Optimized CO_2 Capture with New Demixing Solvent Technology DMX™

Clément Salais

Axens SOLUTIONS

Content

1 Basis for Axens' Involvement in CCS

60 Years of Operational Experience & Technology Improvement in Gas Sweetening

1957
First DEA

1977
MDEAmax
H_2S Removal

1987
Energized **MDEA**
CO_2 removal/deacidification

2005
SPREX®
H_2S Bulk Removal
(+RSH)

2008
HySWEET®
Acid Gas + RSH Removal

2013
COSWEET™
Deep COS Removal

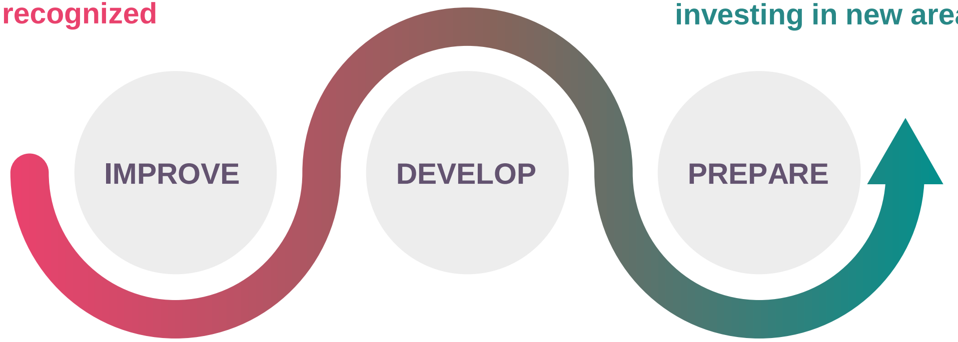
2016
AGAT™
Acid Gas

A Strategy Embedded to Operators Challenges

Consolidate and reinforce our offer in the fields in which we are recognized

Build on “adjacencies”

Prepare our offer for a low-carbon future by investing in new areas



- Catalysts / Solvents
- Revamping
- Energy Efficiency
- Catalysts Life Cycle Analysis
- Digitalization

