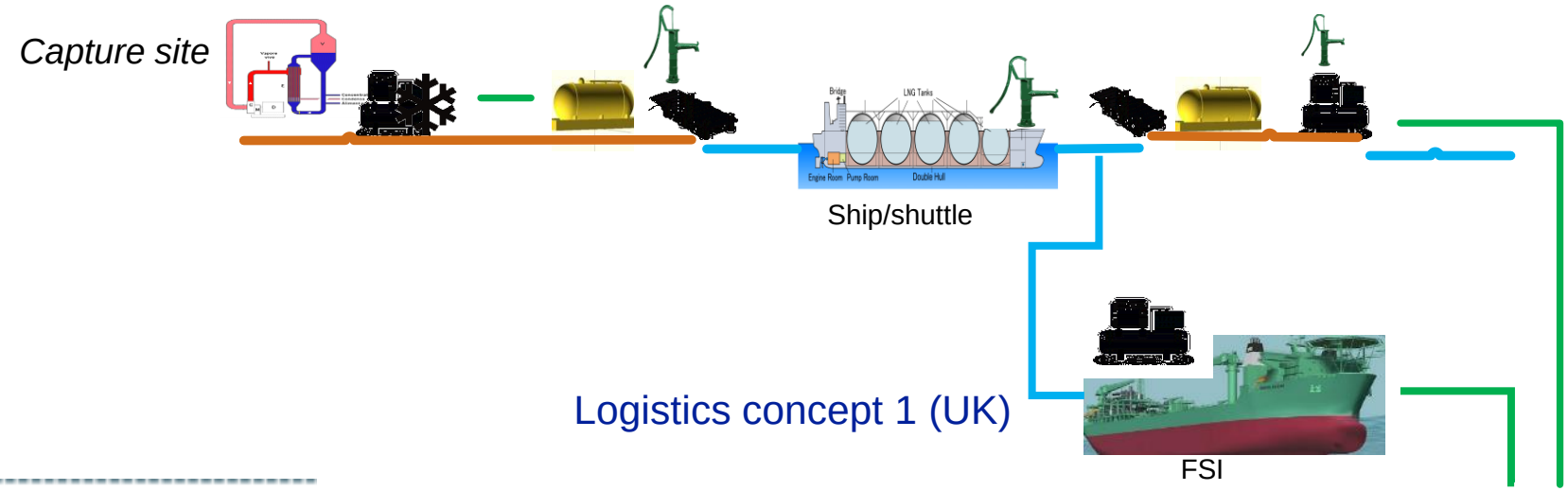
- **Transport cases**
  - **Storage**
    - **Concept no. 1 – Standalone case (UK)**
    - **Concept no. 2 – Northern lights (Norway)**
    - **Concept no. 3 – Dutch case**
  - **Transport**
    - **Ship transport (all concepts)**
      - **Medium pressure: 13-18 barg, -30°C (operating)**
    - **Pipeline transport (Concept 1 and 3)**
      - **Dense phase (above the liquid line)**



INDUSTRIAL UNIT

Ship transport (all cases)

Logistics concept 2 (Norway) & 3 (Dutch)



