TotalEnergies

A welcome from TotalEnergies

PÉTROLE GAZ ÉLECTRICITÉ HYDROGÈNE

BIOMASSE ÉOLIEN SOLAIRE

CCS and CCU as parts of the industrial carbon management chain

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Avoid

Avoid emissions before they happen

- Energy mix evolution: multi-energy approach
- Sanction projects with lowest possible emissions
- Design assets to limit emissions

- 10% Energy produced from renewables
- 20% CAPEX ➔ REN

Reduce

Reduce emissions of existing assets

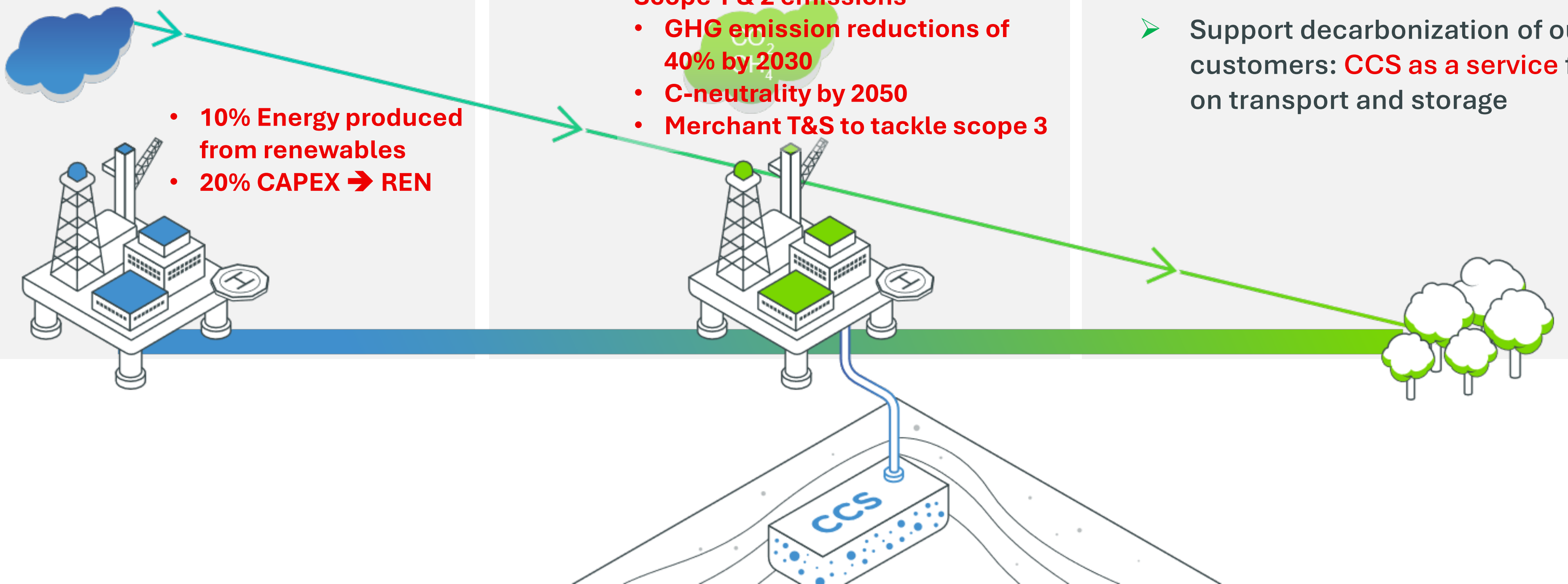
- Development of Carbon Footprint Reduction projects and practices
- CCS projects for TotalEnergies' assets
- Utilize CO_2 for eFuels and other materials

