Cost Reduction in CCS

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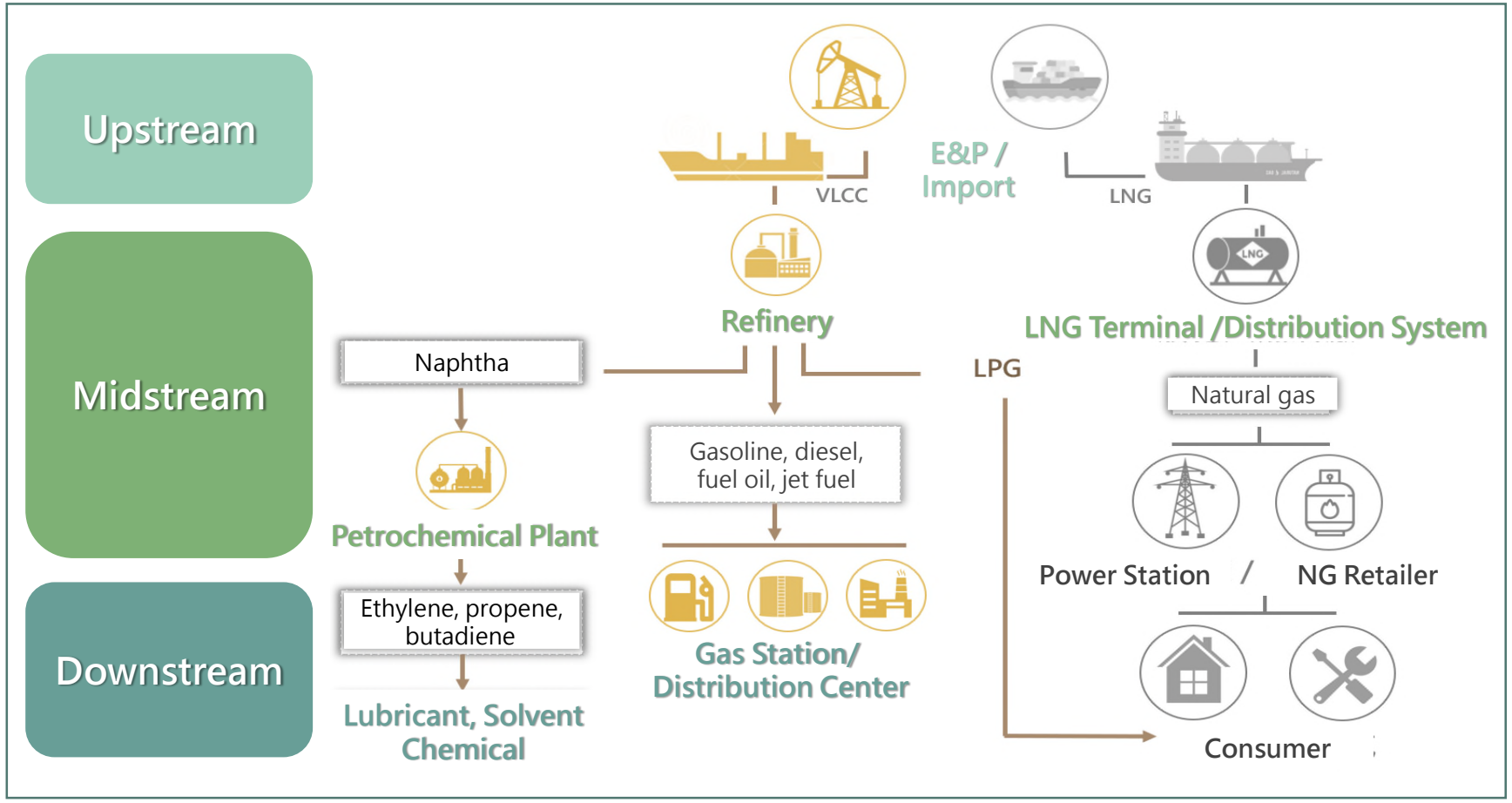
CPC
2024.04.23

- A state-owned oil company is responsible for supplying sufficient energy to the domestic market.
- Our current business includes exploration and production, LNG import and distribution, refining, petrochemicals, petroleum product sales and gas stations.