- Oil to Chemicals
- Biofuels or Biochemicals

- Waste plastic recycling
- **CCS**

Axens/IFPEN Involvement in CCS Projects

CO_2 3D
DMX DEMONSTRATION DUNKIRK

Sleipner | AdvAmine™

Solaize | Pilot Tests

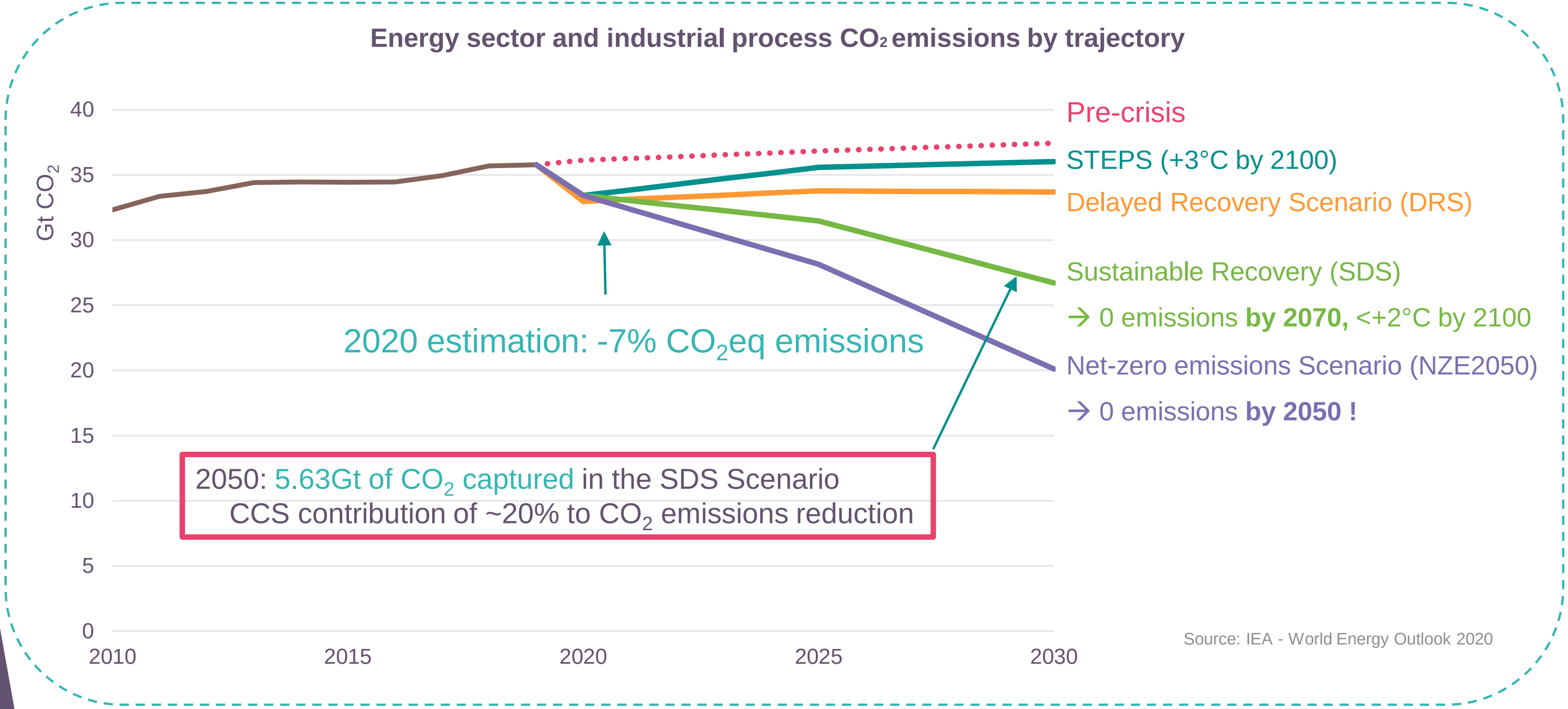
Brindisi | Pilot Tests

In Salah | CO_2 Drying

Rhourde Nouss | CO_2 Drying

2 CCS a Major Tool to Fight GHG Emissions

Evolution of Energy Sector Emissions – IEA Scenarios



Current CCS Facilities Around the World

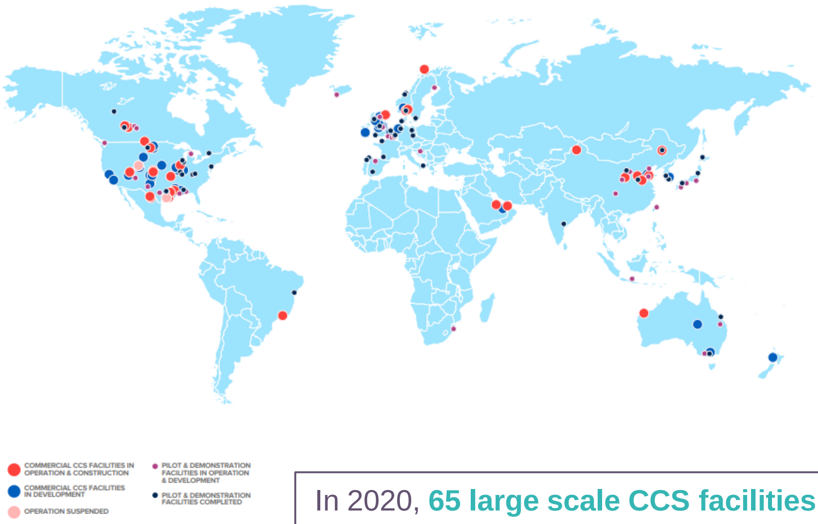


FIGURE 5 WORLD MAP OF CCS FACILITIES AT VARIOUS STAGES OF DEVELOPMENT

In 2020, **65 large scale CCS facilities**:

- 26 in operation
- 3 under construction
- 13 in advanced development
- 21 in early development
- 2 on hold

