



Saipem-Novozymes collaboration

Bluenzyme™ 200 for CO₂ Capture

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Who We Are



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Low Carbon Solutions
CO2 Management CM



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Business Lead
Carbon Capture



The future of carbon capture

What if there was a



reliable



efficient



sustainable

alternative to capture carbon

that made it possible for you to reduce cost and improve the environment?

DEPENDENCE ON TRADITIONAL CHEMICALS IS STEEPED IN UNCERTAINTY

The current operational and environmental risks you face with an amine-based system

THE CHALLENGES OF TRADITIONAL AMINE CARBON CAPTURE

Solvent stability yields
questionabel reliability

Waste-producing process not efficient
Toxic waste

High regeneration temperature
Requires steam



SAIPEM - NOVOZYMES PARTNERSHIP

Uniquely Combine Groundbreaking Innovative Process Engineering With Best-in-class Bio-solutions



Saipem contribution

- SAIPEM is a major international EPC and offers solutions for the full value chain of CCUS
- SAIPEM has an extensive track record in plant construction and commissioning
- SAIPEM has developed the most advanced enzyme-based carbon capture process with and expectation to bring global carbon capture to the next level

Together, Saipem and Novozymes offers the most efficient, affordable and ecofriendly carbon capture process



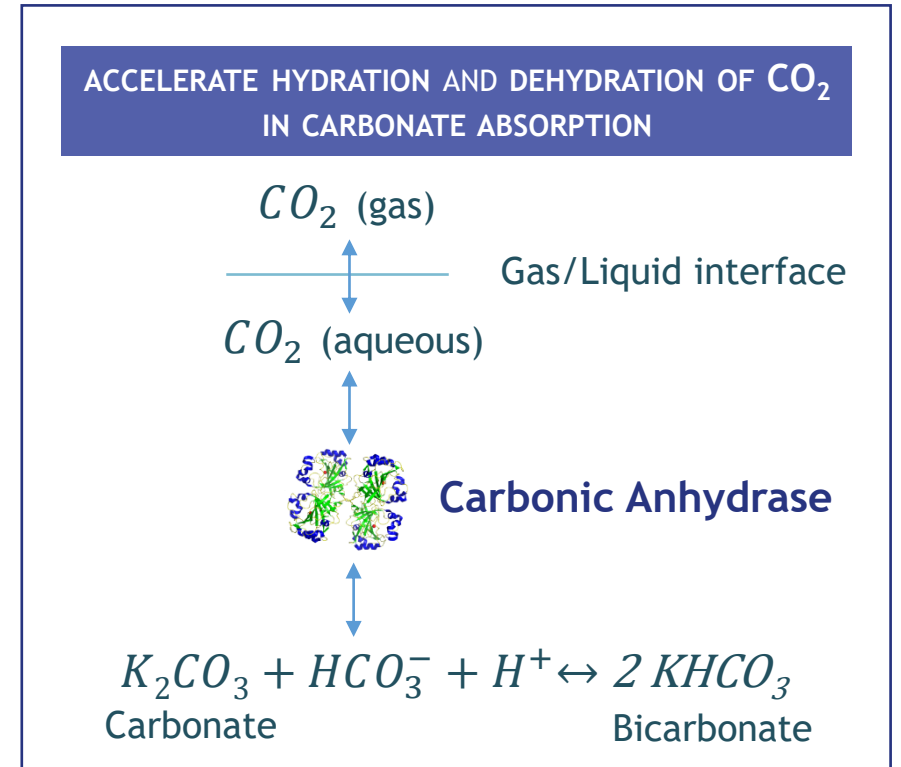
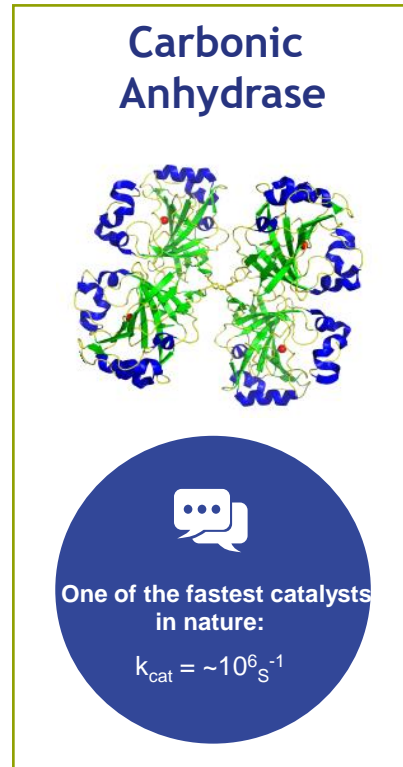
Novozymes contribution

- NOVOZYMES has a global supply chain for enzyme products and already supply large quantity enzymes in bio-industrial solutions such as Biofuels
- NOVOZYMES have world leading standards within enzyme quality of large-scale commercial products
- NOVOZYMES has world largest R&D muscle within enzyme research



Carbonic anhydrase enzymes is a catalyst

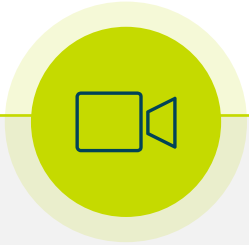
- We are using a biological CO₂ regulation mechanism evolved by nature over millions of years
- Used by trillions of living organisms living right now (including you)
- All plants, all animals, all microbes
- It is ‘by nature’ non-toxic and highly efficient, providing 1 million reactions per second per molecule
- The enzyme molecule is a non-living biochemical - no biohazards
- Simply think of it as a catalyst