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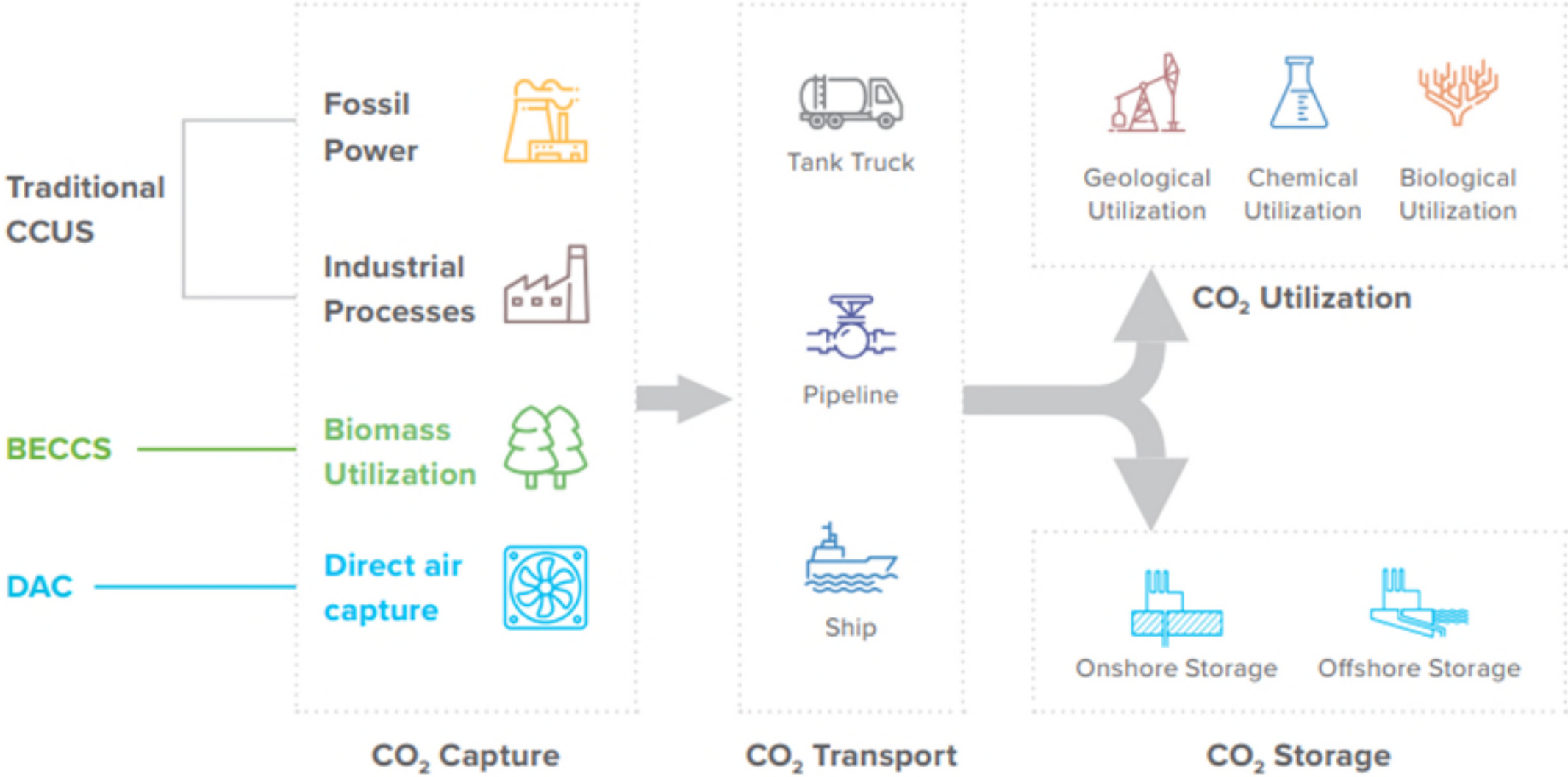
What is CCUS

What is CCUS



(GCCSI, 2023)

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Cost Reduction in CCS

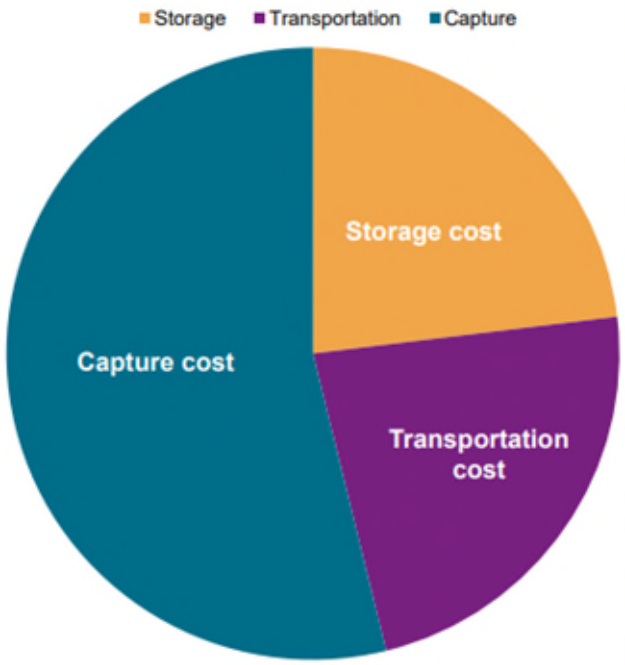
CCS Cost Composition

Purity of CO_2 stream
- Type of industrial process
- Position of CO_2 capture
- Share of CO_2 capture

Technology
- Type of separation technology
- Technology/process maturity

Size
- Size of capture equipment
- Plant size and utilization

Location
- WACC
- Energy price based on location
- Materials costs based on location



