Société Chimique de France

INSTITUT DE FRANCE Académie des sciences

Fondation de la Maison de la Chimie

FRANCE CHIMIE

5èmes Rencontres académie-industrie du CNC

CO_2 déchet ou matière première :
Etat de l'art et perspectives 2035

TotalEnergies

Les défis pour 2035 autour du captage de CO_2 – quel rôle pour les membranes et les matériaux poreux ?

Schlumberger membrane capture
Gulf of Thailand

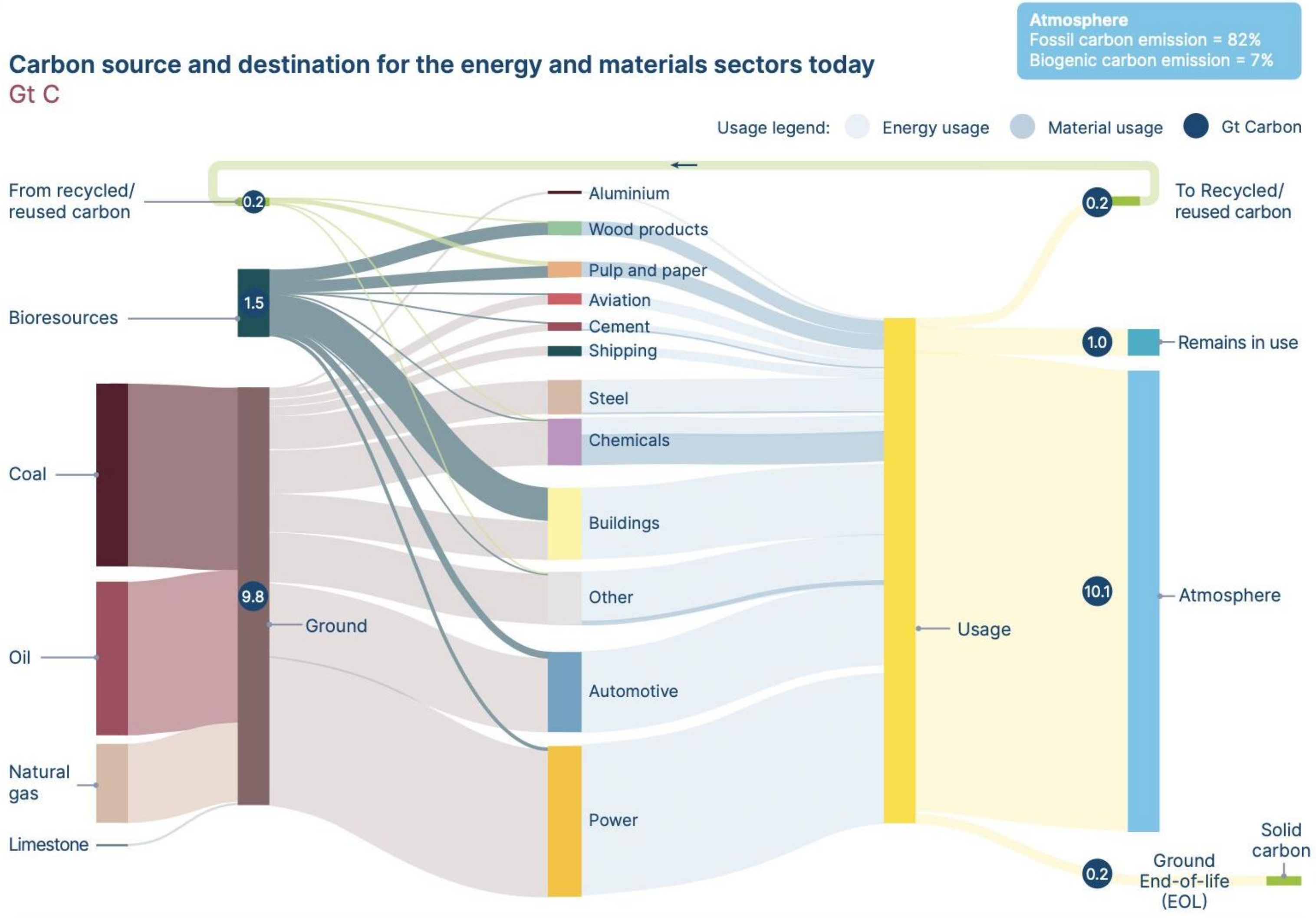
Svante laminated sorption contactor

Svante pilot @ Chevron,
Bakersfield, CA

Dr. Philip Llewellyn
Scientific Advisor
CO_2 Techno Hub

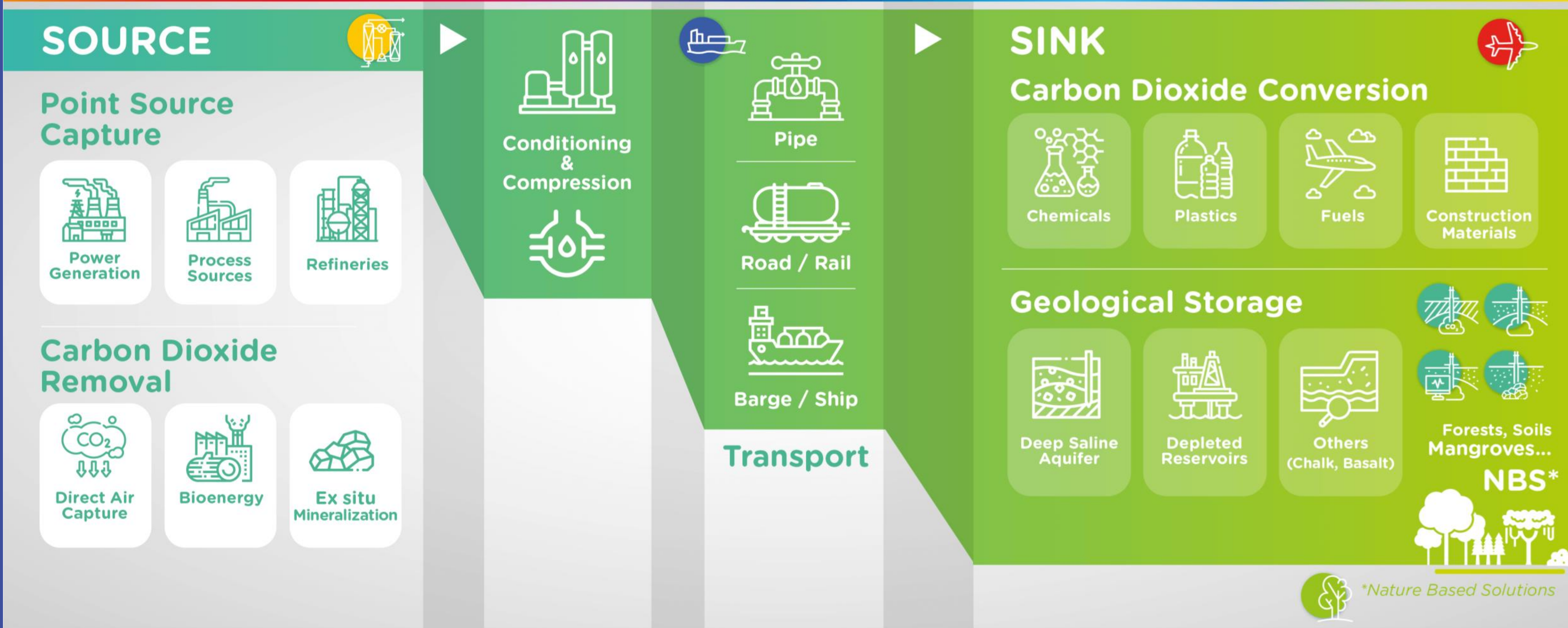
The majority of carbon today comes from fossil sources and ends up in the atmosphere