**Each enzyme molecule
converts on average**

**32.5 million CO₂
molecules in
the process**





Let's visit the lab to see the carbonic anhydrase in action



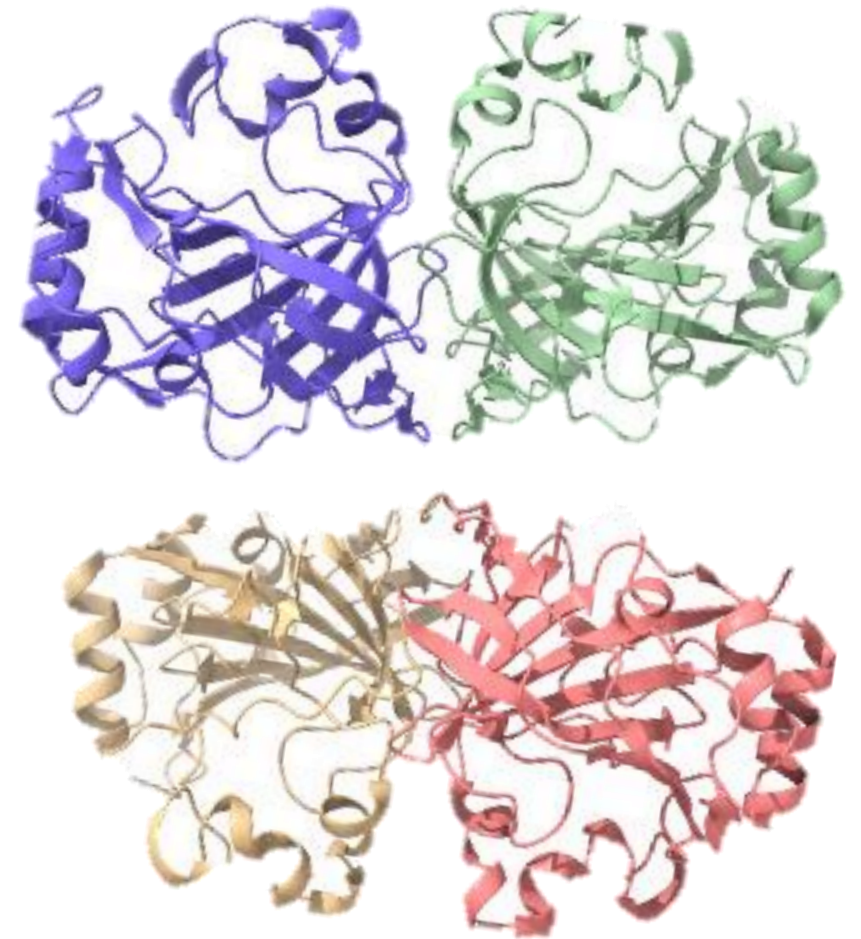
ENZYME: CARBONIC ANHYDRASE 1T1

Commercial Name: Extrapture

- Origin: *Thermovibrio ammonificans* Developed by Saipem

Characteristics:

- Molecular weight: 26005 g/mol
- Conformation: Tetramer
- Reaction catalyzed: $\text{CO}_{2(l)} + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_{3(l)}$
- Temperature tolerance: $T_{1/2}(70\text{C})$: 7-8 days
- Formulation: 1M Carbonate solution
- pH: 9.5-9.7





Novozymes is the world leader in biosolutions



CO₂ CAPTURE

Post Combustion Proprietary Technology

K₂CO₃ is an attractive solvent but is kinetically slow
the use of K₂CO₃ + enzyme assures a high CO₂ capture rate

High sustainability

Low environmental impact: it doesn't generate toxic wastes as amine plant
Competitive for "GREEN APPLICATIONS"



Energy Efficient

Low-grade residual heat sufficient to regenerate the solvent
Heat recovery to reduce OPEX



High durability

Low corrosion rates and low toxicity of the solvent
Low-cost material can be used (PVC or CPVC)



Simple

3 main process steps: Quench / conditioning, Absorption, Stripping
Low complexity process