Location
- Location/risk factor
- Location of storage site

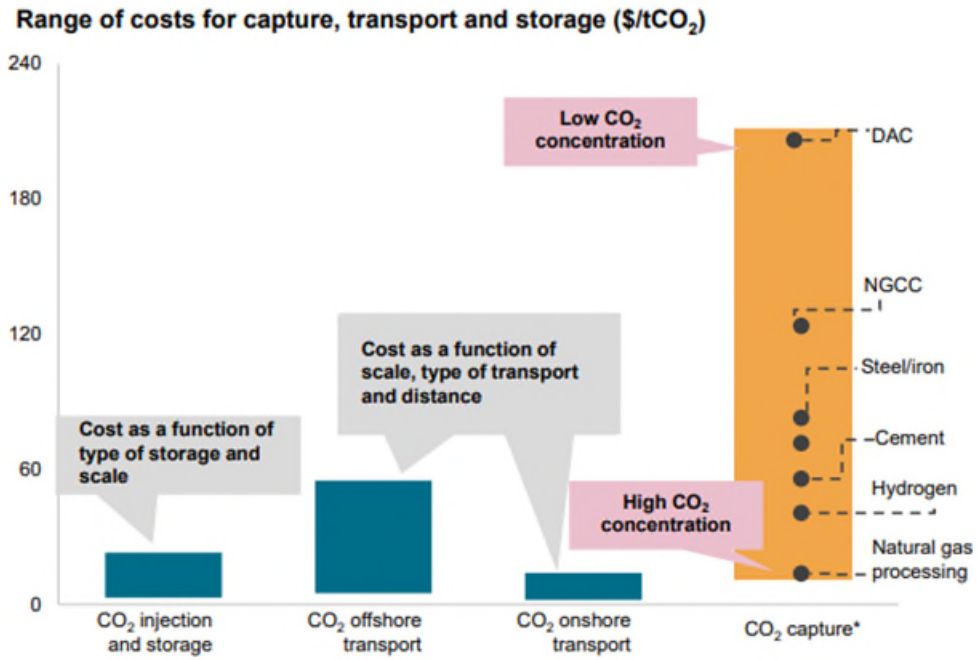
Volume
- Volume of CO_2 stored

Type of storage
- Oil and gas depleted reservoir
- Saline formation

Location
- Location/risk factor
- Distance to storage site

Volume
- Volume of CO_2 stored

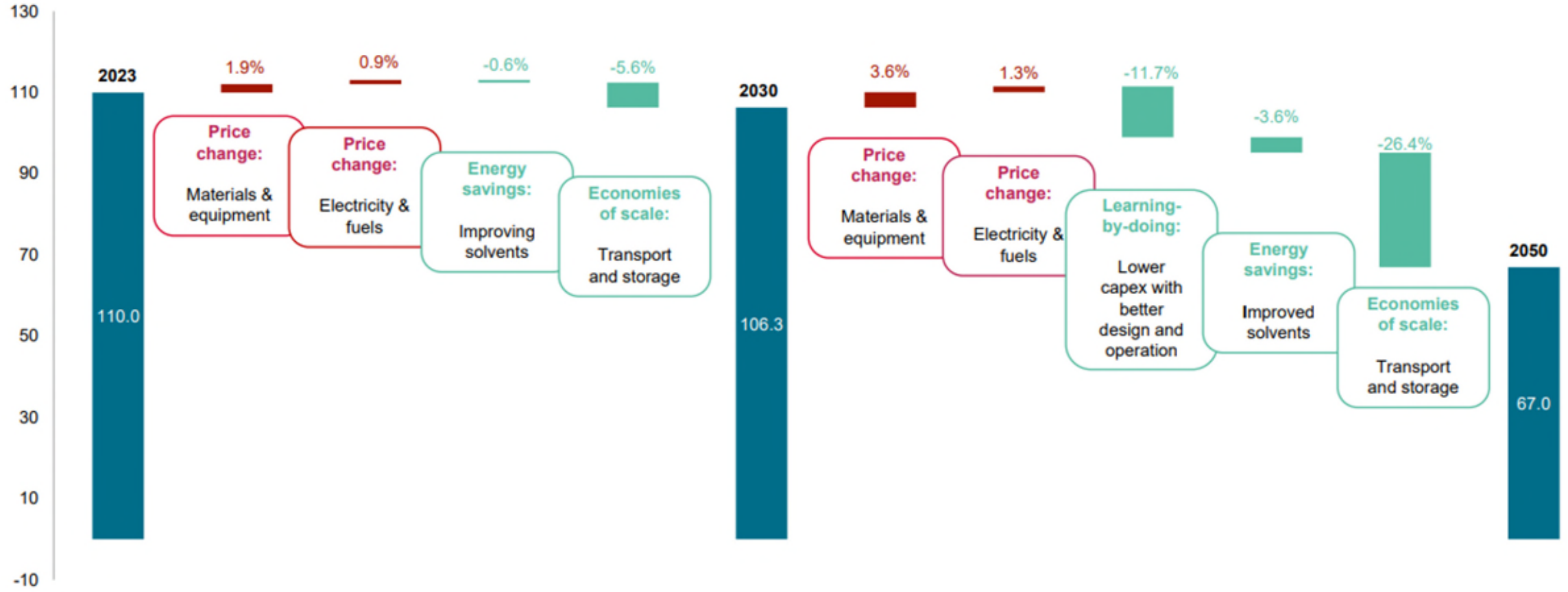
Type of transportation
- Pipeline
- Ship
- Truck or rail



(S&P Global, 2024)

Key Factors Driving the CCS Cost

CO_2 avoidance cost over time and contributing factors (2023$/t$CO_2$)