TotalEnergies

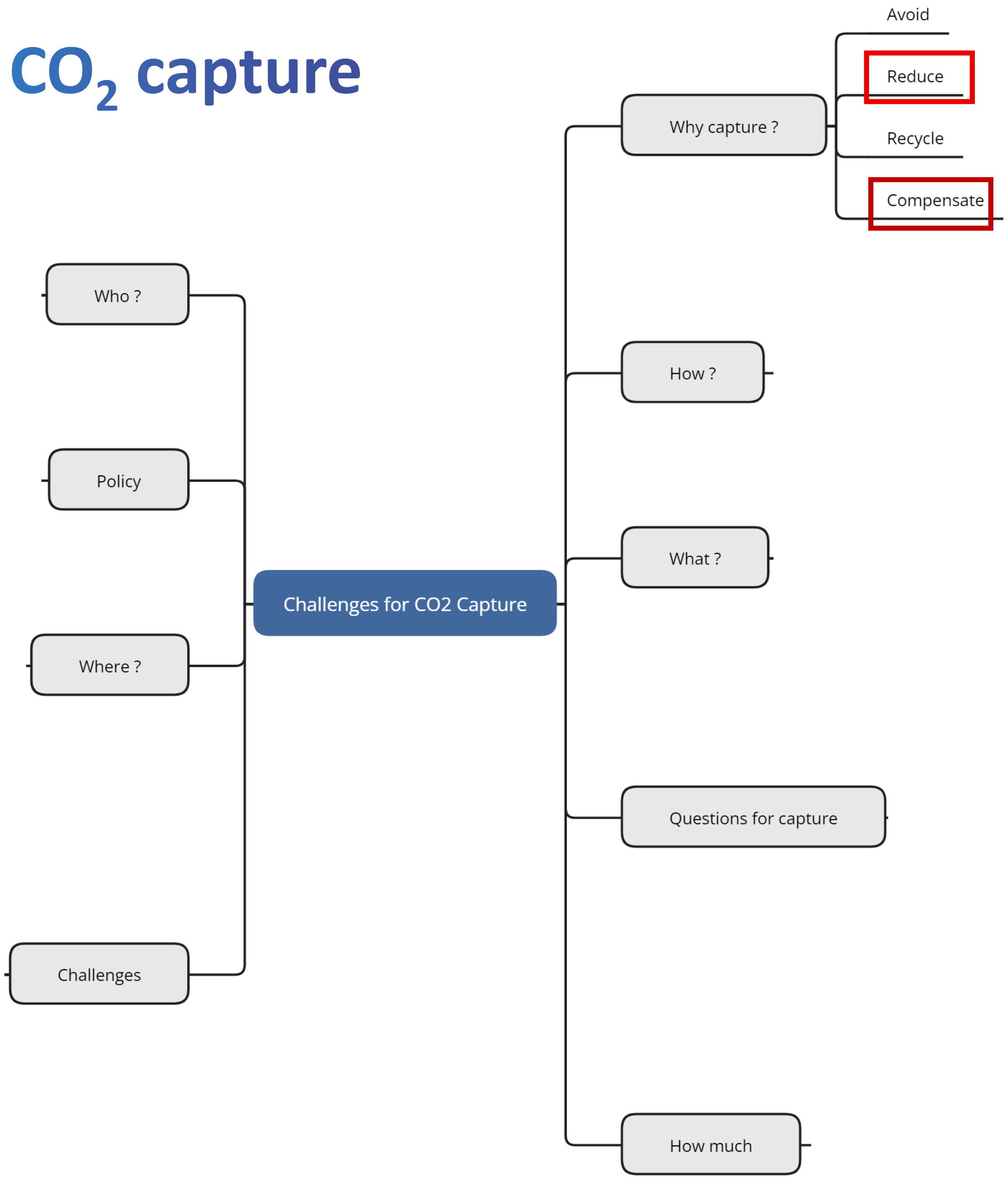


SOURCE: Systemiq analysis for the ETC; ETC (2023), *Fossil Fuels in Transition*.