Scaleable

No proprietary items: equipment available on the market
Standard equipment



Maturing the CO2 Solutions technology to large scale

CO₂ SOLUTIONS

CO₂ SOLUTIONS SAIPEM

CO₂ SOLUTIONS by SAIPEM **novozymes** Rethink Tomorrow



<2014
0.5 tpd



2014-2015
1 tpd



2015
10 tpd



2017
10 + 10 tpd



30 tpd project, Can\$10.0 M
- Commissioned in Q1 2019

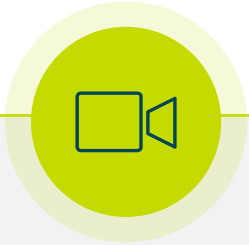
2019
30 tpd



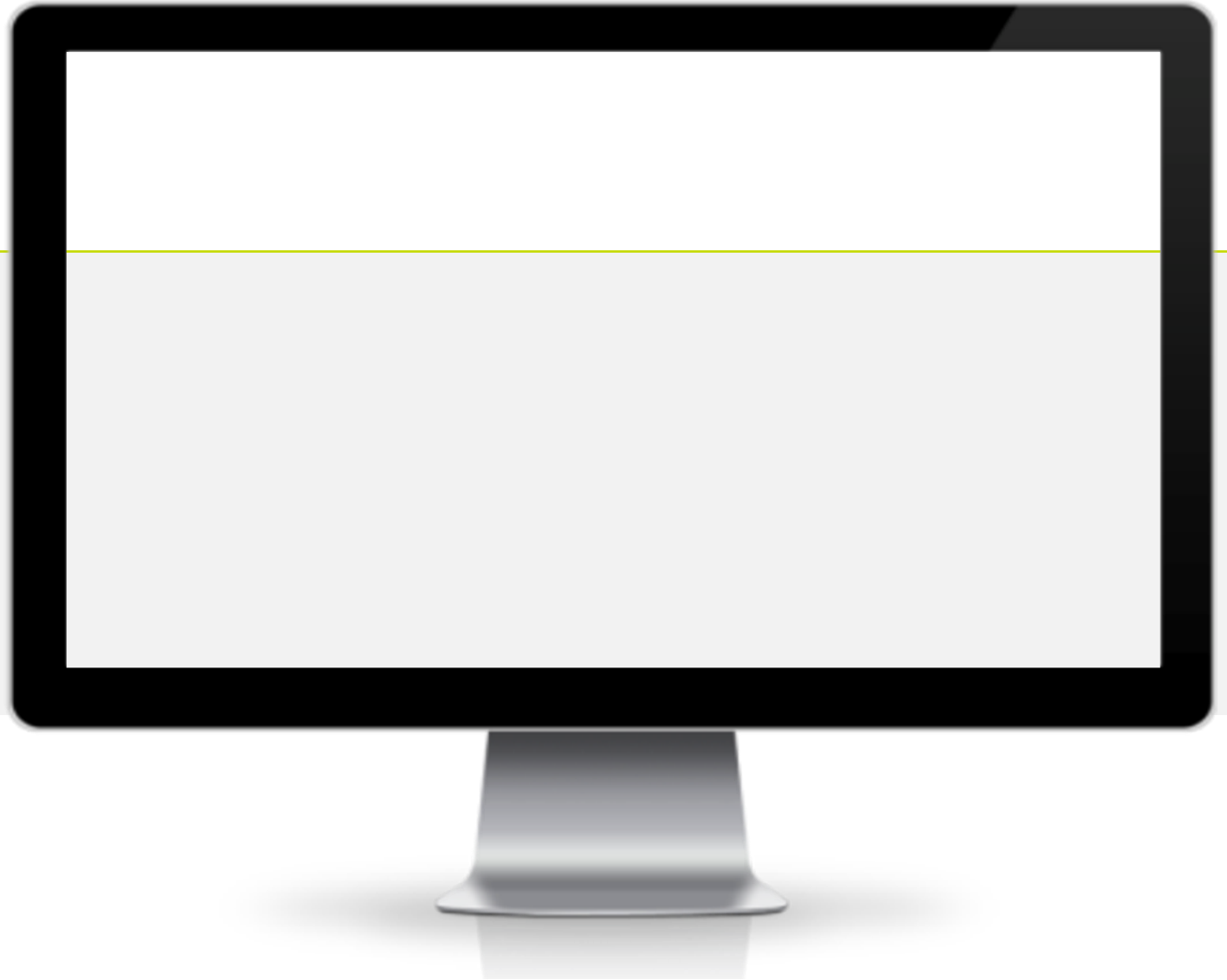
Commercial projects



2022
30 tpd optimized plant
from 2019



Blueenzyme™ 200 Virtual tour



BLUENZYME 200

Industrialized Product to capture 200 TPD of CO₂

Design Drivers

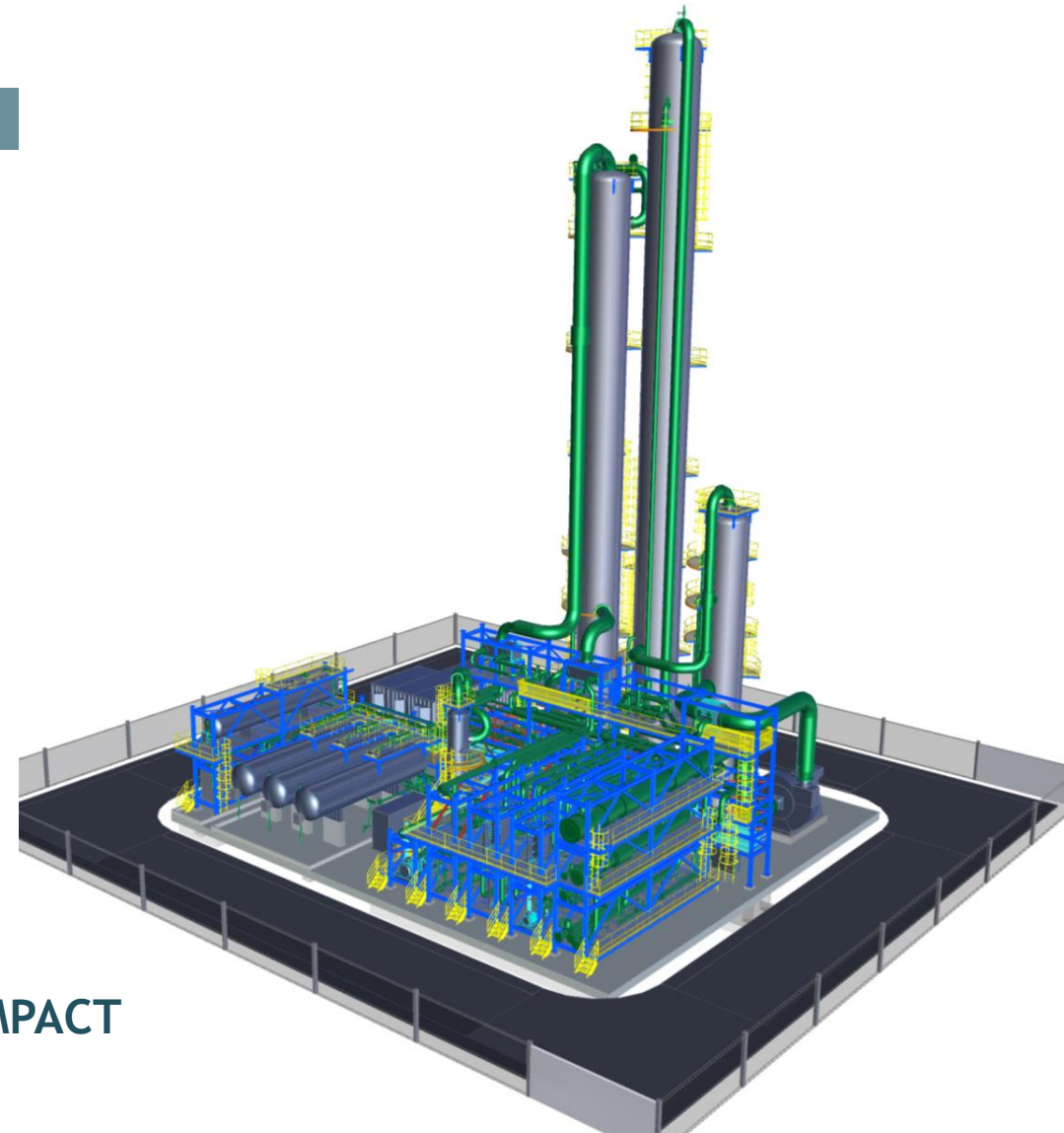
Modular design - compatible with truck transportation