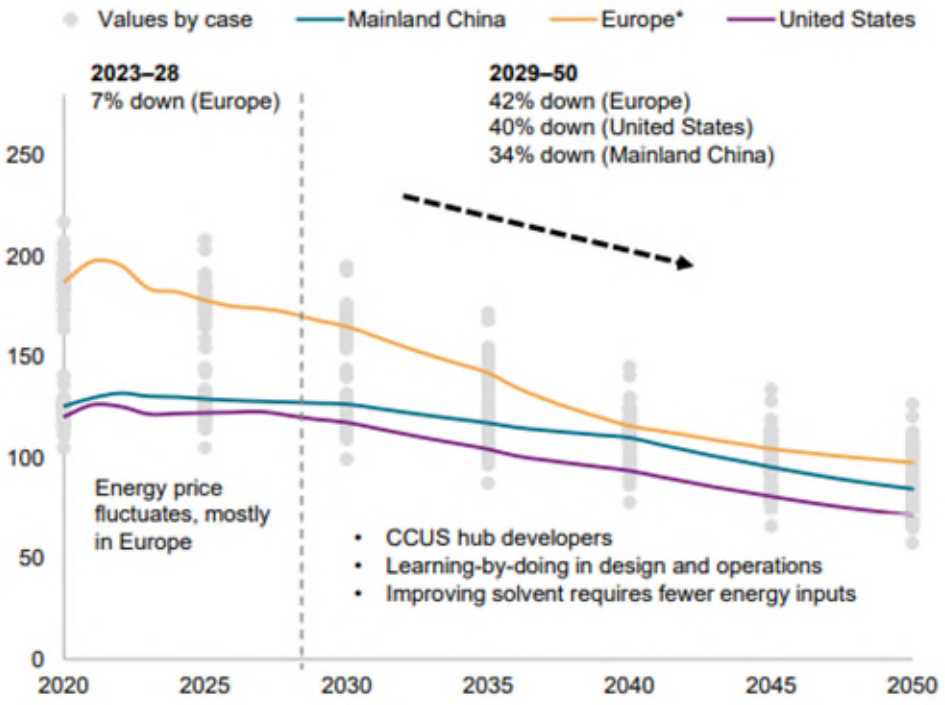


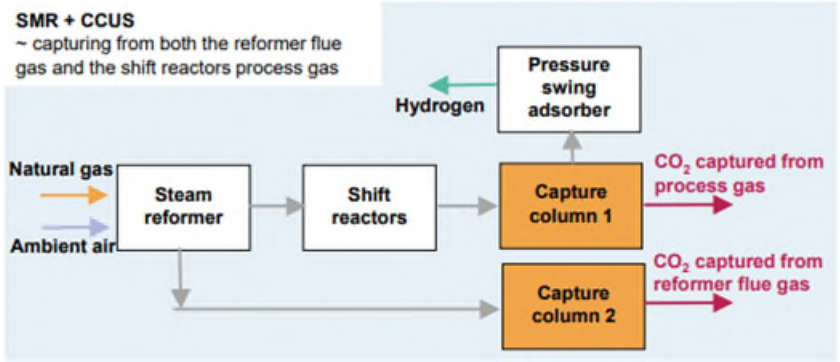
Data compiled March 5, 2024.
The numbers in the figure refer to the LCCA of cement in the United States.
Source: S&P Global Commodity Insights.

(S&P Global, 2024)

SMR v.s. ATR

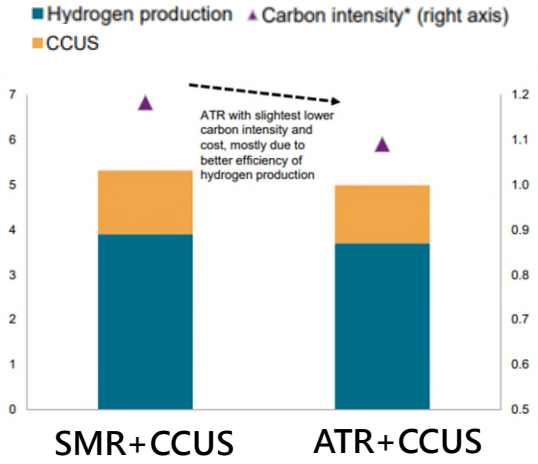
SMR: CO_2 avoidance cost outlook(2023$/t$CO_2$)