Scope 1 & 2 emissions

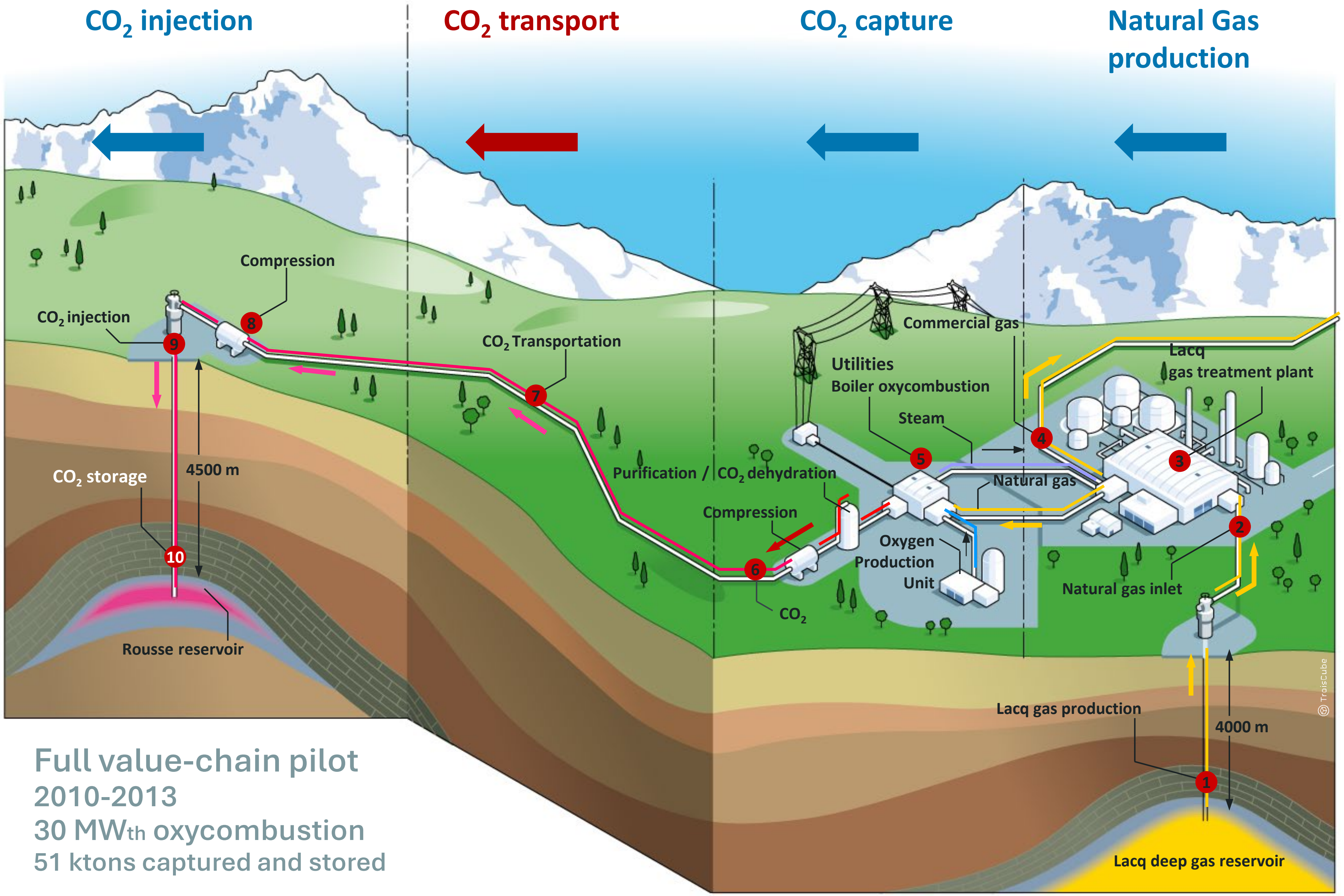
- GHG emission reductions of 40% by 2030
- C-neutrality by 2050
- Merchant T&S to tackle scope 3

Compensate

- Compensate for residual emissions that could not be avoided or reduced:
  - Natural Based Solutions: developing natural carbon sinks
  - Other offsetting solutions incl. Cookstoves, Direct Air Capture CCS (DACCS), Bio-Energy CCS (BECCS)…
- Support decarbonization of our customers: CCS as a service focused on transport and storage



Lacq and Rousse: A complete CCS chain



Full value-chain pilot
2010-2013
30 MWth oxycombustion
51 ktons captured and stored

Take home points

Full CCS chains are largely feasible

Technical difficulties manageable

More difficult to manage:
- Public perception
- Political acceptance

Additional points
- Small scale project
- Things have changed since 2013

Northern Lights development; leveraging the existing onshore and offshore infrastructure in Øygarden, Norway.

GASSNOVA equinor Shell TotalEnergies

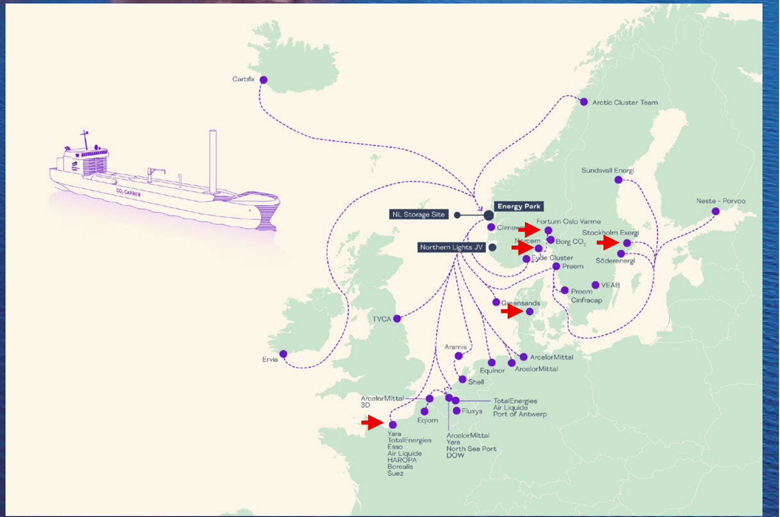
1st injection : August 2025

Phase 2 : +3.5 Mtpa

Phase 1 : 1.5 Mtpa

CO_2 from:

- **Cement (Heidelberg, Brevik, NO)**
- **Ammonia prod. (Yara, NL)**
- **Waste to Energy (Stockholm Exergi (SE), Ørsted (DK), … Celsio (NO))**