CCUS - multi-disciplined challenges
- full-value chain approaches desired



Challenges for CO_2 capture



CCS and CCU as parts of the industrial carbon management chain

Avoid

Avoid emissions **before they happen**

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

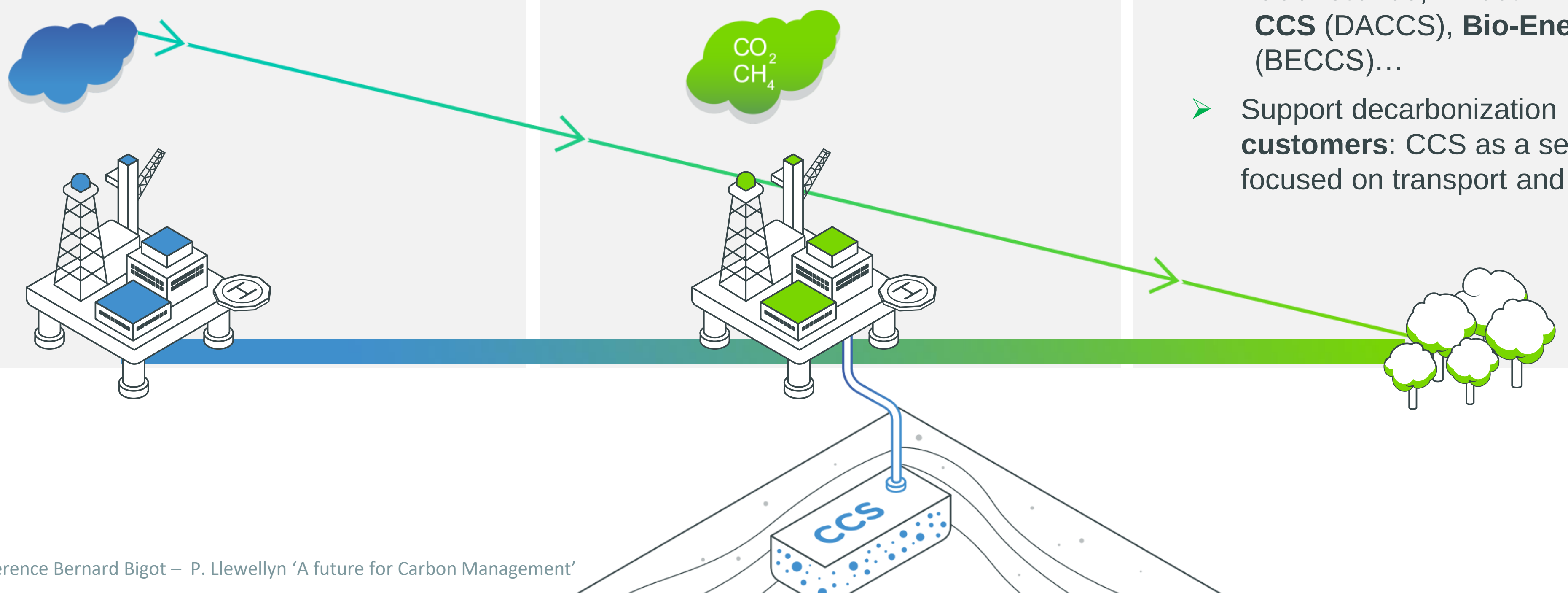
Reduce

Reduce emissions of existing assets

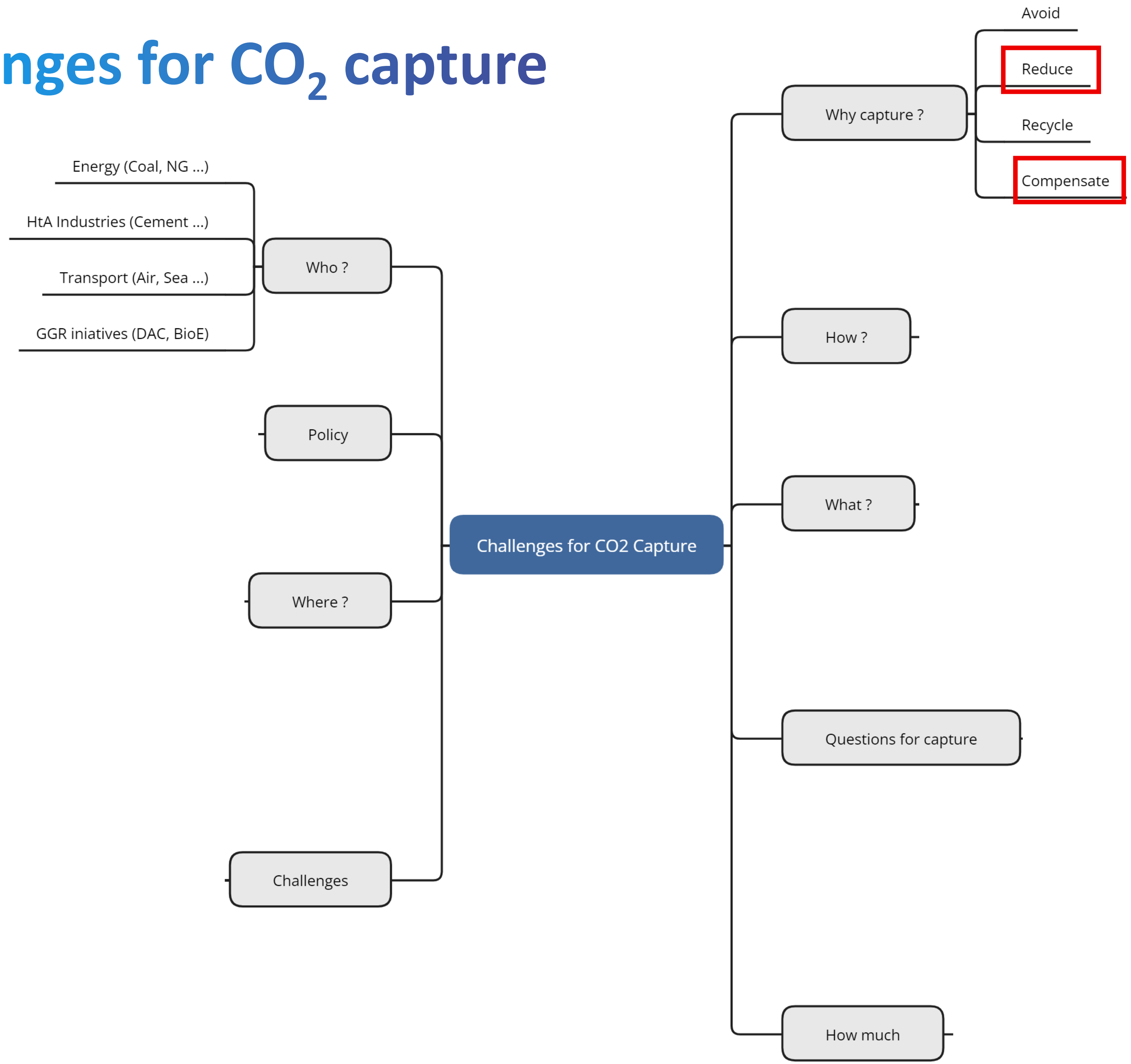
- Development of **Carbon Footprint Reduction** projects and practices
- **CCS** projects for TotalEnergies' assets
- **Utilize** CO_2 for eFuels and other materials

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



Challenges for CO_2 capture



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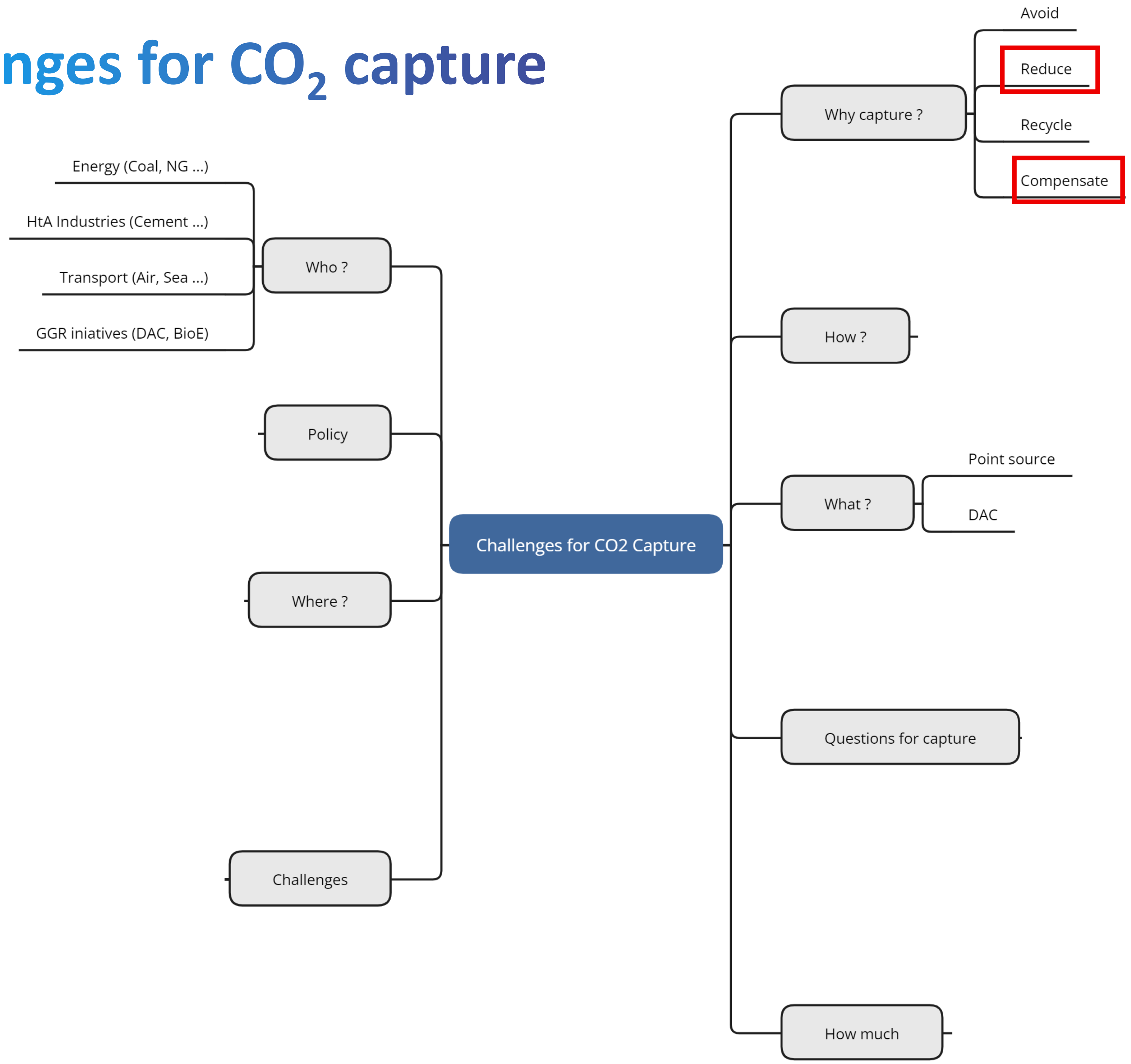