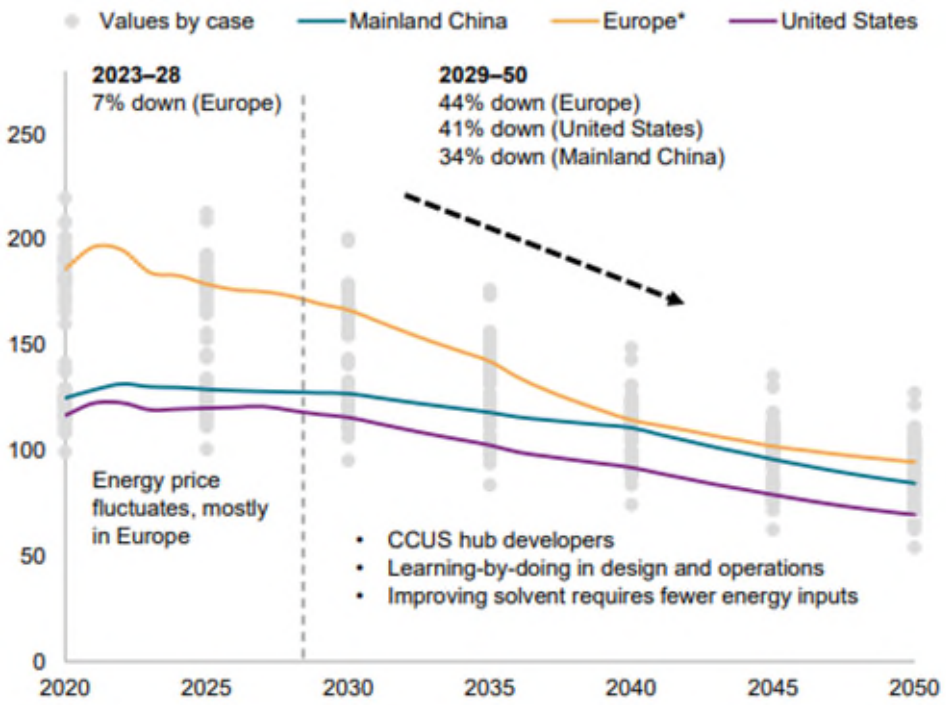
Levelized cost of Hydrogen production

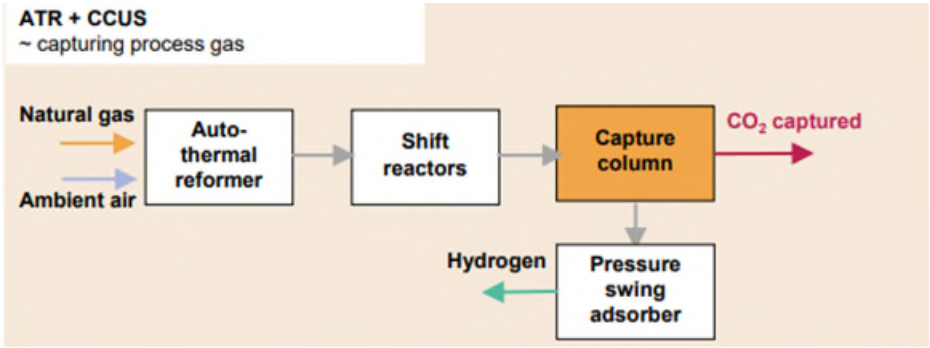
(left: 2023$/kg$H_2$, right: kg$CO_2$/kg$H_2$)



(S&P Global, 2024)

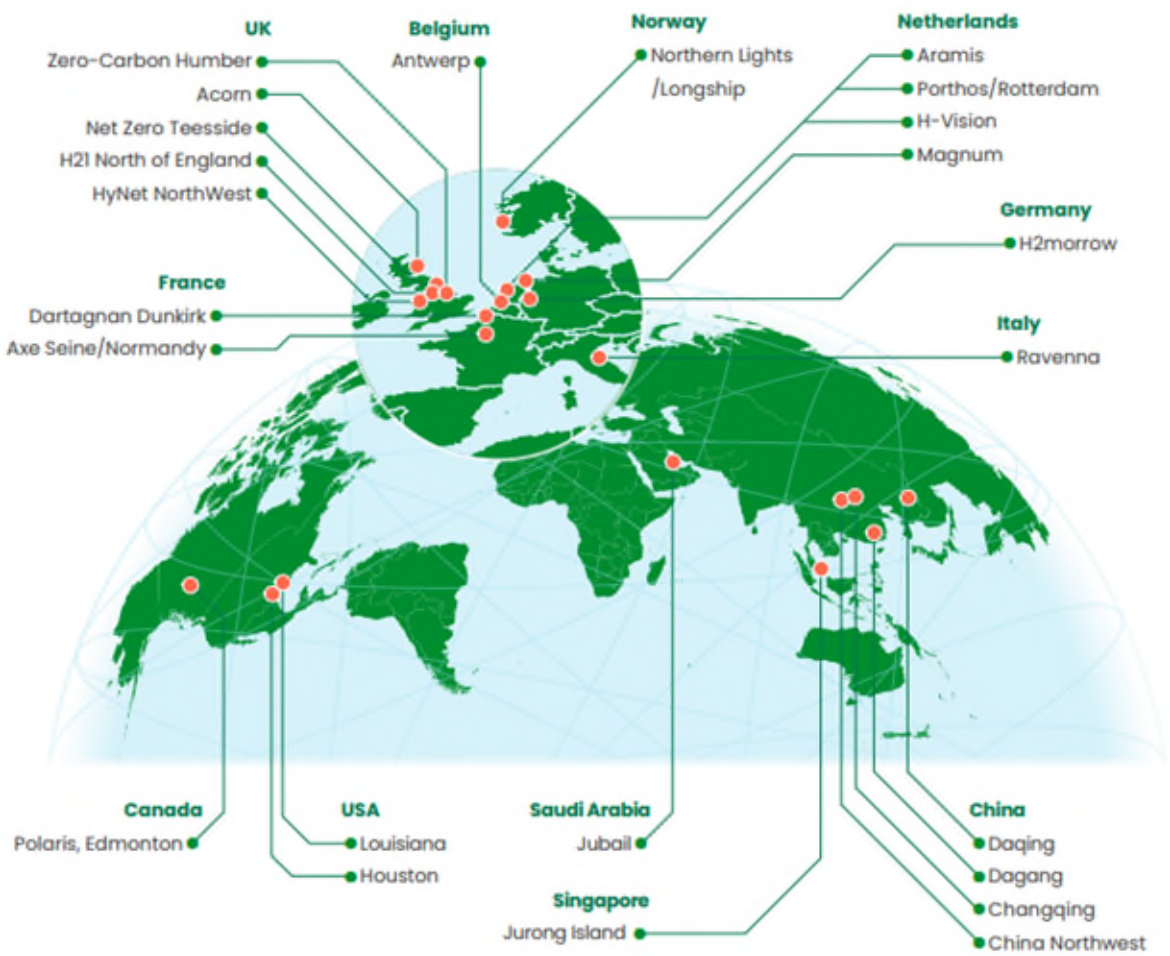
ATR: CO_2 avoidance cost outlook(2023$/t$CO_2$)