Plug & Play - concept Minimization of site works: module fast hook-up and minimal underground works

Efficient supply chain - Dedicated Supply Chain to support delivery



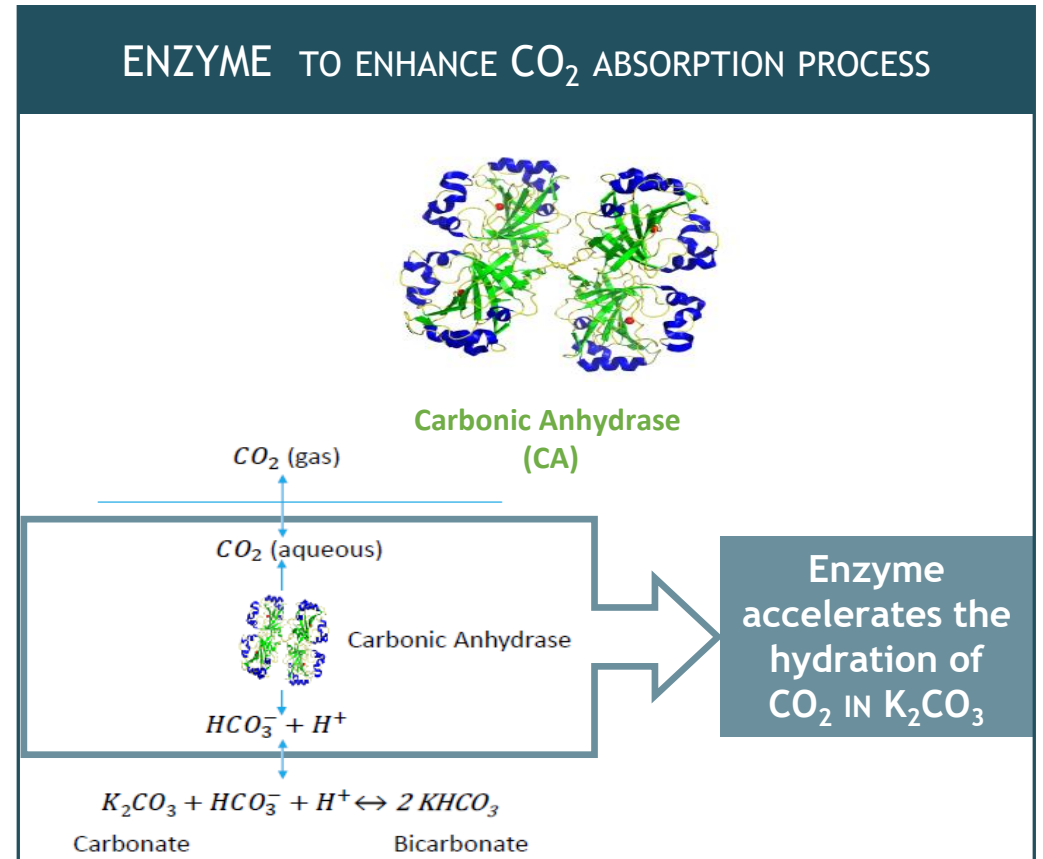
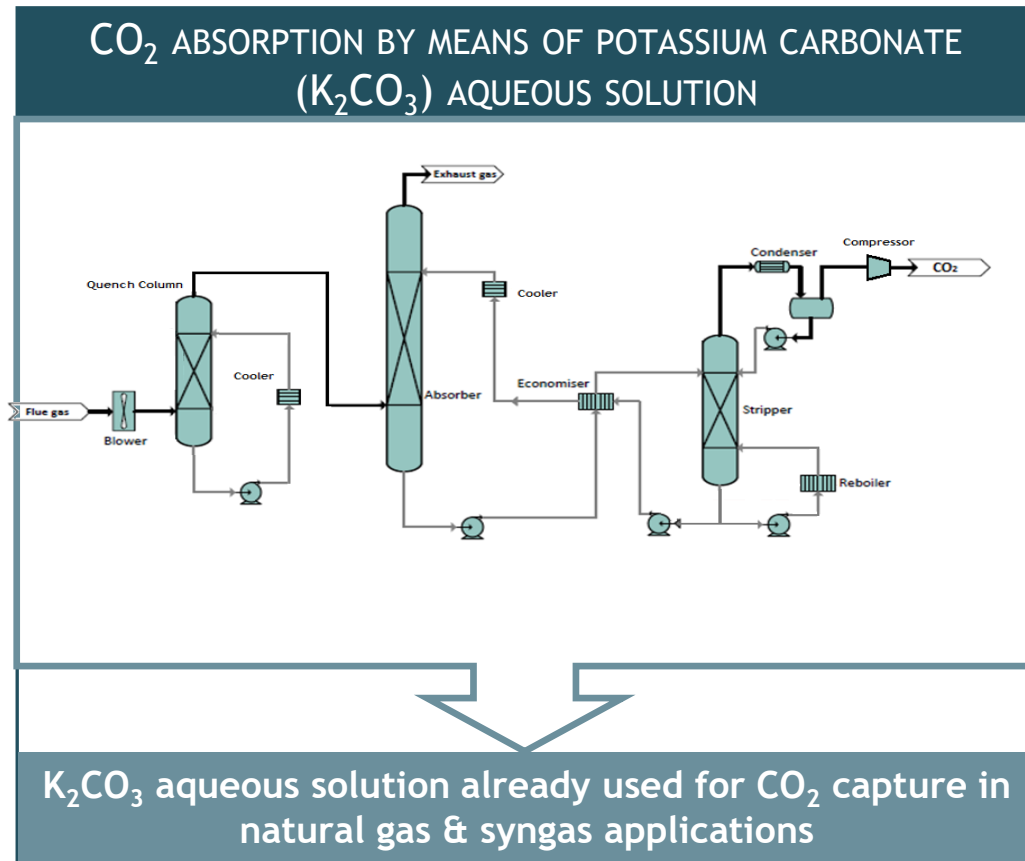
READY-MADE PRODUCT WITH LOW ENVIRONMENTAL IMPACT