Deploying CCS strategy

Reducing emissions and developing profitable business

CCS for our assets

Reduce emissions from existing assets

- Ichthys (Australia)
  under study
- Cameron LNG (US)
  Hackberry Carbon Sequestration project under study *(with potential to decarbonize other industrial emitters)*
- Refineries

Avoid emissions in greenfield projects

- North Field East & South (Qatar)

Offering CCS services

Build a profitable, scalable business and offset Scope 3 emissions by offering CCS solutions to our customers

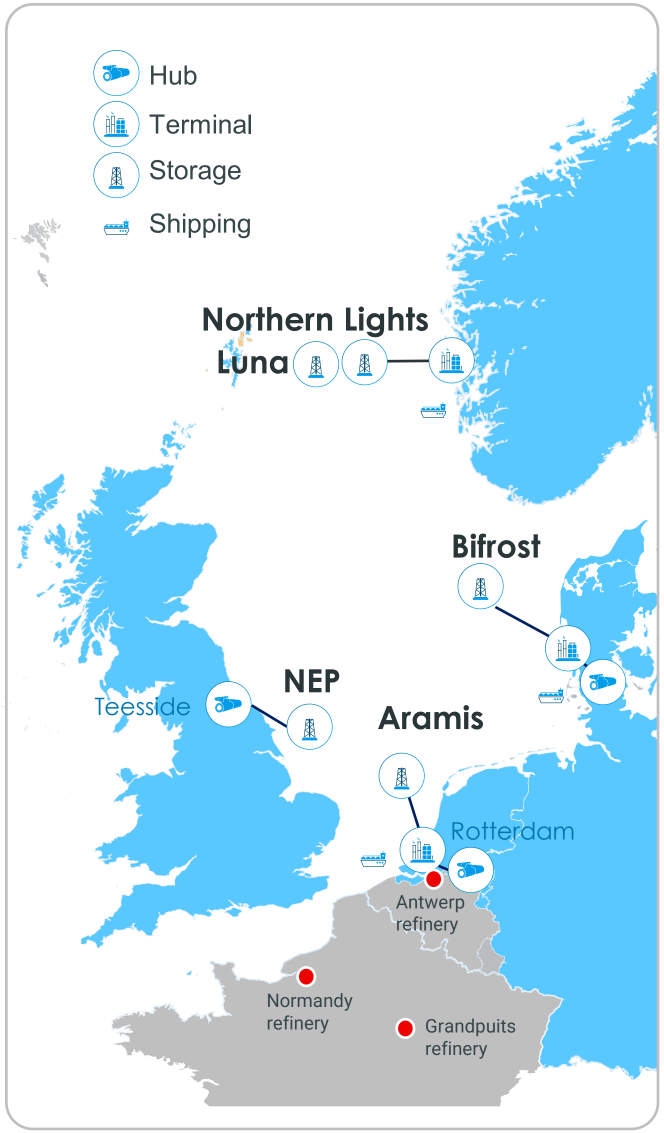
North Sea core area

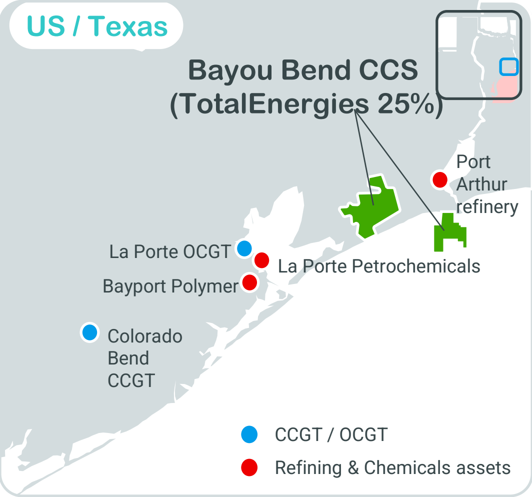
- Construction completed, Northern Lights
- Under development/study:
  - Focusing on our depleted assets and saline aquifers
  - Aramis (NL, op.), Bifrost (Denmark, op.), NEP (UK), Luna (Norway)

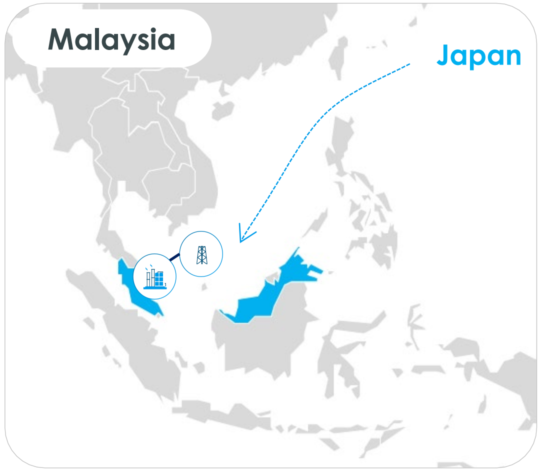
Worldwide growth

- Bayou Bend (US), Southern Cluster (Malaysia)