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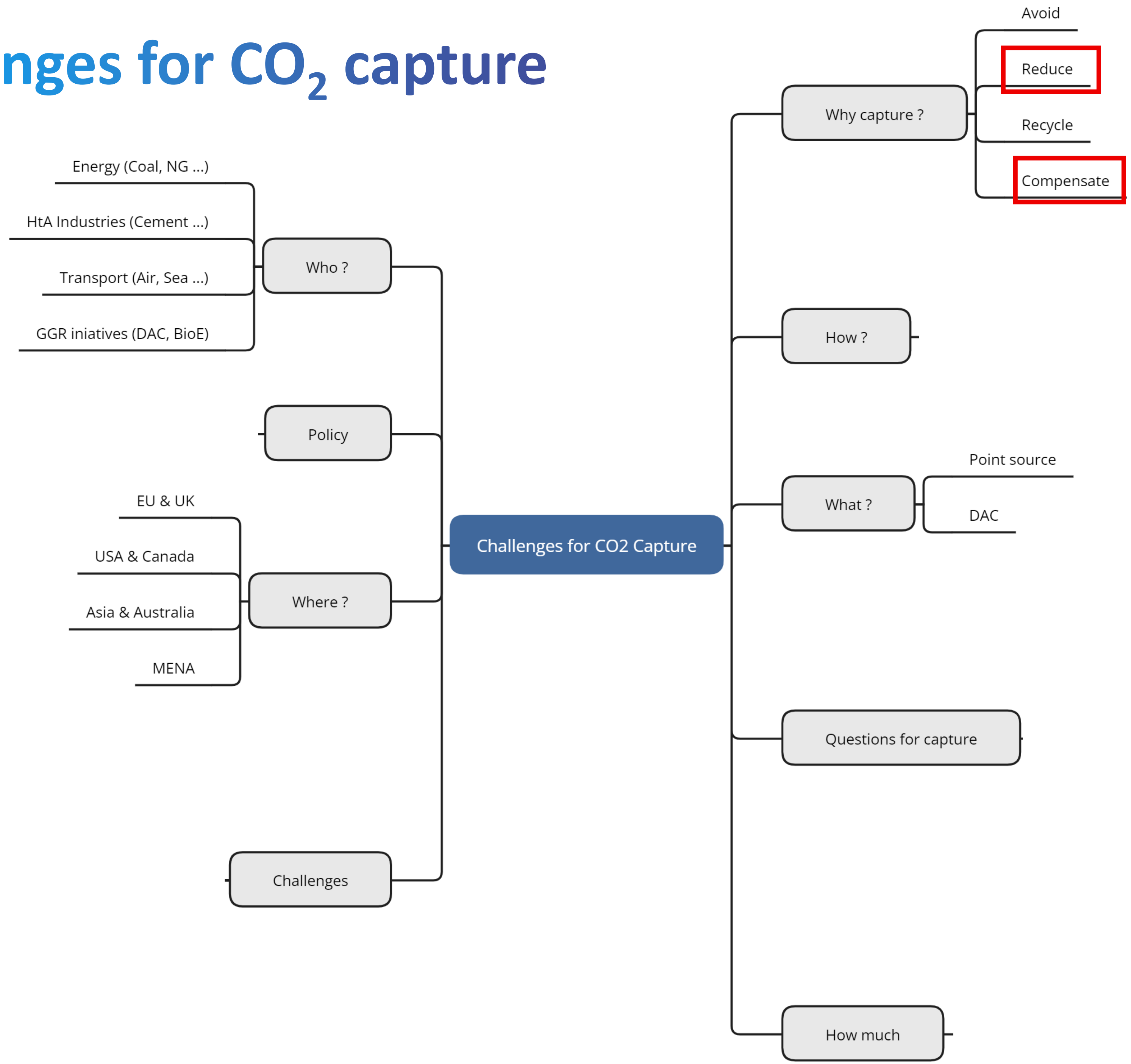
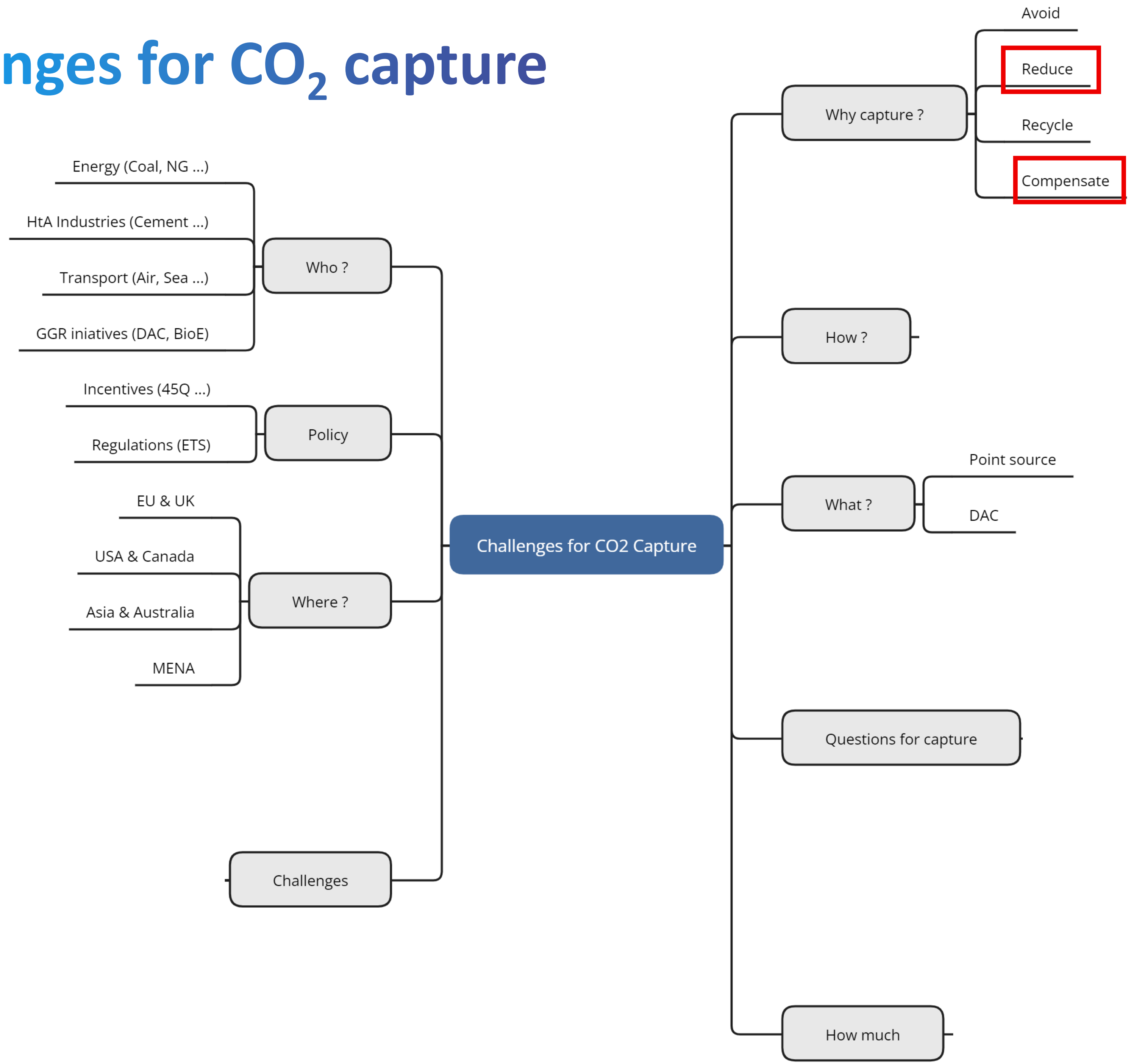
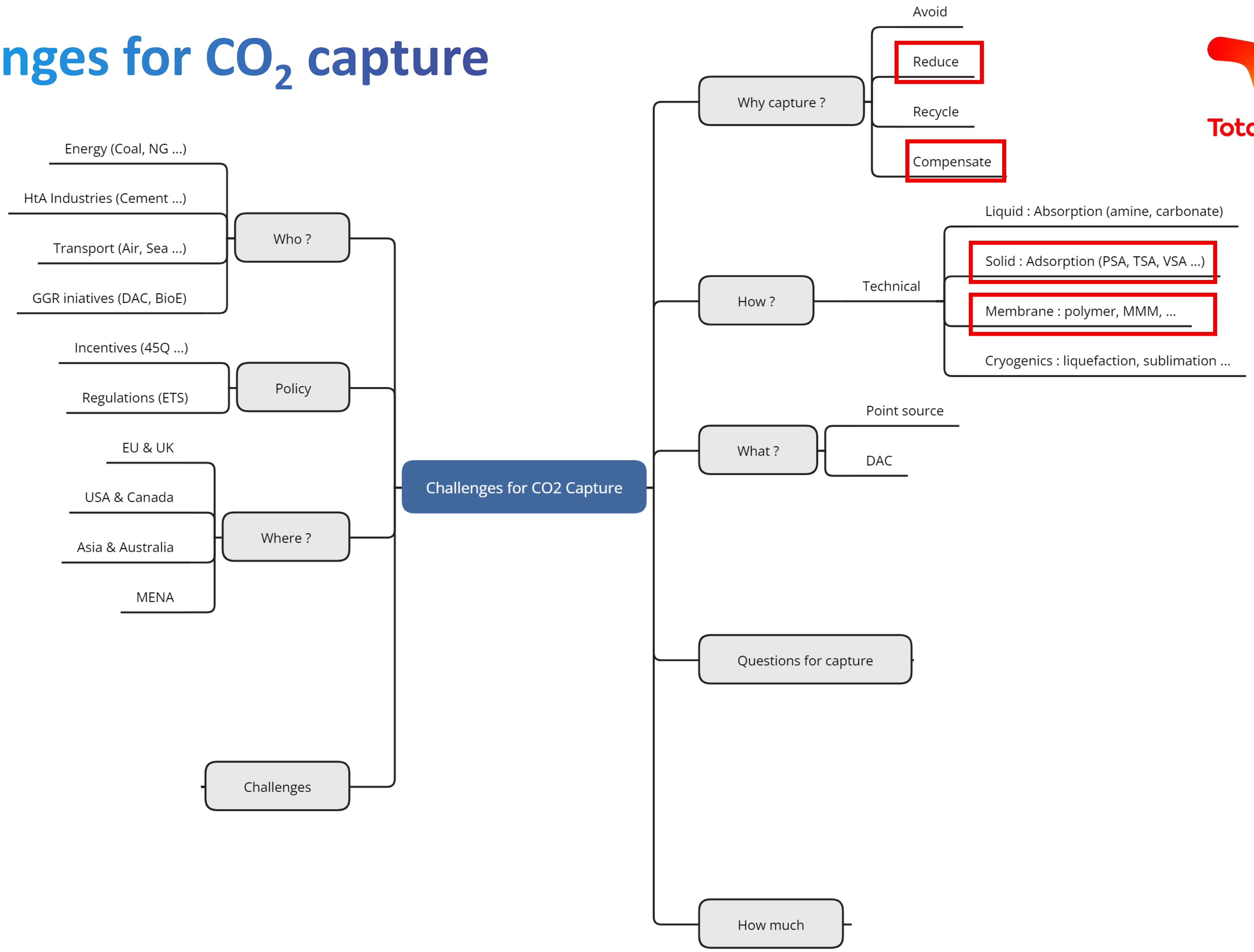