CARBON CAPTURE PROPRIETARY TECHNOLOGY

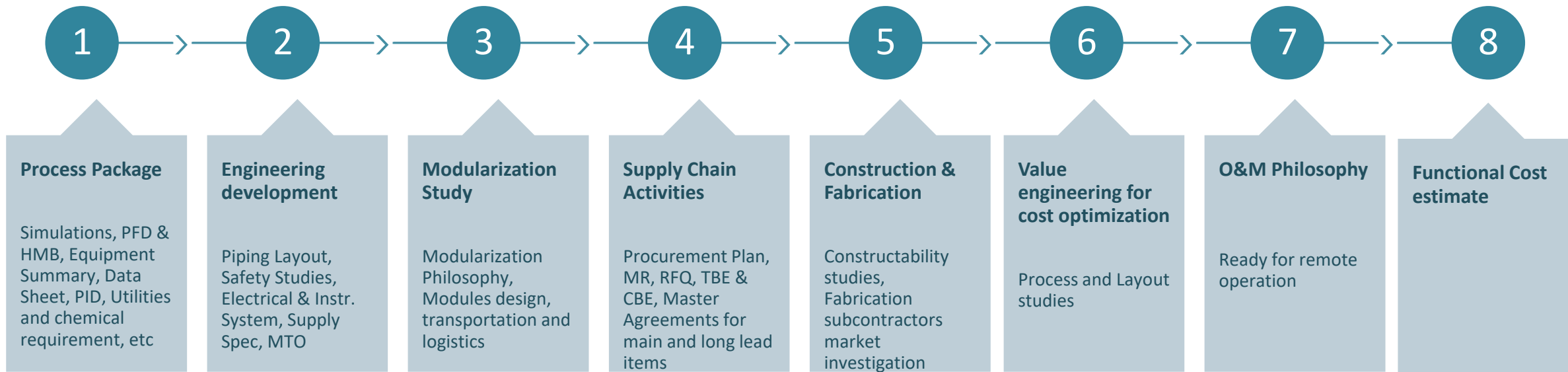
A Simple Solution

K_2CO_3 is an attractive solvent but is kinetically slow
the use of K_2CO_3 + enzyme assures a high CO_2 capture rate



BLUENZYME 200

Main Elements Of The Industrial Solution Package



Pre-engineered Package to secure cost and de-risk the delivery schedule



BLUENZYME 200

Technical Features and Performances

Typical Flue Gas

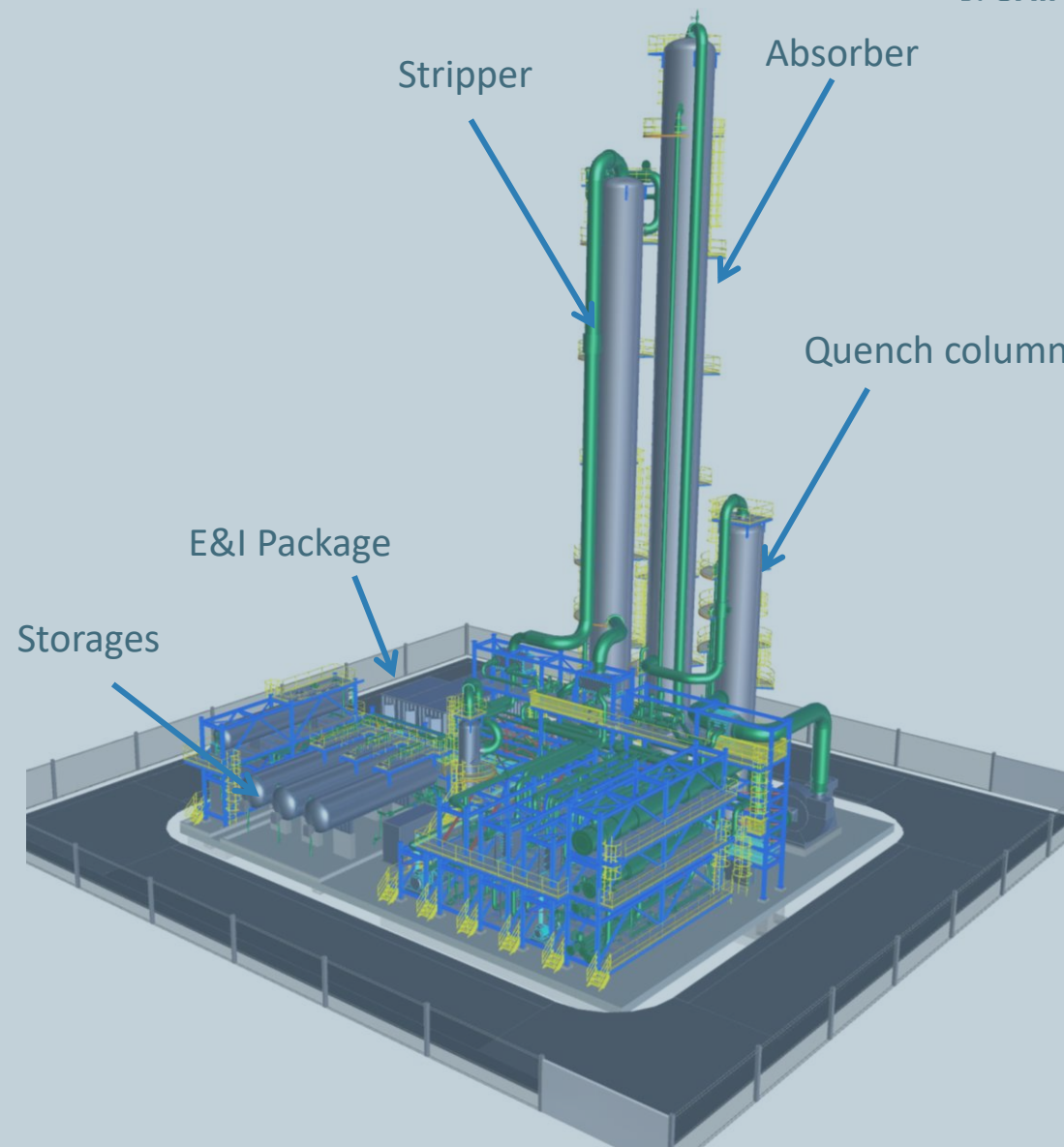
- Exhaust Flow = **47,000 Nm³/h**
- Flue gas CO₂ content = **10% vol (wet)**