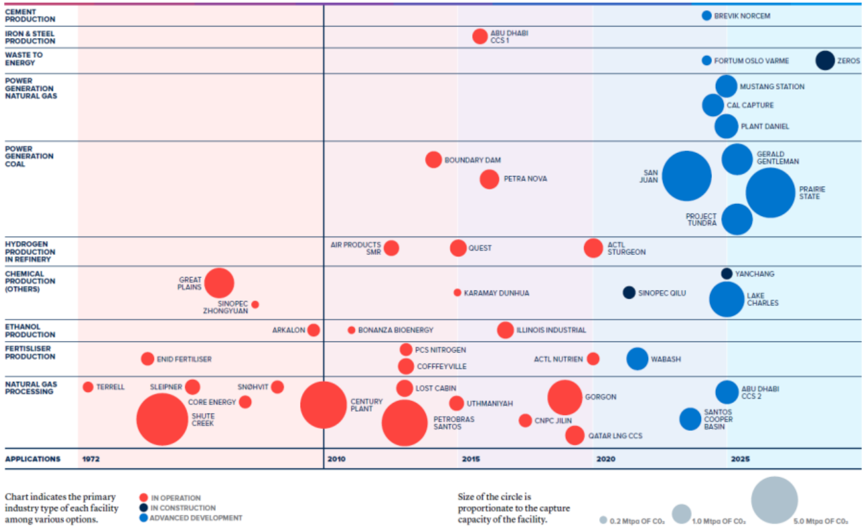
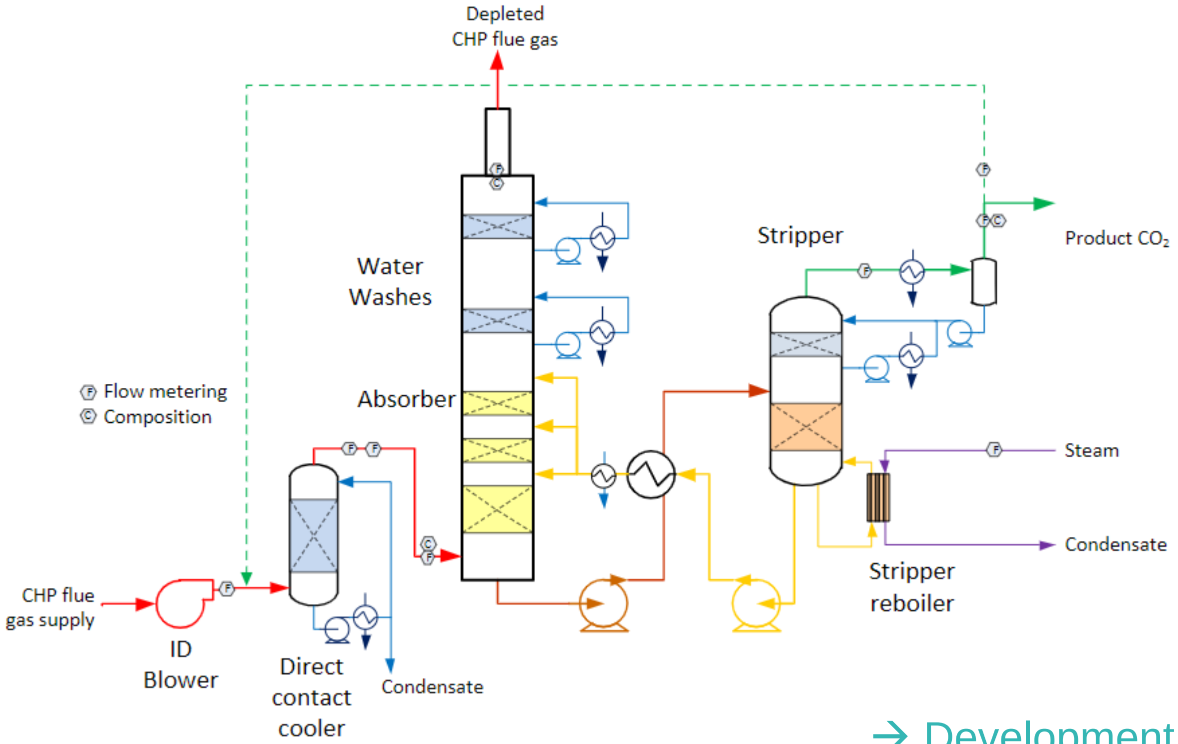


FIGURE 6 A PORTFOLIO OF COMMERCIAL CCS FACILITIES IN VARIOUS POWER AND INDUSTRIAL APPLICATIONS FACILITIES INCLUDE THOSE IN OPERATION, UNDER CONSTRUCTION AND IN ADVANCED DEVELOPMENT. AREA OF CIRCLES IS PROPORTIONAL TO CURRENT CCS CAPACITIES.