Challenges for CO_2 capture



Challenges for CO_2 capture



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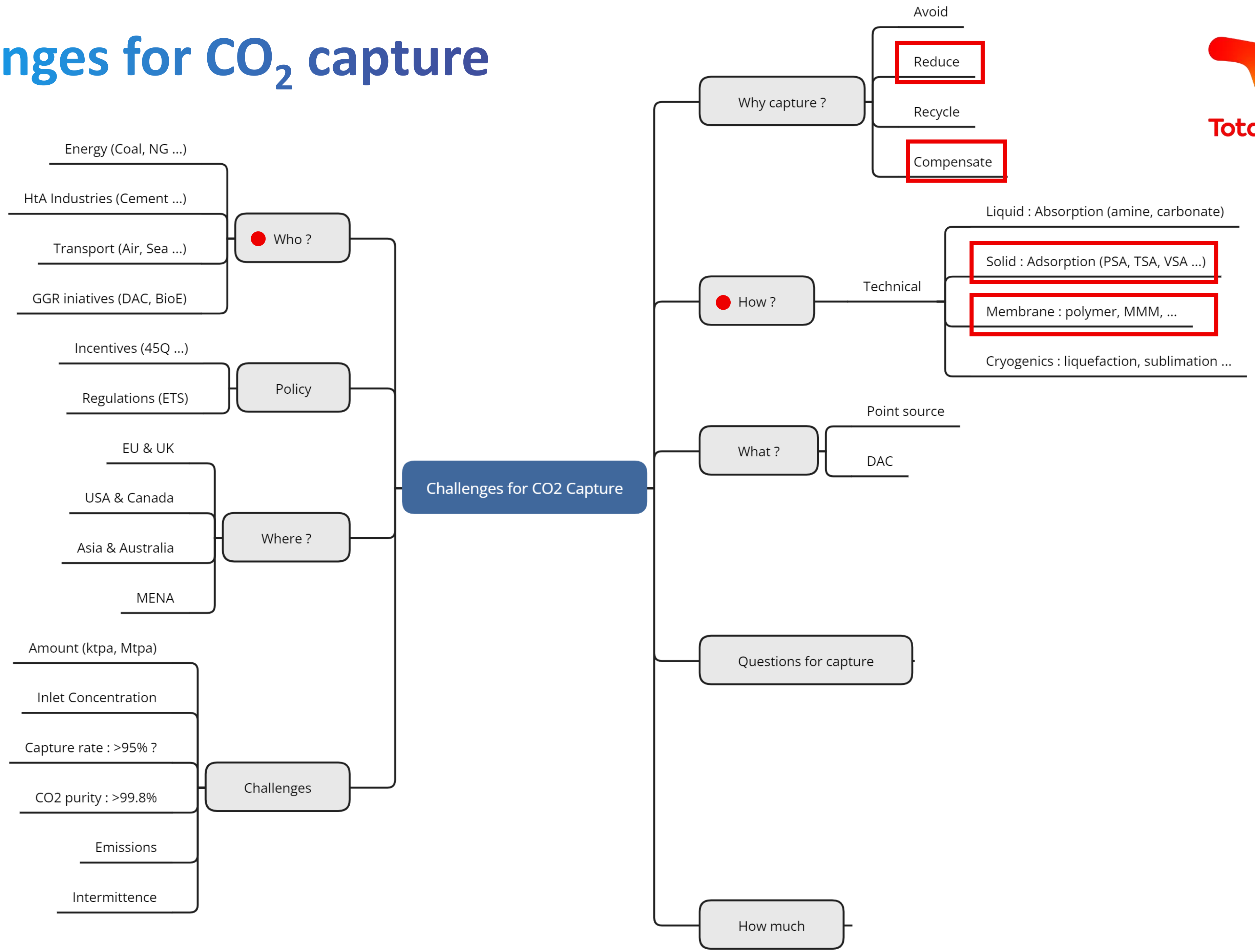