2030 target (Company share)
> 10 Mt/y

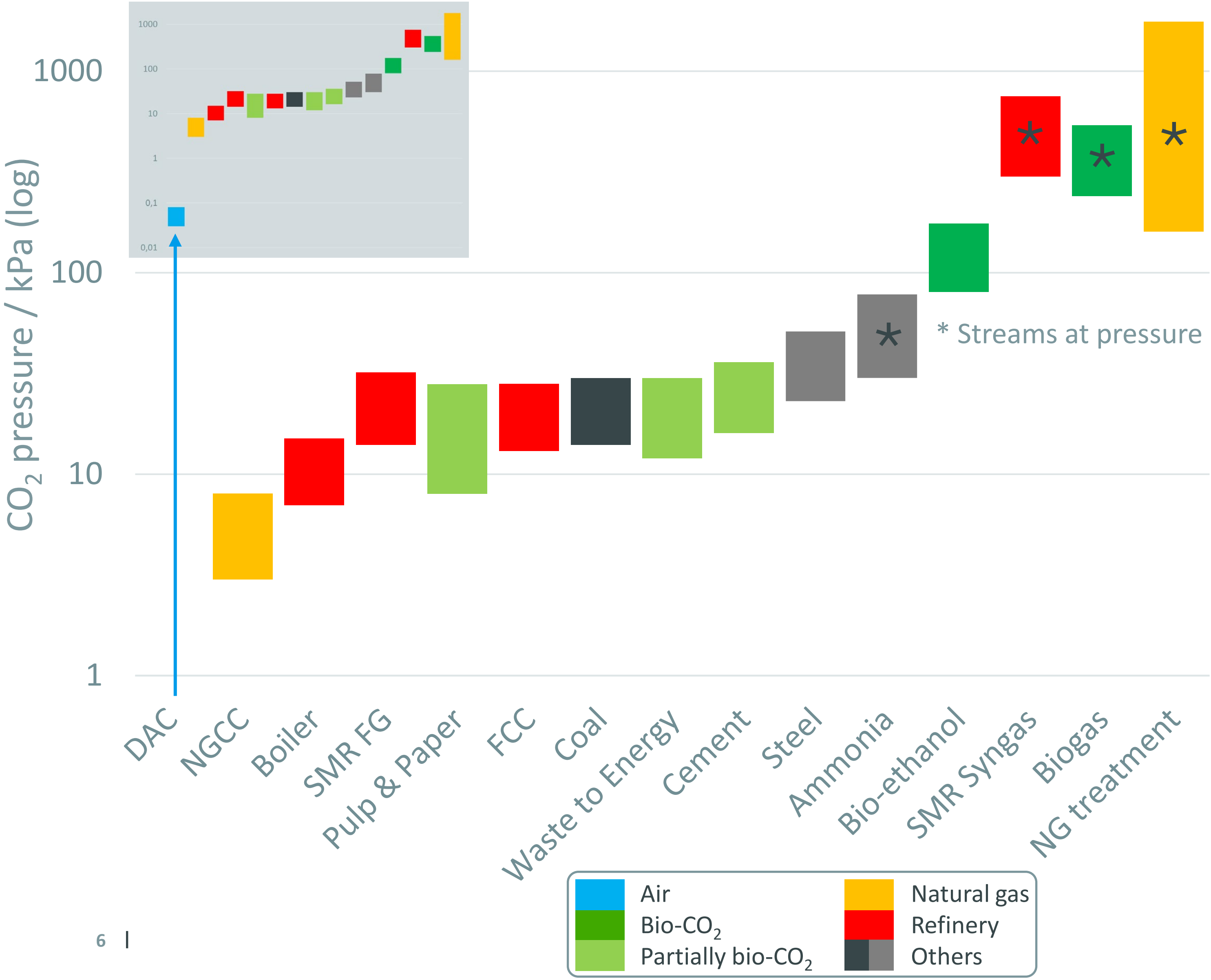






A diversity of sources where we can capture CO_2

→ which ones are best suited for capture? Sector, Techno., Quantity, Time for deployment



Stream	Main	Contaminant
Air	N_2	O_2, H_2O
NGCC, boiler, SMR FG	N_2	O_2, H_2O, NO_2
P&P	N_2	VOC, CO, NOx, SOx, dust
FCC, coal	N_2	O_2, H_2O, NOx, SOx, dust (Hg)
WtE, cement	N_2	NOx, SOx, HCl, HF, metals, dioxins, furans
Steel	N_2	CO, H_2, particulates
SMR SG	CO, H_2	CH_4
NG, biogas	CH_4	H_2S