Economies of Scale – CCUS Hub

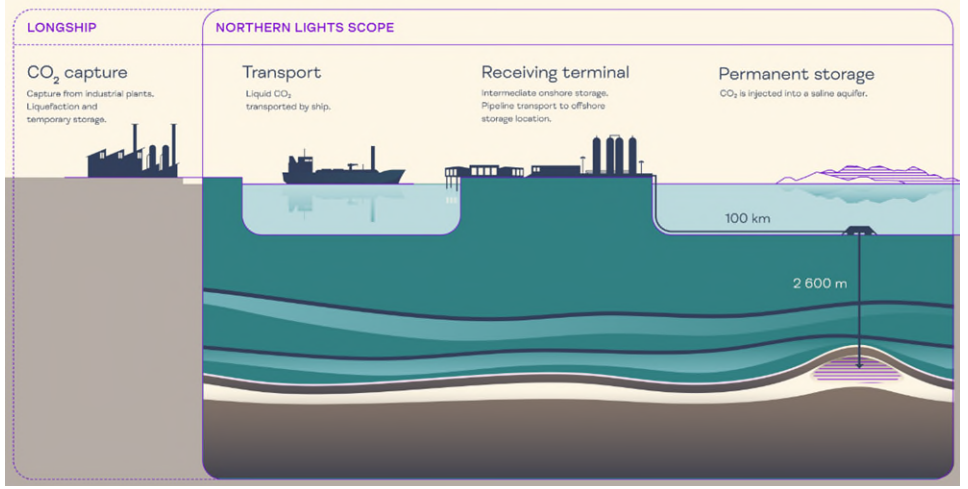
A CCUS hub takes carbon dioxide from several emitting sources, and then transports and stores it using common infrastructure.



- **Faster scale up**
  - The average large-scale CCS project is around 1 Mtpa.
  - CCUS hubs are aiming at around 5-10 Mtpa.
- **Lower costs and investment risks**
  - Collective transport and storage infrastructure bring economies of scale in construction and operations.
- **More government support**
  - A hub can decarbonize an entire industrial region, supporting jobs and attracting new clean industries (e.g., H_2 producer and consumer).

(The CCUS Hub, 2023)

Norway - Northern Light (Cross-border T&S)



Norway (2024H2)

- Heidelberg Materials' cement factory (previously Norcem) in Brevik: **0.4 Mtpa**
- Hafslund Oslo Celsio' s waste-to-energy plant (previously FOV) in Oslo: **0.4 Mtpa**

Netherlands (2025)

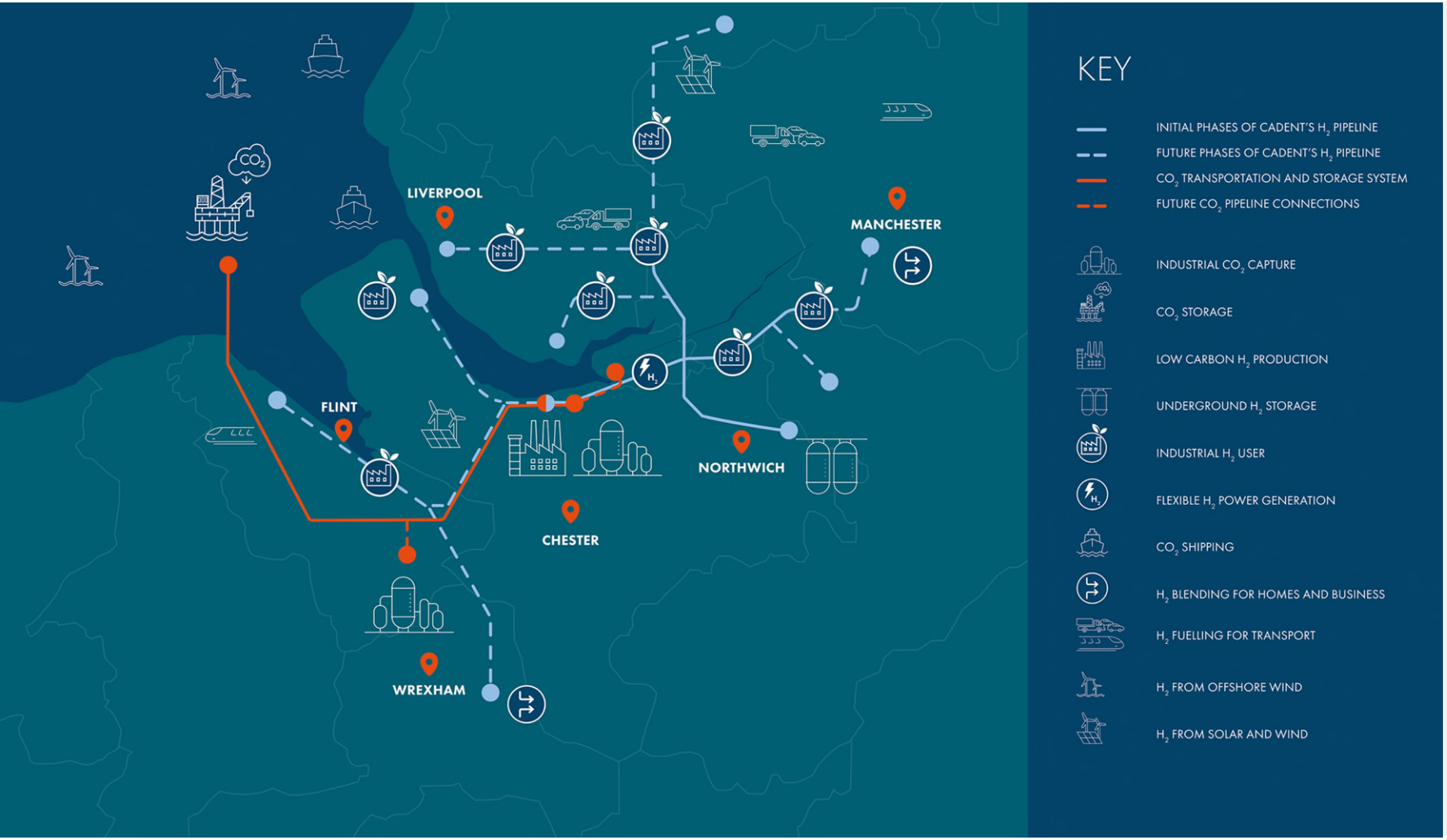
- Yara' s ammonia plant in Sluiskil: **0.8 Mtpa**。