oad diversity of CO_2 capture technologies

TotalEnergies

Air

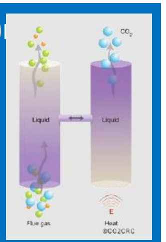
Biogenic
Biogas
Fermentation

Process
Cement
Steel
Refinery
Nat. Gas treatment

Energy
Coal
NGCC
… boilers

X

Absorption (alt. solvents)

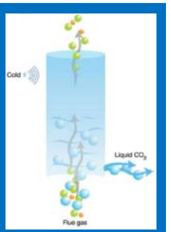


Syngas	TRL 8
Flue gas	TRL 6
DAC	TRL 6

\+ Well established
Pure CO_2

− Heat demand
High capex & Layout
Atmospheric emissions & waste

Cryogenic liquefaction

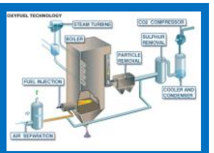


Syngas	TRL 8
Flue gas	TRL 5-7
DAC	?

\+ No heat required
Pure CO_2
No atmospheric emissions

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

Oxycombustion

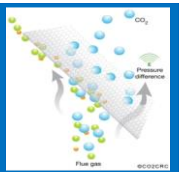


Boilers	TRL 7
FCC	TRL 4 – 5
Gas turbines	TRL 4

\+ No heat required
For gas turbines: high efficiency

− Oxygen demand
Low purity CO_2, requires purification

Membranes

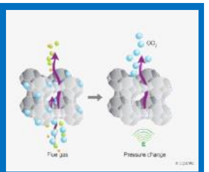


Biogas	TRL 9
Natural gas	TRL 4-5
Flue gas	TRL 2

\+ No atmospheric emissions
No heat required

− Electricity demand
Low purity CO_2

Adsorption

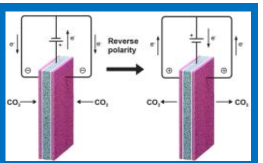


Flue gas	TRL 4 – 6
DAC	TRL 6

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

− Heat or Power demand
Low purity CO_2

Electrochemical



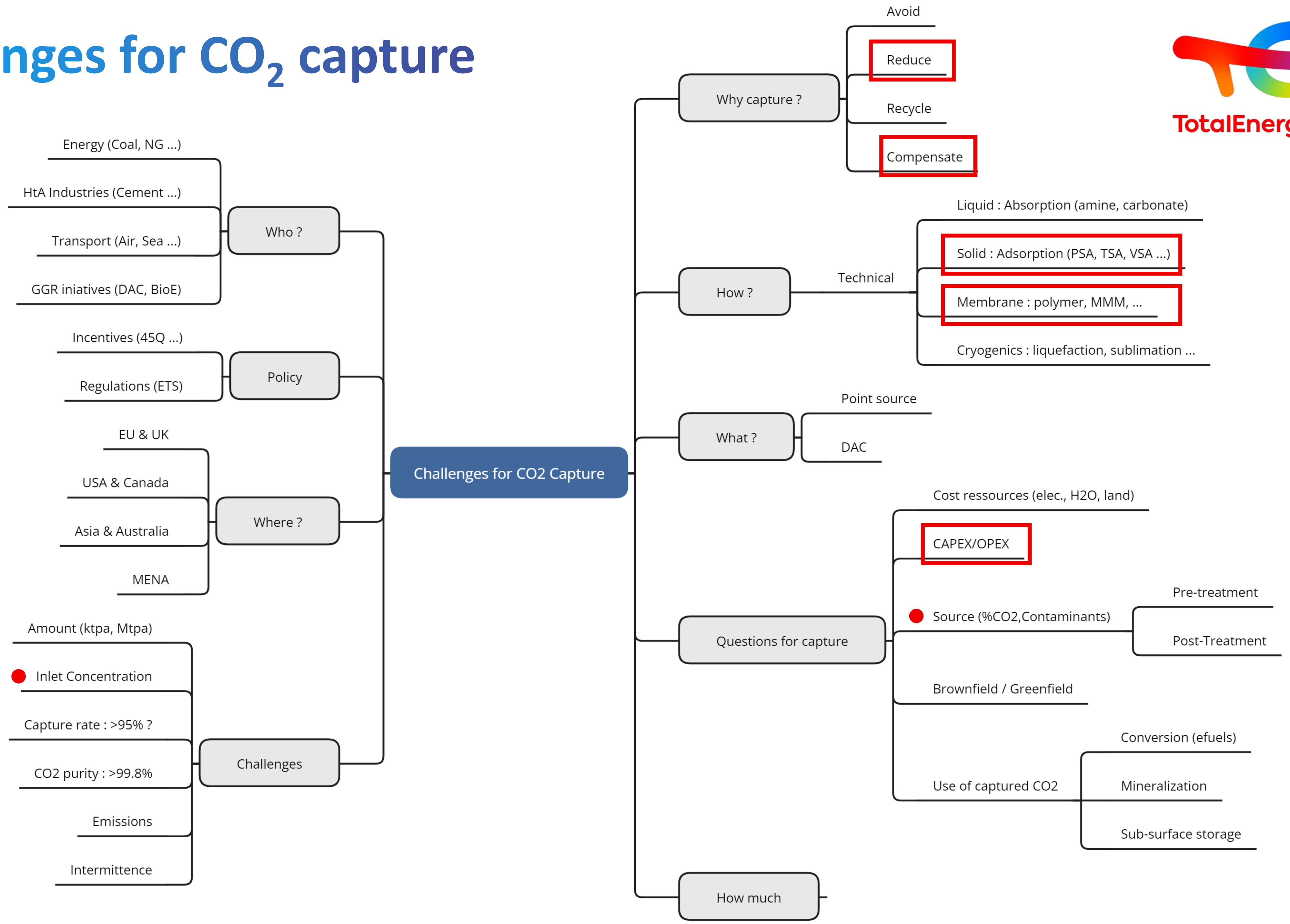
DAC	TRL 2-3

\+ No heat required
Potentially v. low energy demand

− Electrode degradation
Electrode design
Efficiency

- TRLs are debatable
- As of today, not **ONE** 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