Source: Global CCS Institute, Global Status of CCS 2020

3 The DMX™ Process

Absorption of CO_2 on Flue Gas – MEA Based Process

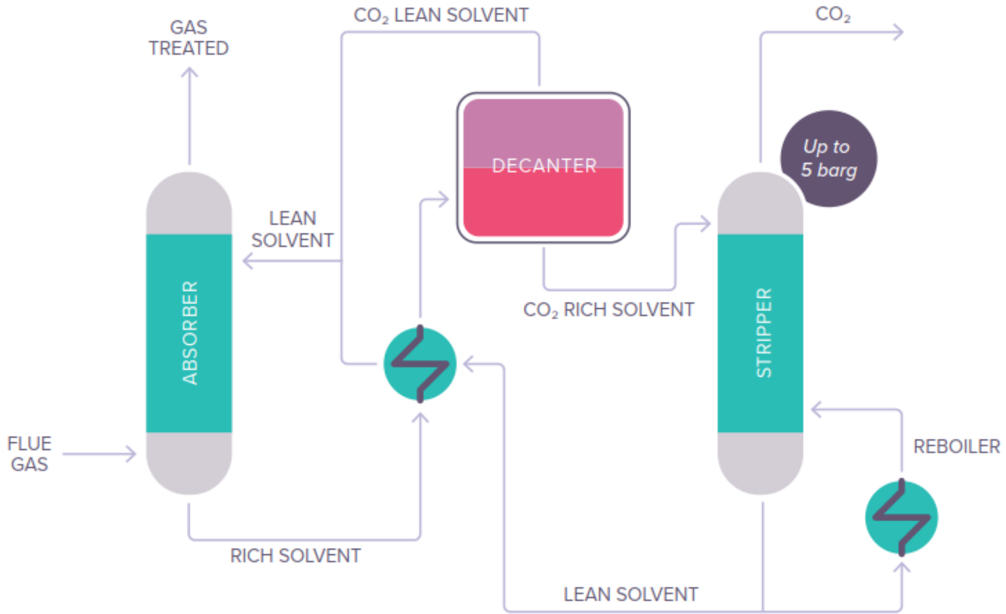


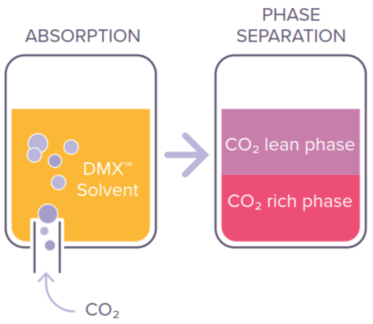
Courtesy of Energy Procedia, GHGT-12

- Energy intensive
  - **3.7 GJ/ton CO_2**
- High solvent degradation rate
  - Solvent reclaiming
  - Volatile compounds
  - High grade metallurgy

→ Development of new technologies

Absorption of CO_2 on Flue Gas – DMX™ Process





- DMX™ Solvent:
  - Demixing capability
  - High capacity (4 times MEA)
  - Thermally stable
  - Low sensitive to oxygen