- Key challenge of contaminants
- Developing Hubs or Clusters

TCM Norway

Owners : Shell, equinor, TotalEnergies, GASSNOVA

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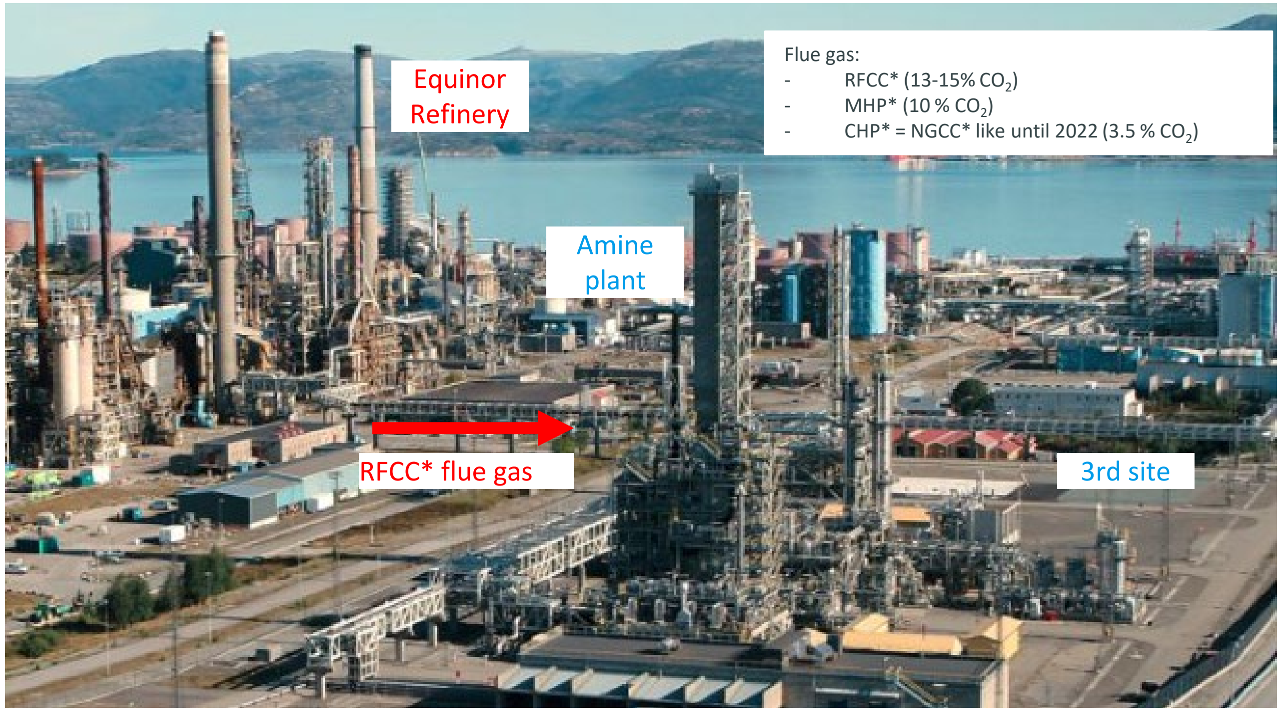
Objectives: open test center for accelerating CO_2 capture deployment and technology derisking



Amine Plant (75 kT_{CO2}/y ~ 12 MWe)

- Benchmark of solvents at the industrial scale
  ⇨ TRL 6-7
- Evaluation of Solvent performance
  - Energy
  - Solvent Degradation
  - Solvent Emission Monitoring
- Design data for scale up
- Operational issues (corrosion, foaming…)

3rd site (18 kT_{CO2}/y ~ 3 MWe)

Plug and play, non-solvent technologies

⇨ More disruptive technologies, lower TRL (4-5)

2012 | 2012 - 2014 | 2014 - 2015 | 2015 - 2016 | 2016 | 2016 - 2017 | 2019 | 2021 | 2022 | 2023

Aker Solutions, ALSTOM, Cansolv 1st campaign, Carbon Clean Solutions, Cansolv 2nd campaign, ION, FLUOR, MITSUBISHI HEAVY INDUSTRIES, RTI, Cansolv 3rd campaign, ION — Solvent Technologies

MTR, TDA, MOF4AIR, ACCSESS, InnoSepra — Emerging Technologies Membranes, Adsorbents, RPB, enzyme

*
RFCC: Residue Fluid Catalytic Cracking
MHP: Mongstad Heat Plant
CHP: Combined Heat and Power
NGCC: Natural Gas Combined Cycle power plant

TotalEnergies is agnostic with respect to capture

A broad diversity of 'emerging' CO_2 capture technologies

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Air

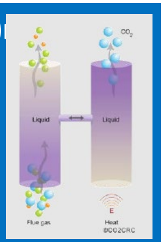
Biogenic
Biogas
Fermentation

Process
Cement
Steel
Refinery
Nat. Gas treatment

Energy
Coal
NGCC
... boilers

X

Absorption (alt. solvents)

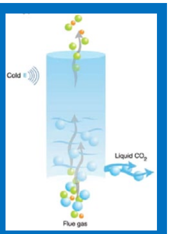


Syngas	TRL 8
Flue gas	TRL 6
DAC	TRL 6

+ Well established
  Pure CO_2

− Heat demand
  High capex & Layout
  Atmospheric emissions & waste

Cryogenic liquefaction

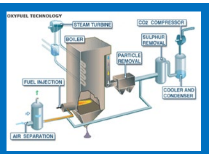


Syngas	TRL 8
Flue gas	TRL 5-7
DAC	?