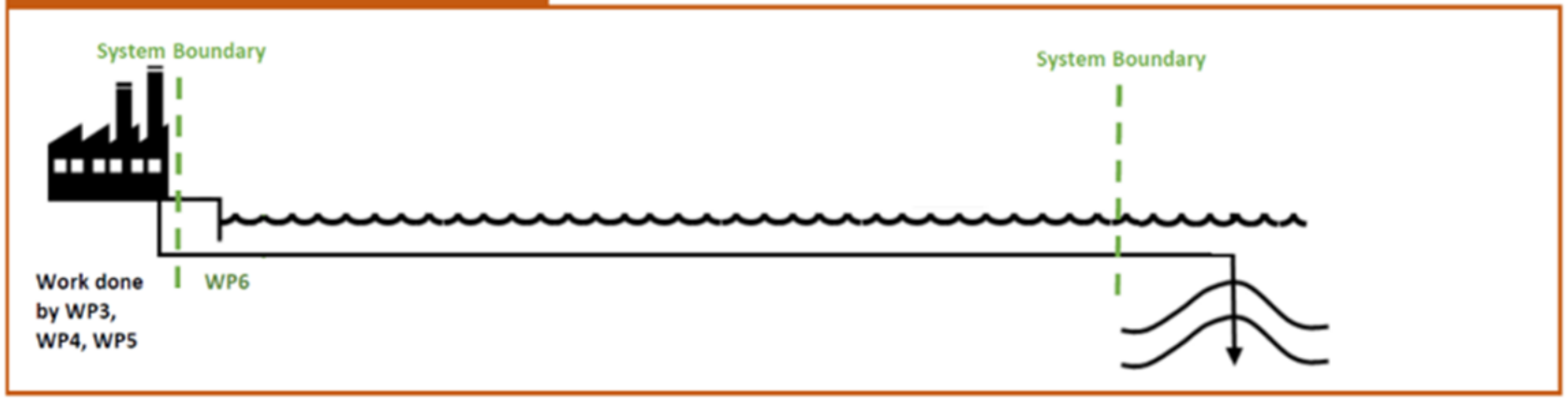
GASSCO BREVIK engineering

CO2 3D DMX DEMONSTRATION DUNKIRK

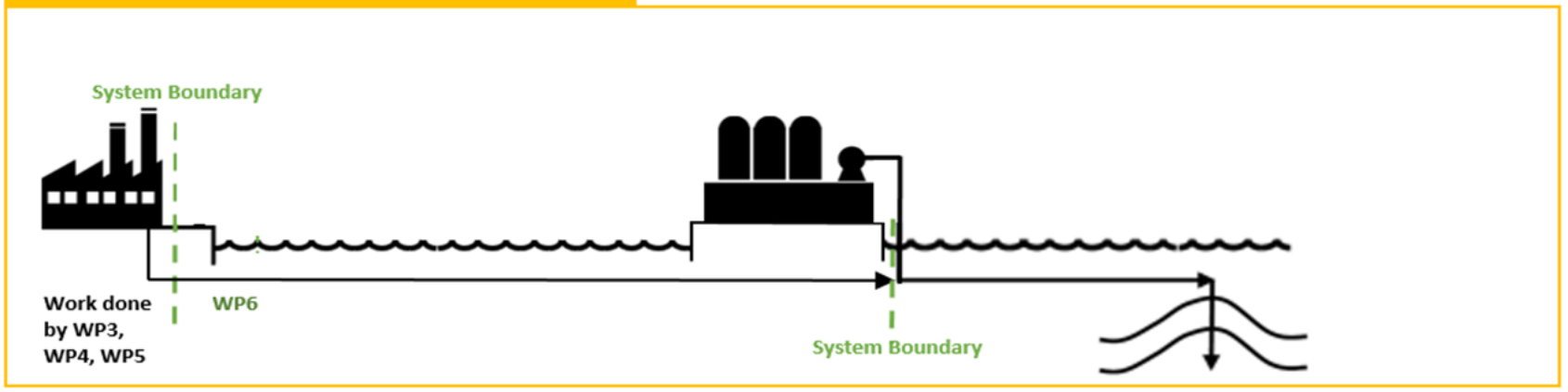
INDUSTRIAL UNIT

Pipeline (Only Dutch and UK storage)

Concept 1a – "Standalone" : Pipeline



Concept 3a – Tie in to "Dutch projects" by pipeline



KEY TAKEAWAYS

- **3D project is an important demonstration project and the preparation of all studies to create an EU CCUS hub : Pilot start-up in June 2022**
- **Our ambition : A CCUS facility Dunkirk-North Sea at 2025 : Capture and Conditioning in Dunkirk and Storage in the North Sea**
- **Part of the CO2 could be used to create valuable products : Methane, Kerosene, etc.**

ACKNOWLEDGEMENT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 838031.

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3D proje

Name of organization