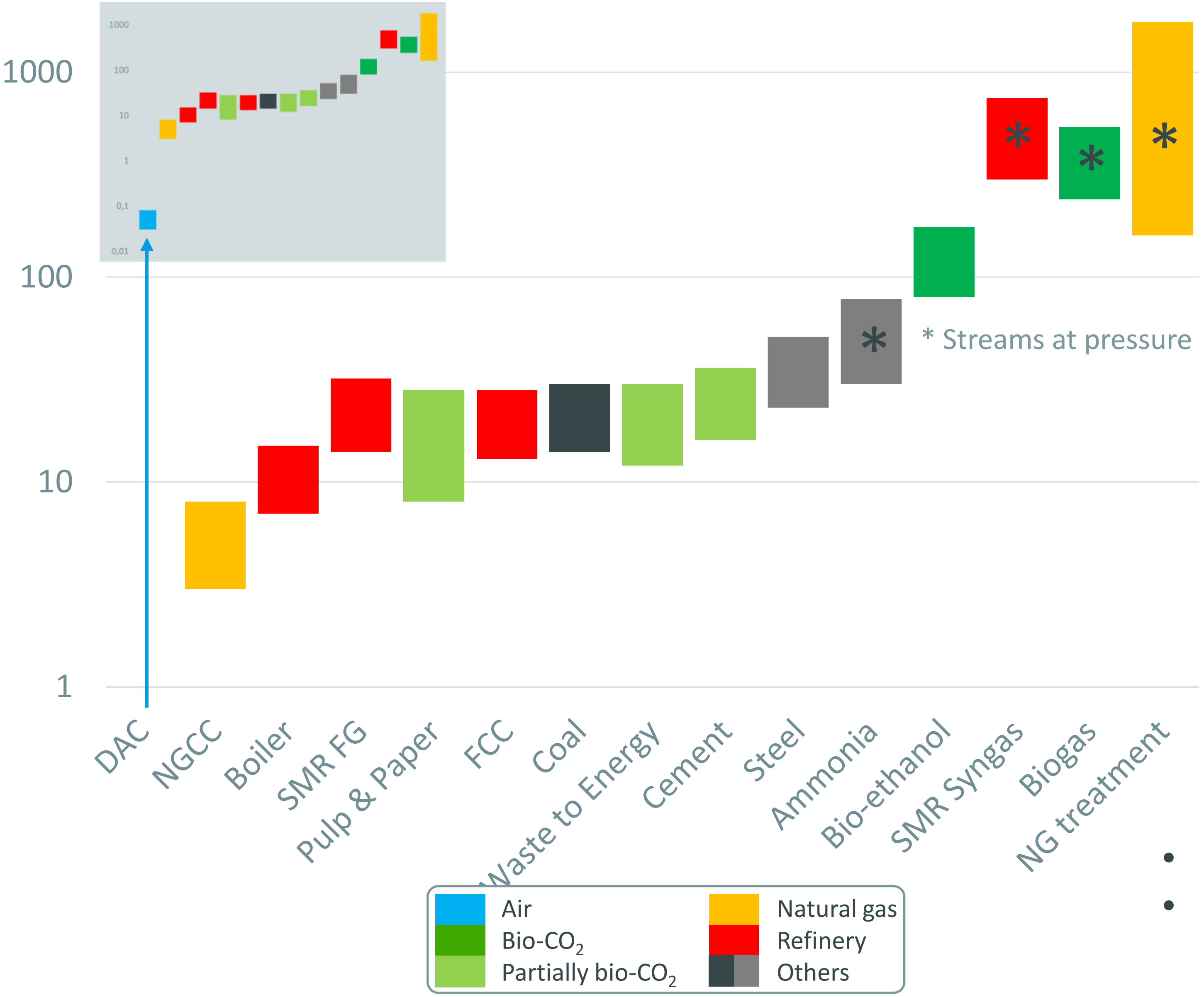
Challenges for CO_2 capture



A diversity of sources where we can capture CO_2

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

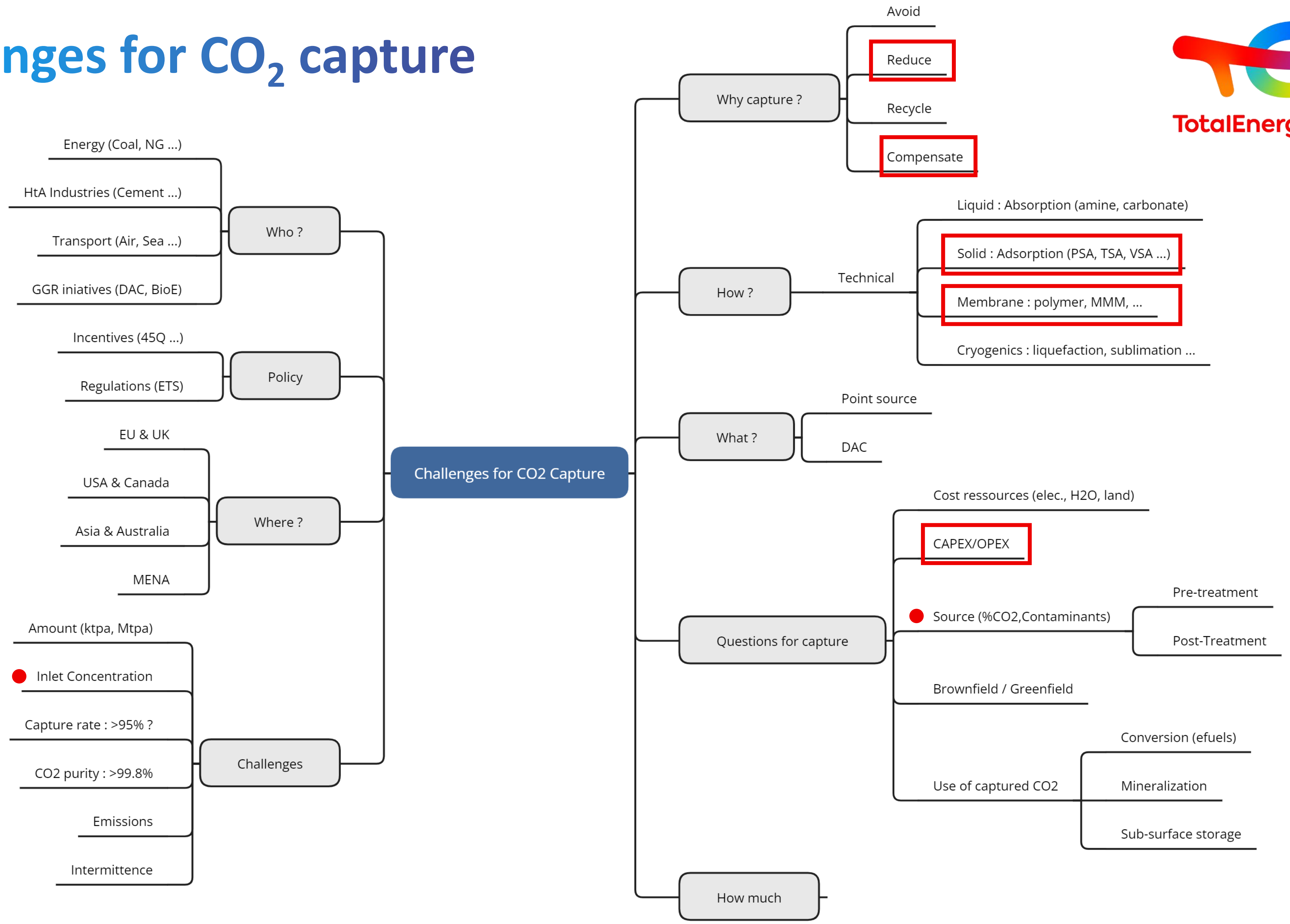
TotalEnergies



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

Challenges for CO_2 capture



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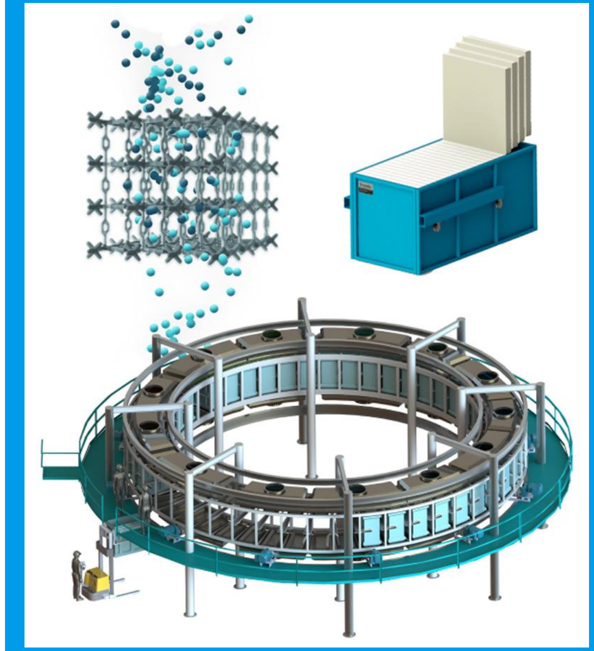
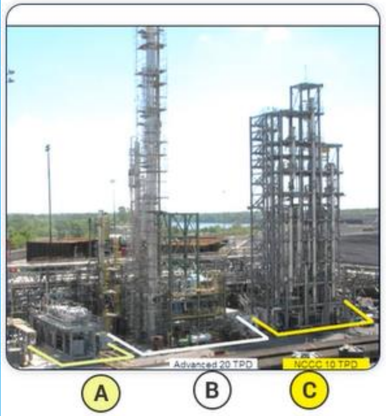


- Challenges for CO2 Capture
  - Who ?
  - Policy
  - Where ?
  - Challenges
    - Amount (ktpa, Mtpa)
    - Inlet Concentration
    - Capture rate : >95% ?
    - CO2 purity : >99.8%
    - Emissions
    - Intermittence
  - Why capture ?
    - Avoid
    - Reduce
    - Recycle
    - Compensate
  - How ?
    - Technical
      - Liquid : Absorption (amine, carbonate)
      - Solid : Adsorption (PSA, TSA, VSA ...)
      - Membrane : polymer, MMM, ...
      - Cryogenics : liquefaction, sublimation ...
  - What ?
    - Point source
    - DAC