+ No heat required
  Pure CO_2
  No atmospheric emissions

− Electricity demand
  High capex
  CO_2 preconcentration (15% → 50%)

Oxycombustion

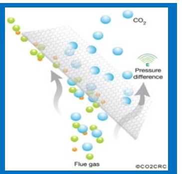


Boilers	TRL 7
FCC	TRL 4 – 5
Gas turbines	TRL 4

+ No heat required
  For gas turbines: high efficiency

− Oxygen demand
  Low purity CO_2, requires purification

Membranes

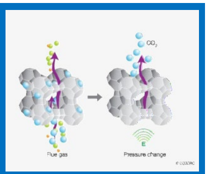


Biogas	TRL 9
Natural gas	TRL 4-5
Flue gas	TRL 2

+ No atmospheric emissions
  No heat required

− Electricity demand
  Low purity CO_2

Adsorption

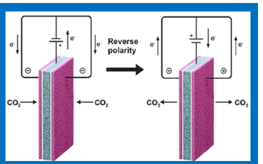


Flue gas	TRL 4 – 6
DAC	TRL 6

+ No atmospheric emissions
  Key technology for DAC
  Suitable for pre-concentration

− Heat or Power demand
  Low purity CO_2

Electrochemical



DAC	TRL 2-3

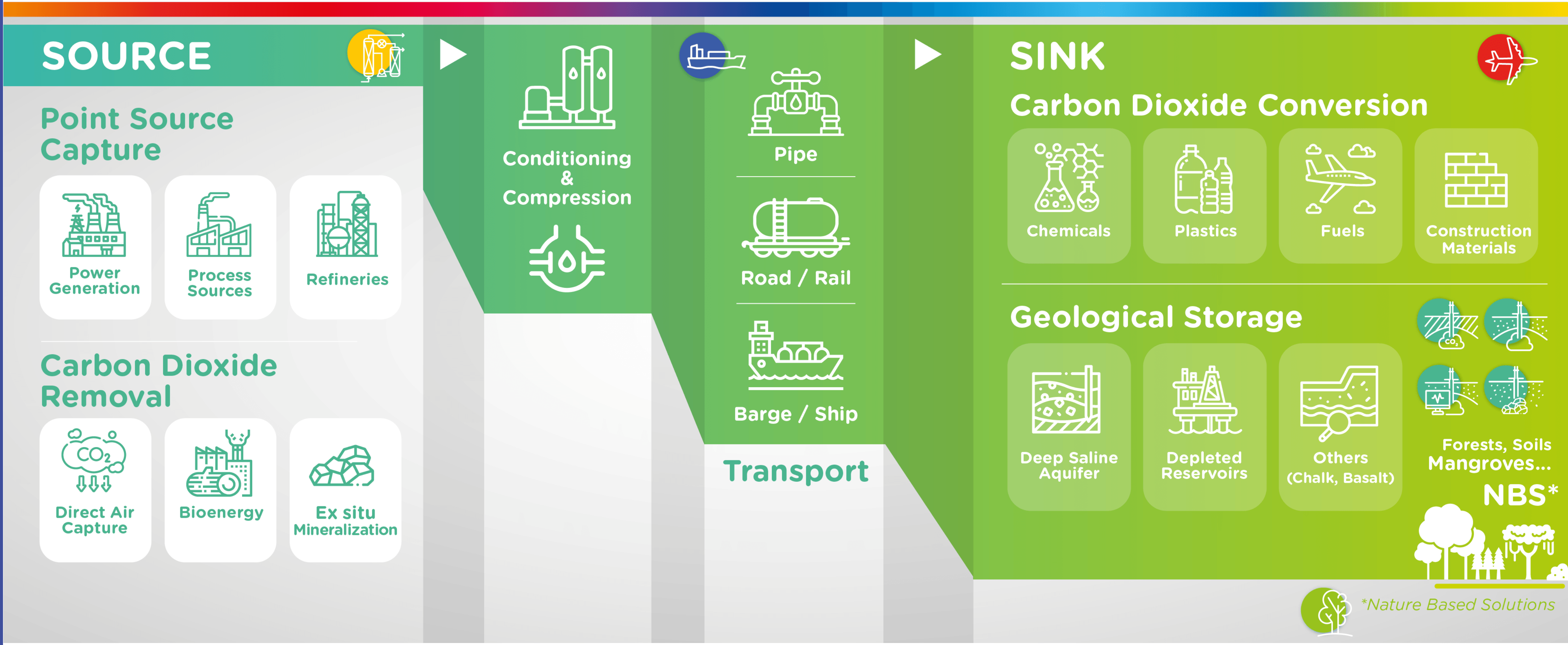
+ No heat required
  Potentially v. low energy demand

− Electrode degradation
  Electrode design
  Efficiency

- As of today, not **<u>ONE</u>** capture technology stands out from the others
- The selection is very related to the application and the context
- Solutions combining several technologies may have advantages
- Costs highly dependent on site, rendering wide ranging R&D estimations
- **Question : what technology will be mature for what source, and WHEN ?**

CCUS : multi-disciplined challenges

... but where are the bottlenecks ?