DMX™ Process – Features

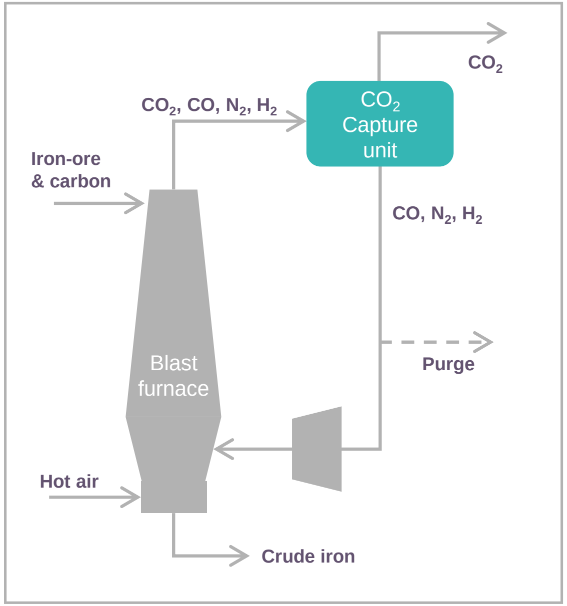
DMX™ Property		Main Impact
Higher CO_2 capacity (x4 MEA)	→	Lower solvent circulation rate
Lower energy consumption for regeneration	→	Smaller regeneration section and lower OPEX
Regeneration of the CO_2 rich phase only	→	Smaller Stripper and reboiler
Less sensitive to O_2	→	Lower by product emission, lower solvent consumption
Thermally stable solvent	→	CO_2 recovery under pressure (5 barg). 1st stages of CO_2 compression not required

→ **High potential of energy saving: up to 30% reduction on energy penalty**

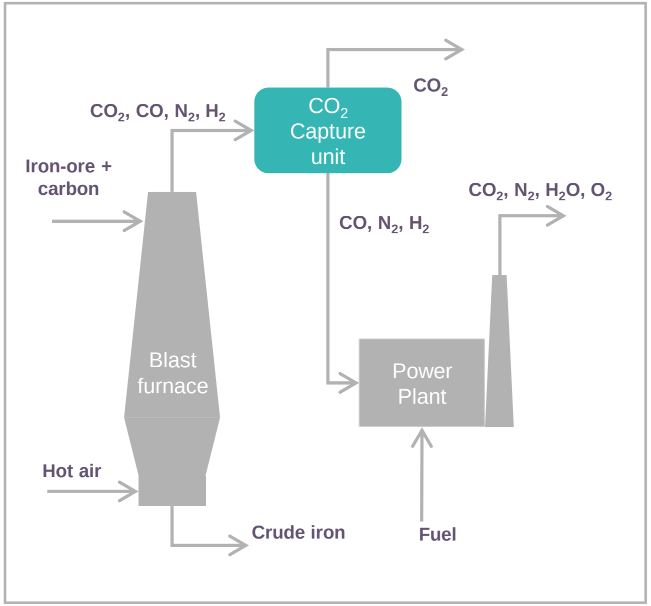
4 Techno-Economic Study in the Steel Industry

CO_2 Capture in Steel Industry: Studied Cases

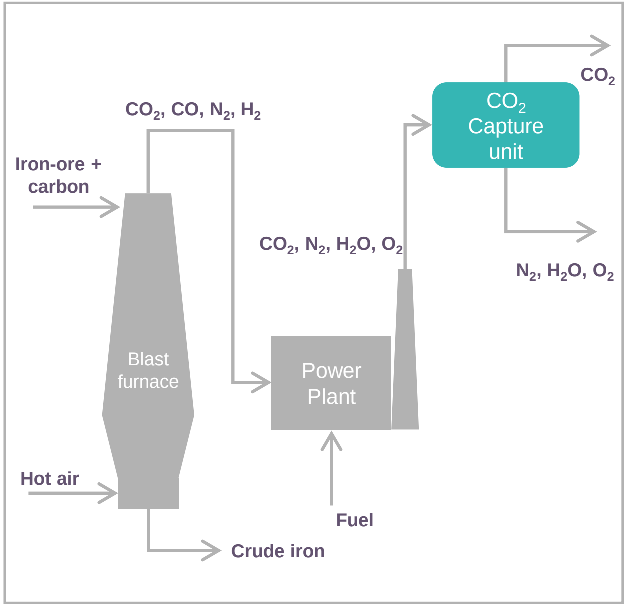
« Top of Gas Recycle» (TGR)



« Blast Furnace » (BF)



« Power Station » (PWS)