Performances

- **> 90%** CO₂ Capture Efficiency
- **200 TPD** CO₂ Capture rate
- **96%** Plant Availability (based on RAM analysis)
- **50%** Plant Turndown

Features

- **21** truckable modules
- Max module size = **14 m x 2.5 m x 4 m**
- Overall Layout = **40 m x 35 m**



SAIPEM IN CCUS

Building on 60+ Years of Relevant O&G EPC Experience

Saipem can master the entire CCUS value chain, thanks to its solid background in process technology, pipeline fluid transportation and reinjection, brownfield repurposing and its new propriety carbon capture technology “CO₂ Solutions by Saipem”

70+

CO₂ REMOVAL PLANTS

>130,000 KM

PIPELINES INSTALLED

136+

PLANTS transform CO₂ into Urea with Snamprogetti™ Technology

7,000+

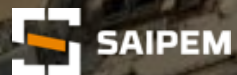
WELLS DRILLED

25+

FLOATING UNITS

85+

MTPA of LNG



Capture



Re-use



Transport

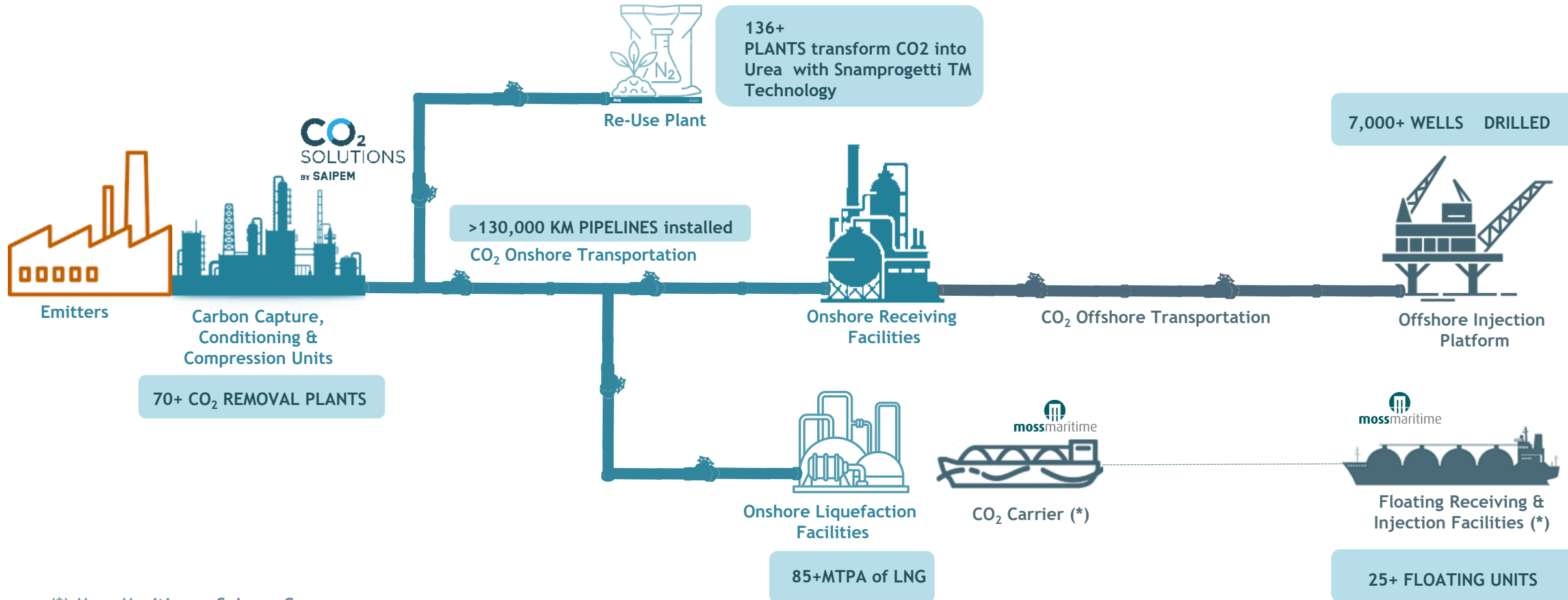


Storage

Sonsub

END-TO-END CO₂ MANAGEMENT

Saipem Can Manage Entire CCUS Value Chain



(*) Moss Maritime a Saipem Company



END-TO END CO₂ MANAGEMENT

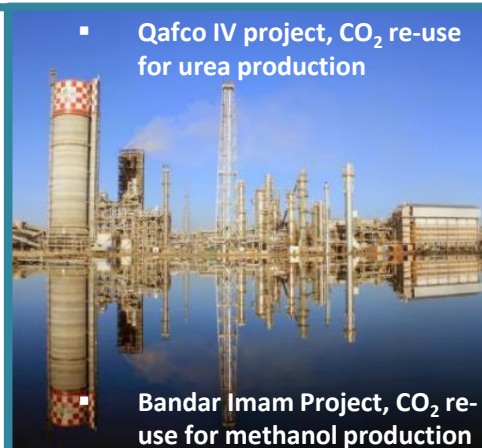
Saipem Flagship Projects in the CO₂ value Chain