What drives the cost of the CO_2 abatement?

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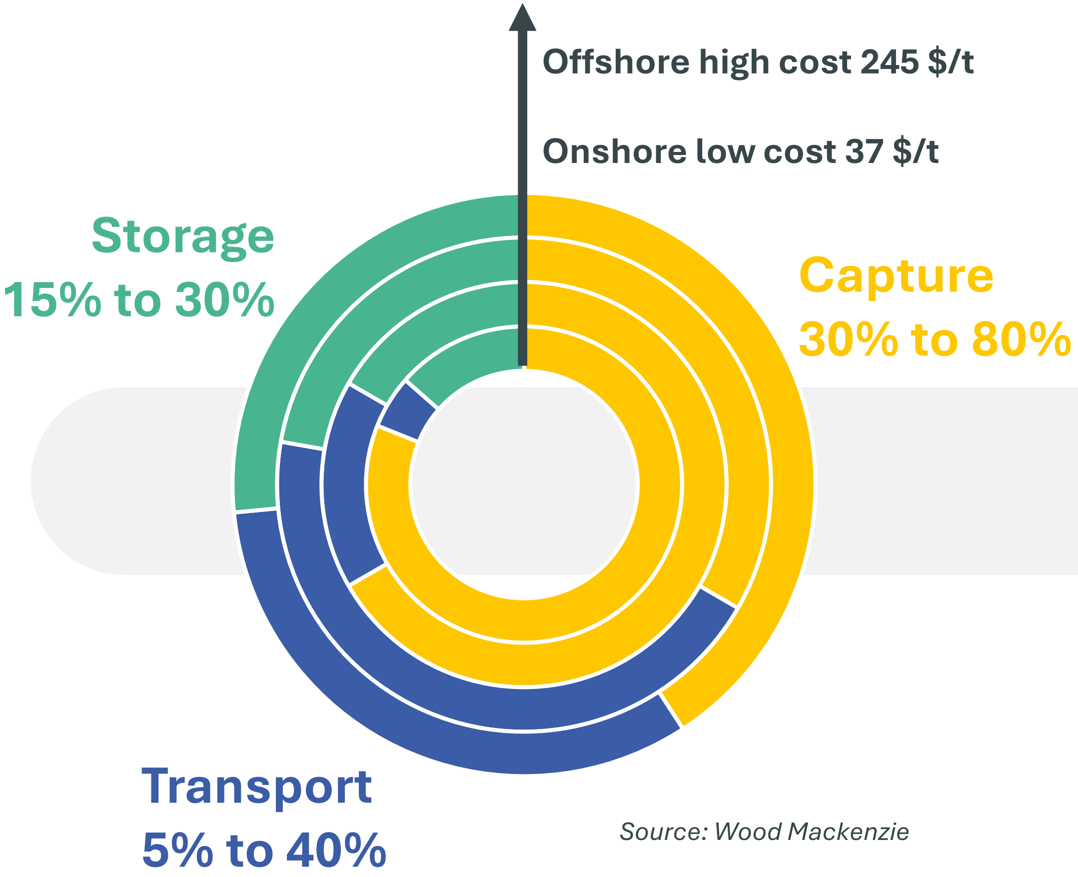
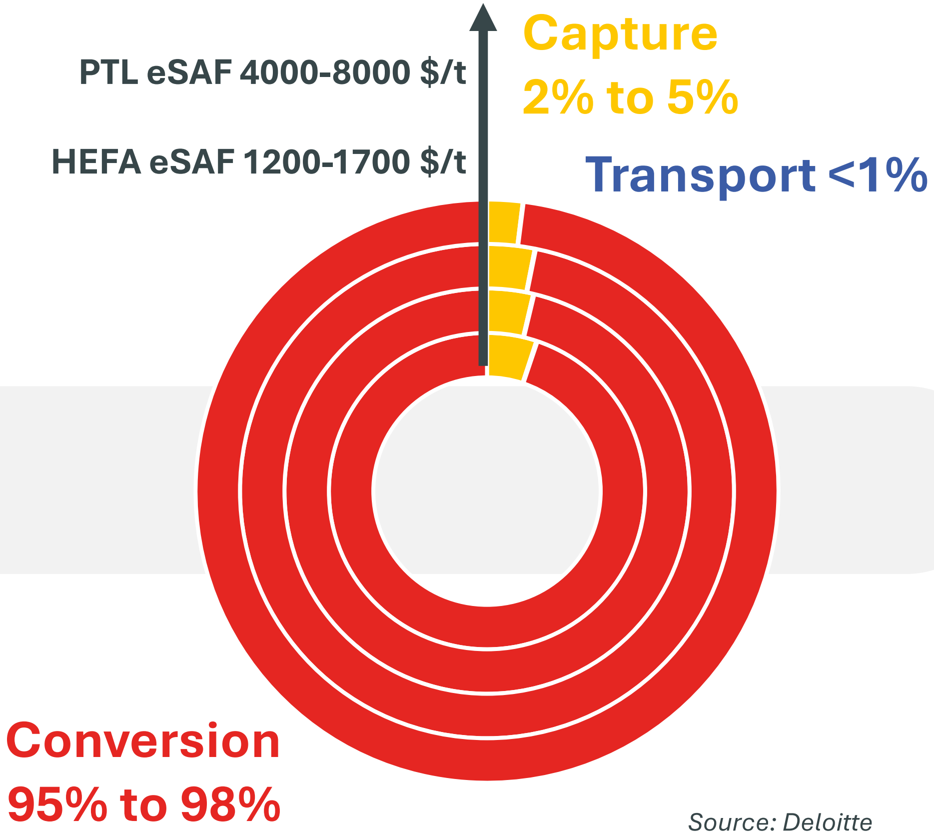
CCS