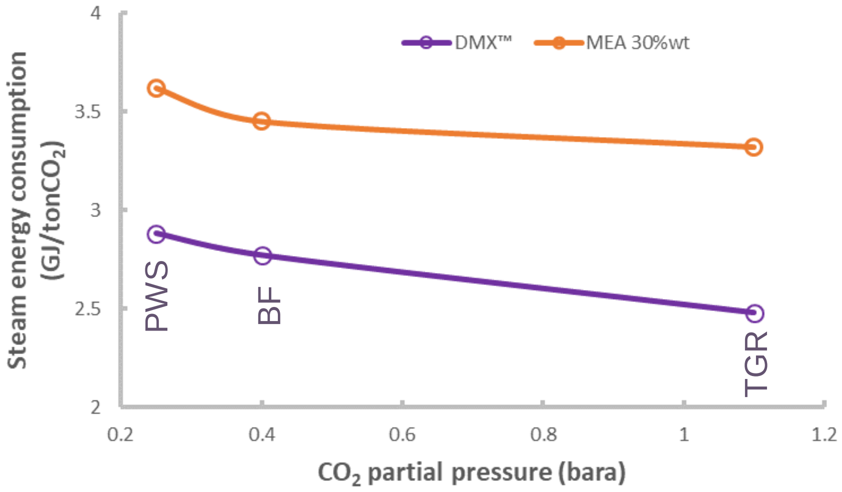


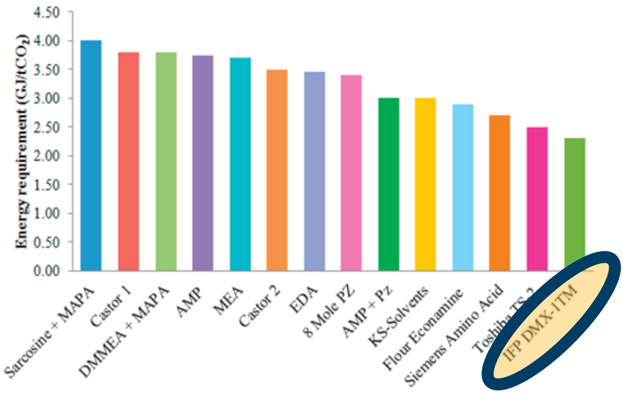
CO_2 Capture in Steel Industry: Gas Characteristics

- TGR and BF
  - High quantities of CO
  - No oxygen
  - P > atm
  - Higher PP_{CO2}
- PWS
  - Similar to coal-fired power plant

	Unit	Top Gas Recycle (TGR)	Blast Furnace (BF)	Power Station (PWS)
Flowrate	Nm^3/h	245,000	390,000	541,700
Temperature	°C	30	80	126.9
Pressure	Bara	3.0	2.15	0.99
CO_2 capture rate	%	> 99	90	90
H_2	Vol.%	7.04	4.45	-
N_2	Vol.%	9.21	46.7	63.35
O_2	Vol.%	-	-	2.42
CO	Vol.%	46.71	25.15	-
CO_2	Vol.%	37.04	23.70	27.10
H_2O	Vol.%	-	-	7.13

CO_2 Capture in Steel Industry: Techno-Economic Study





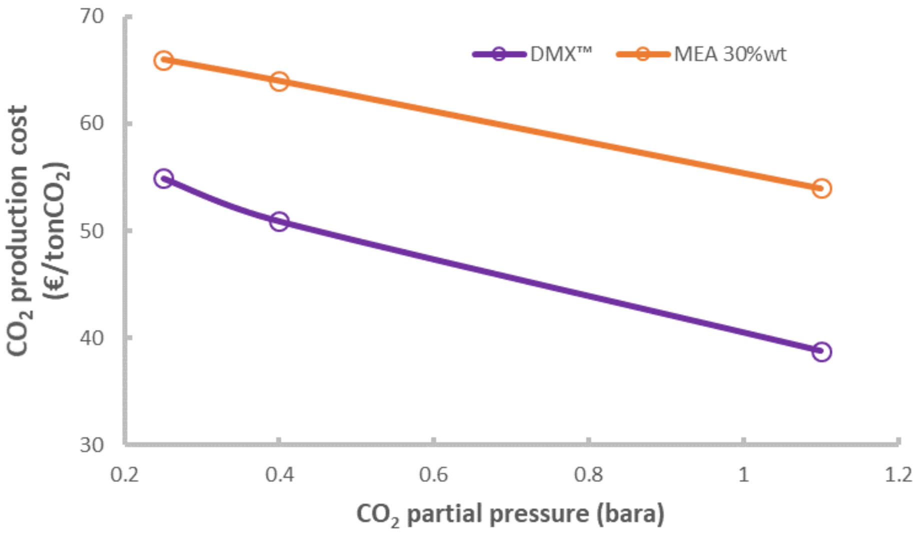
Source: Singh P. (IEAGHG), et al., Energy Procedia 37 (2013) 2021-2046, Oral présentation , GHGT-11, Kyoto, 2012.