CARBON CAPTURE, CONDITIONING & COMPRESSION UNITS



- Ras Laffan Project, acid gas re-injection in dense phase in an LNG facility
- P79 Project, acid gas re-injection in dense phase in an FPSO

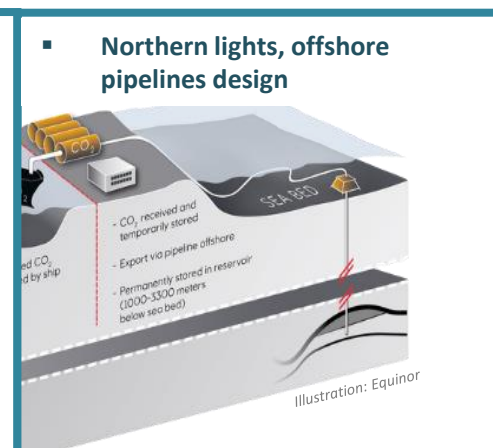
RE-USE PLANT



- Qafco IV project, CO₂ re-use for urea production

Bandar Imam Project, CO₂ re-use for methanol production

CO₂ OFFSHORE TRANSPORTATION



- Northern lights, offshore pipelines design

- CO₂ received and temporarily stored
 - Export via pipeline offshore
 - Permanently stored in reservoir (1000-3300 meters below sea bed)

Illustration: Equinor

LCO₂ CARRIER



- Northern Light Project, LCO₂ Cargo handling system
- CETO Project, design of LCO₂ carrier

FLOATING RECEIVING & INJECTION FACILITIES



Stella Maris CCS
 The Stella Maris CCS Project

CO₂ SOLUTIONS BY SAIPEM

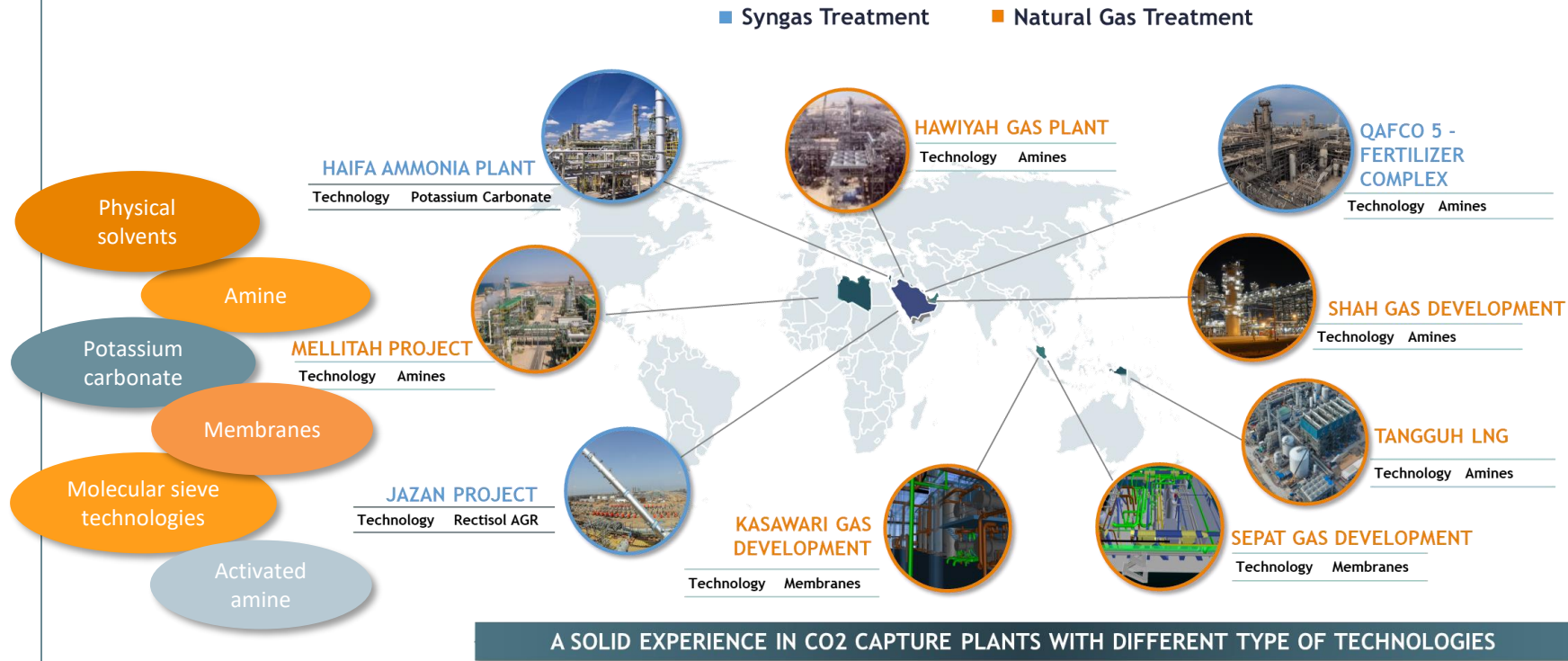
CO₂ CAPTURE



- Bluenzyme™ 200

CO₂ CAPTURE

Deep Knowledge Of Proven And Reliable Technologies



And now..