Source: Wood Mackenzie

CCU (eSAF)

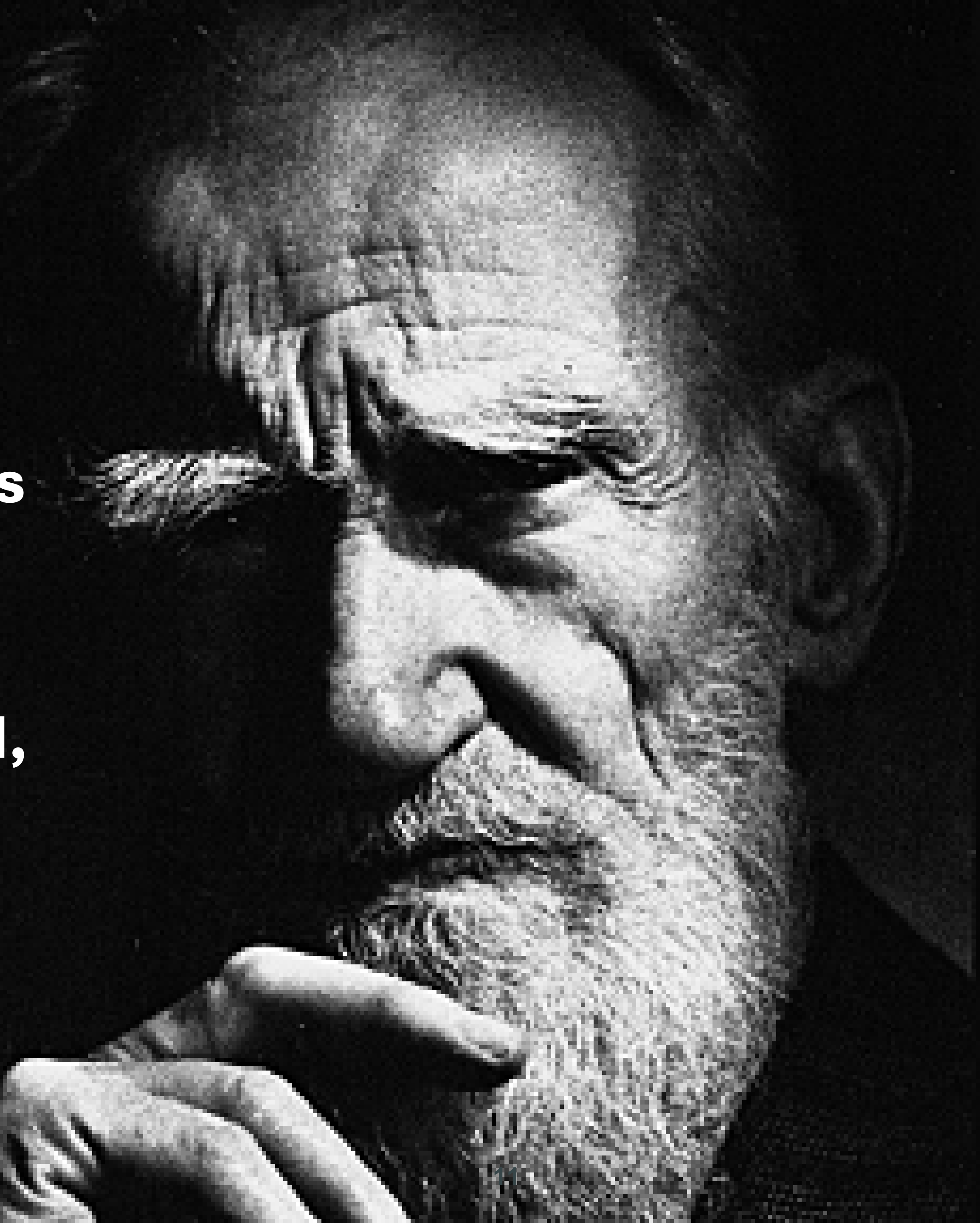


Source: Deloitte

George Bernard Shaw

Progress is impossible without change, and those who cannot change their minds cannot change anything.

If all the economists were laid end to end, they'd never reach a conclusion.



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