- 30% OPEX (vs MEA)

- 25% savings on steam energy consumption
- 2.5 $GJ/tonCO_2$ achieved on TGR case with $99\%^+$ capture rate

CO_2 Capture in Steel Industry: Techno-Economic Study

- Steam assumed to be produced by dedicated boiler
  - 21€/ton steam
- Cost of CO_2 captured
  - 40€/tCO_2 on TGR case
  - can be further reduced with heat integration



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Industrial Demonstration of DMX™

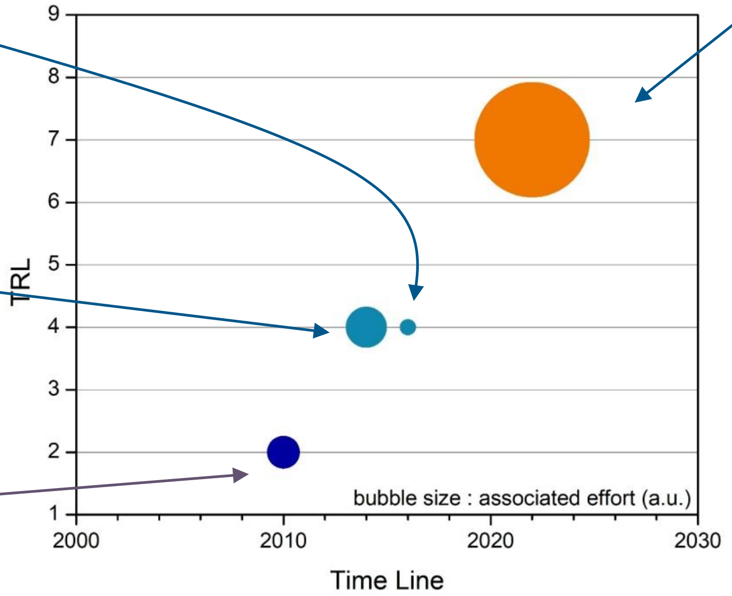
3D & DinamX Projects

DMX™ Process - Technology Readiness Level (TRL)

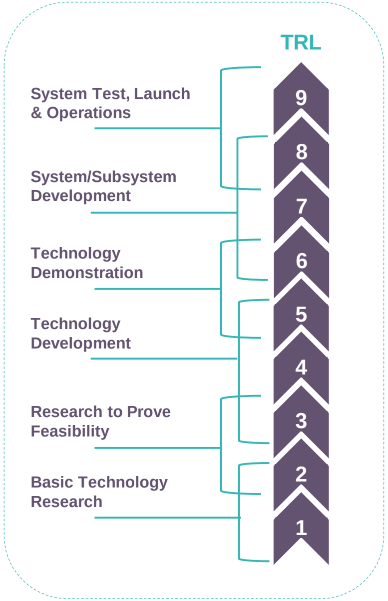
VALORCO project (steel mill case)

OCTAVIUS (coal case)