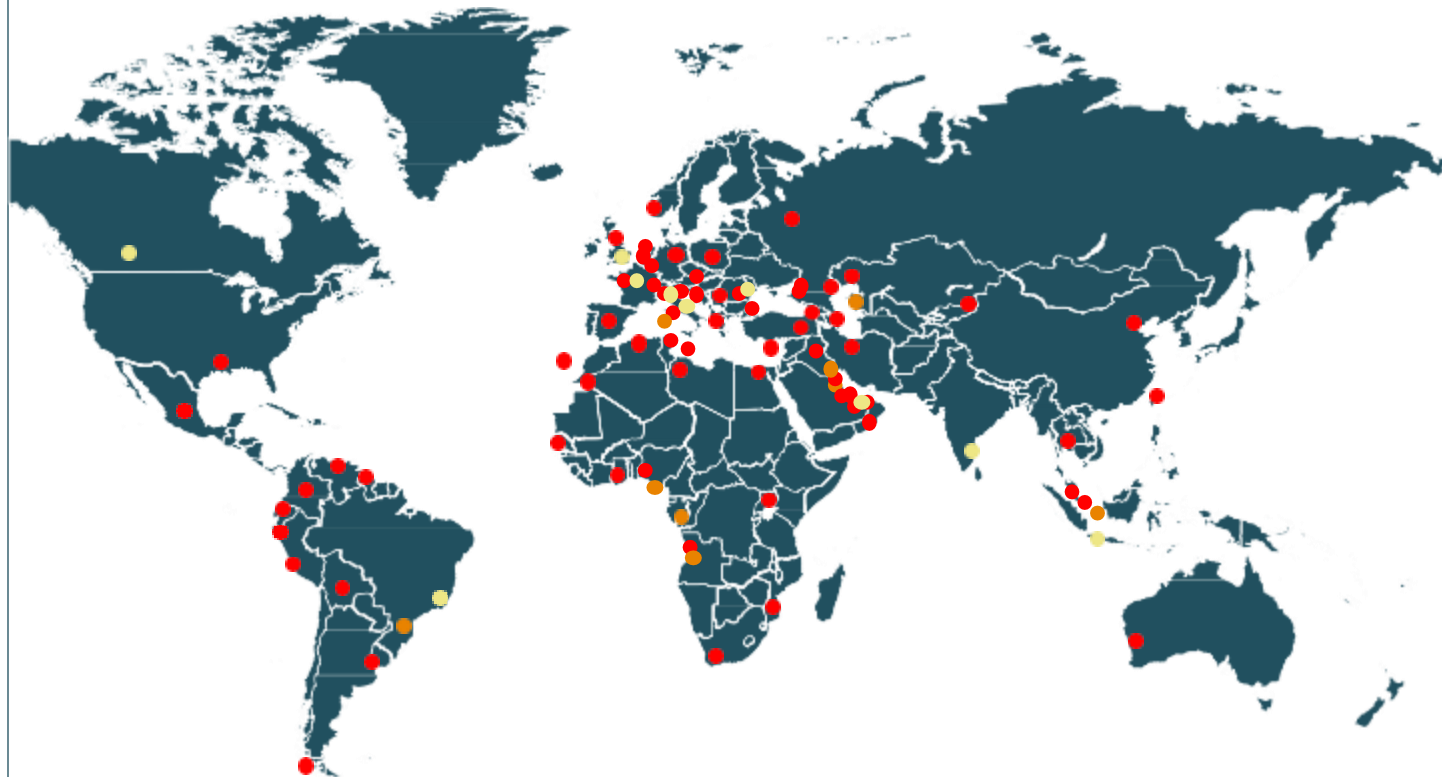
A Proprietary technology for Post-combustion CO₂ Capture



And an established Collaboration with



SAIPEM IN THE WORLD



- Engineering centres
- Prefabrication yards
- Other relevant sites (headquarters, branches, etc.)



KEY FIGURES *

WE OPERATE IN **> 55** COUNTRIES

> 30,000
EMPLOYEES WORLDWIDE

> 129
DIFFERENT NATIONALITIES

8 PREFABRICATION YARDS
Italy, Brazil, Republic of the Congo, Angola, Saudi Arabia, Indonesia, Kazakhstan, Nigeria

7 ENGINEERING HUBS
Italy, Mexico, France, UAE, India

40 VESSELS

298 M €
INVESTMENTS

2,827
ACTIVE PATENTS

* as of 2021

Key takeaways



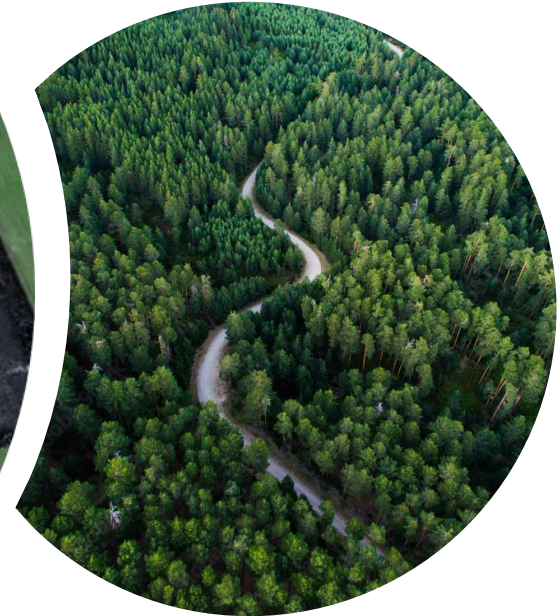
Reliable

- Simple process
- Tolerant to contaminants
- Less equipment



Efficient

- Yields high purity CO₂
- Capture > 90% of CO₂ in fluegas
- Catalyzed solvent
- Runs on low-grade residual heat



Sustainable

- Non-toxic solvent & no toxic waste
- No formation of toxic aerosols
- Longer lifetime due to less corrosion

Thank you!



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Klaus Skaalum Lassen

Business Lead
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