  - Questions for capture
    - Cost ressources (elec., H2O, land)
    - CAPEX/OPEX
    - Source (%CO2,Contaminants)
      - Pre-treatment
      - Post-Treatment
    - Brownfield / Greenfield
    - Use of captured CO2
      - Conversion (efuels)
      - Mineralization
      - Sub-surface storage
  - How much

TotalEnergies

Challenges for CO_2 capture



A MTR 20 TPD System
B Advanced Amine 20 TPD System
C Standard Amine 10 TPD System

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TotalEnergies

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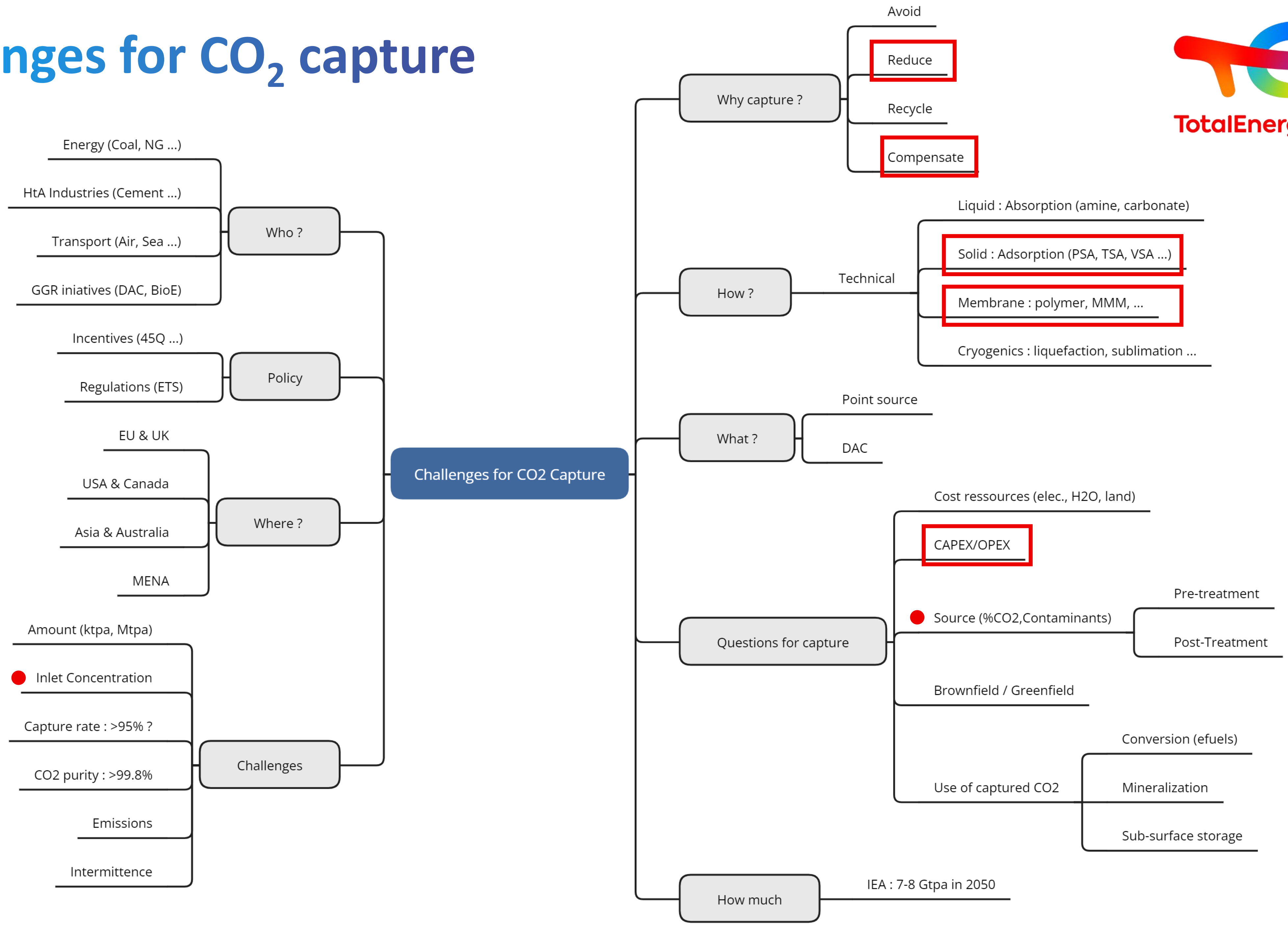

Les défis pour 2035 autour du captage de CO_2 –
quel rôle pour les membranes et les matériaux poreux ?

TotalEnergies

What makes sense ?
→ Sector & asset vs. Time to Deployment ….

(Membranes vs Adsorbents) & Cryogenic

R&T needs a line of sight to Scale : kt vs Mt

Policy needs a line of sight to Market

Svante, 14m "Buck" for 500 tpd (Burnaby)

MTR, 20 tpd skid (NCCC)

Thank You for your Attention