Lab tests @ IFPEN



3D project



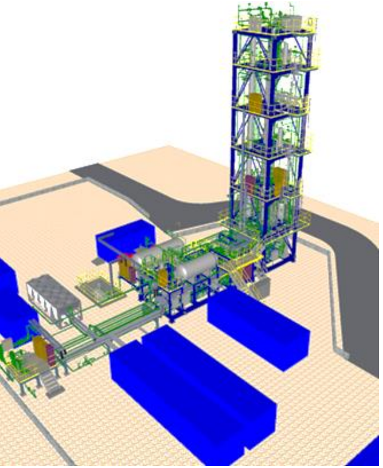
3D Project

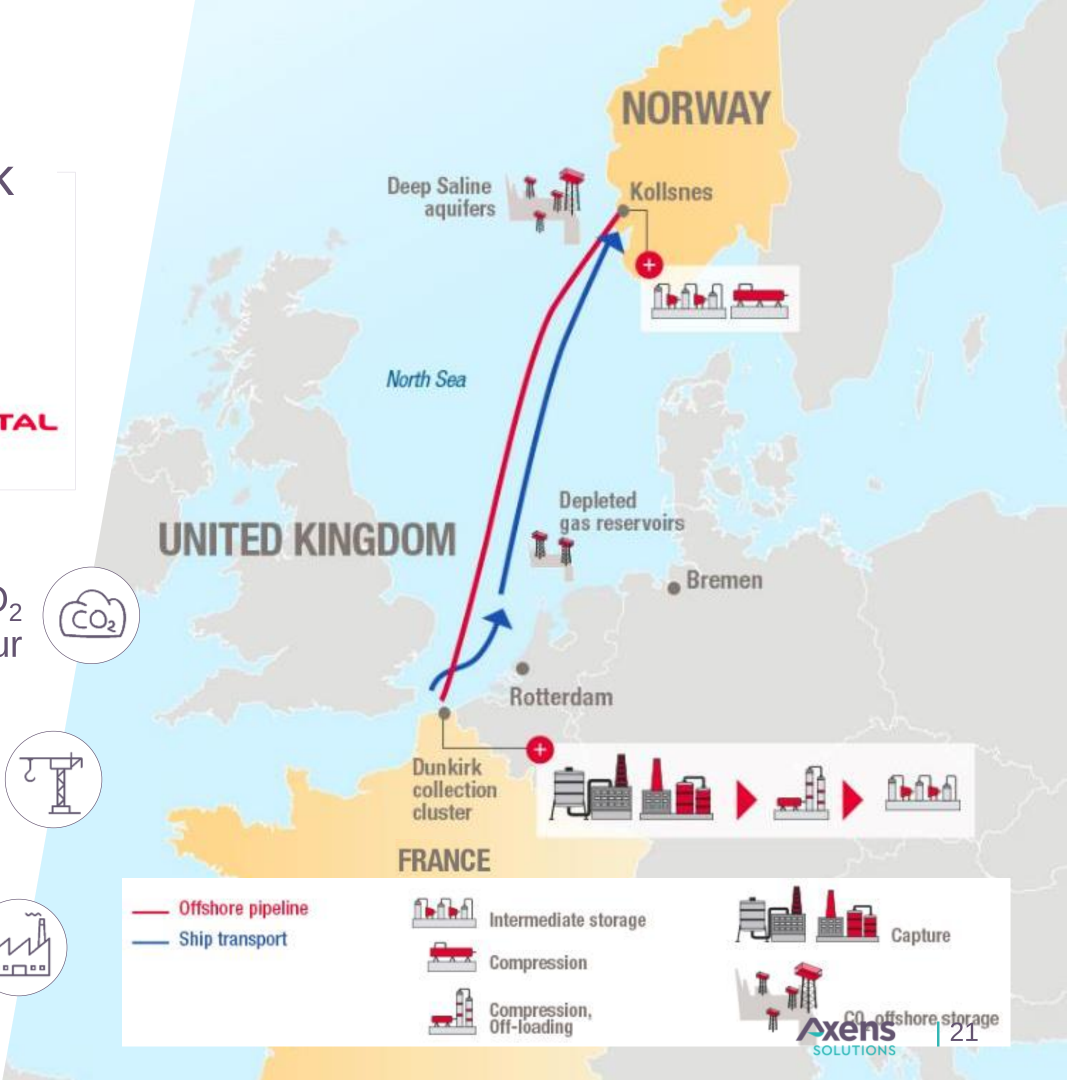
DMX™ Demonstrator in Dunkirk

Capacity = 0.5 t CO_2 captured/hour

Construction in progress @ ArcelorMittal steel mill in Dunkirk

Operation: early 2022





dinamX project

démonstration et applications innovantes du DMX™

- Started January 2020
- Applicability of DMX™ Process to other French industrial emitters
- Techno-economic evaluation

- Studied cases
  - Cement industries (Lime production)
  - Waste to Energy / Incineration

Acknowledgments

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Thank you!

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