Denmark (2026)

- Ørsted' s biomass power plant in Asnæs and Avedøre: **0.43 Mtpa**.

(https://norlights.com/)

UK - HyNet North West (H_2 + CCS)



- **H_2 production**: EET Hydrogen
- **H_2 transportation(pipeline)**: Cadent
- **H_2 underground storage**: INOVYN (salt dome, 35,000 tons)
- **CO_2 transportation(pipeline)**: Eni
- **CO_2 storage**: Eni' s depleted offshore gas field (4.5 Mtpa before 2030, 10 Mtpa after 2030)

(https://hynet.co.uk/)

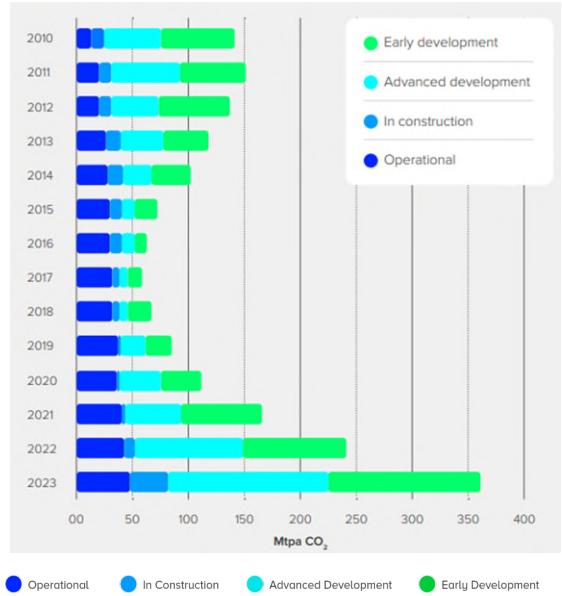
Government Support

Supportive CCS Policies in Key Regions

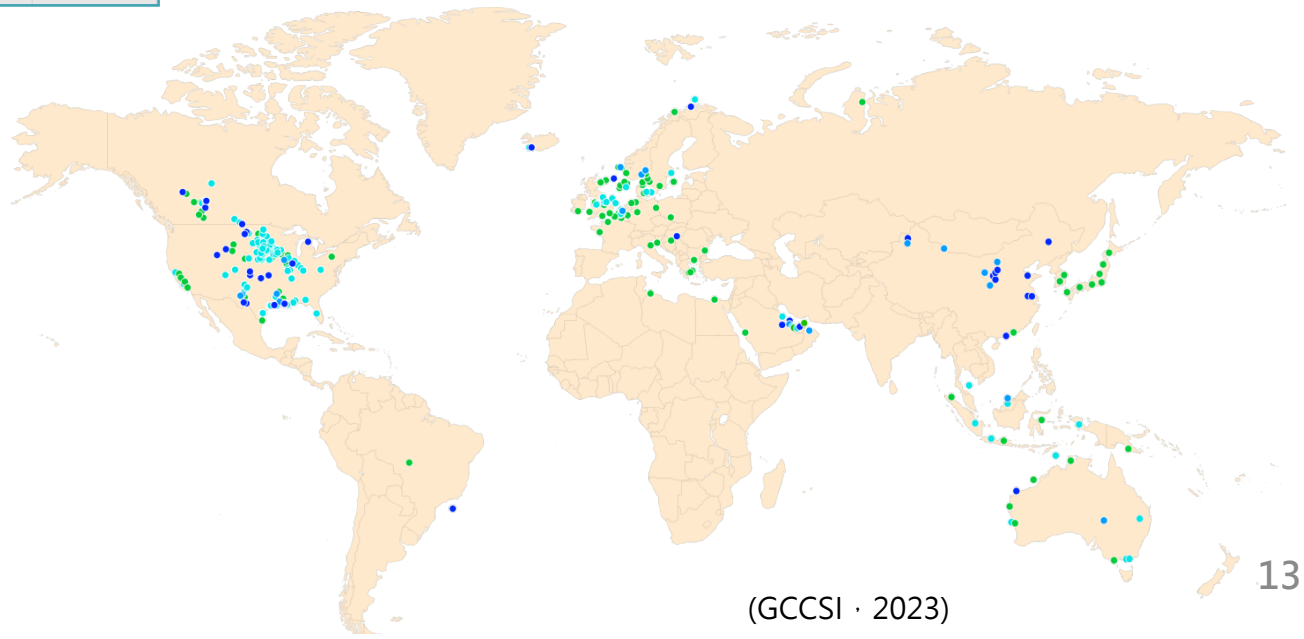
(S&P, 2024)

Countries/markets with supportive carbon capture policies (G20 excluding Argentina, including Norway)										
Country/region	Net zero goals	Carbon border tax	Carbon pricing	CO_2 performance standards and age restrictions	Public RD&D program	Legal and regulatory framework	Tax credits	Grants, financing and loan guarantees	CO_2 offtake or storage guarantees	Blue hydrogen strategy (blue H_2)
Australia	X		X		X	X		X	X	
Brazil	X				X	X				
Canada	X	X*	X	X	X	X	X	X		X
Mainland China	X		X		X					
European Union	X	X*	X		X	X		X		X
France	X		X	X	X	X				
Germany	X		X	X	X	X		X	X	X
India					X		X			
Indonesia	X		X		X					
Italy	X				X	X				
Japan	X		X		X	X	X		X	
Mexico	X				X					
Norway	X		X		X	X		X		
Russia			X*		X					X*
Saudi Arabia					X					X*
South Africa	X		X		X					
South Korea	X		X		X					
Turkey			X*		X					
United Kingdom	X		X	X	X	X			X	
United States	X	X*		X	X	X	X	X		

Data compiled July 30, 2023.
* Proposed policy that is under consultation or review.
RD&D = research, development and demonstration.
Source: S&P Global Commodity Insights.



- 392 CCS facilities with 361 Mtpa capture capacity by 2023.



(GCCSI · 2023)

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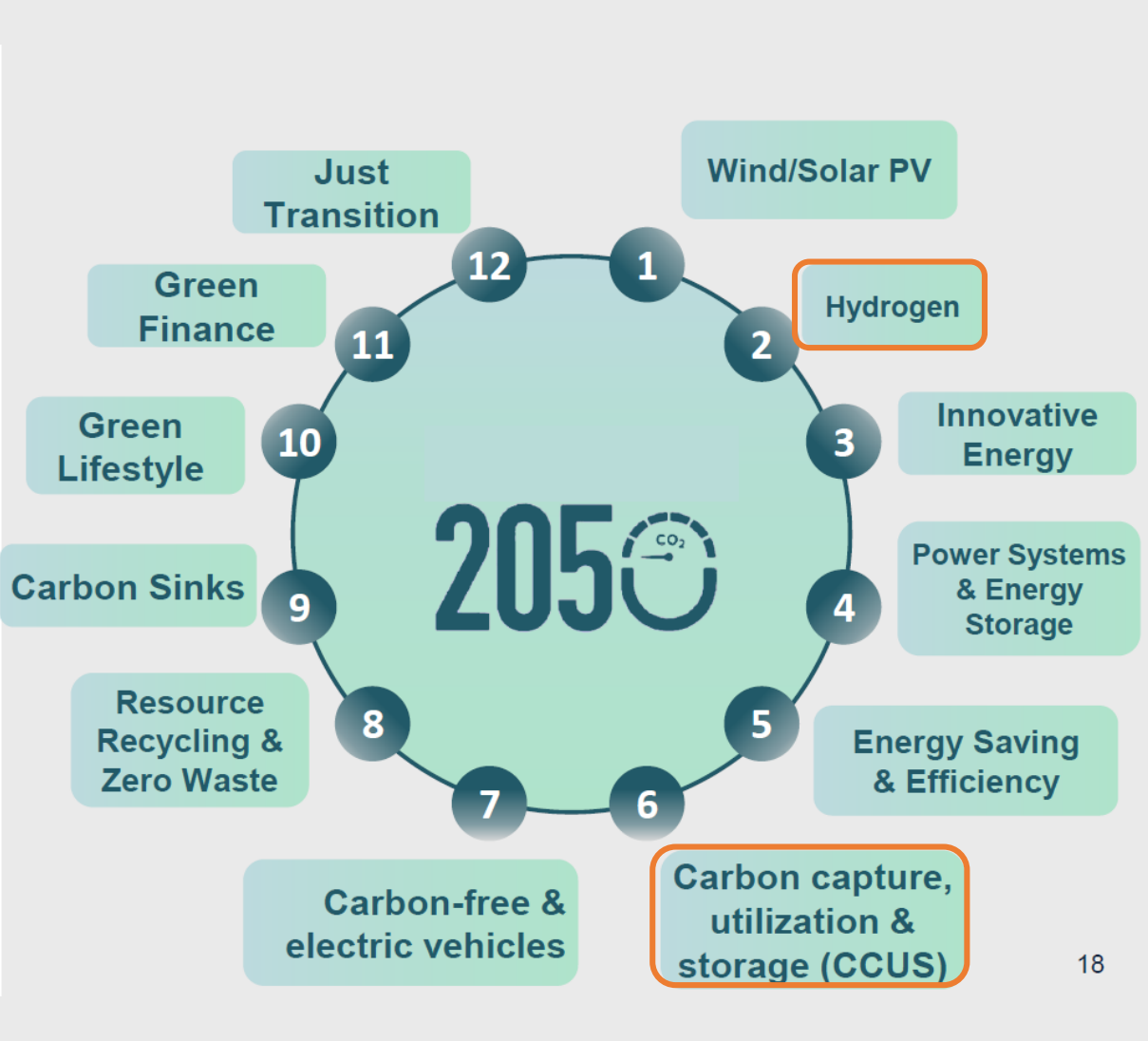
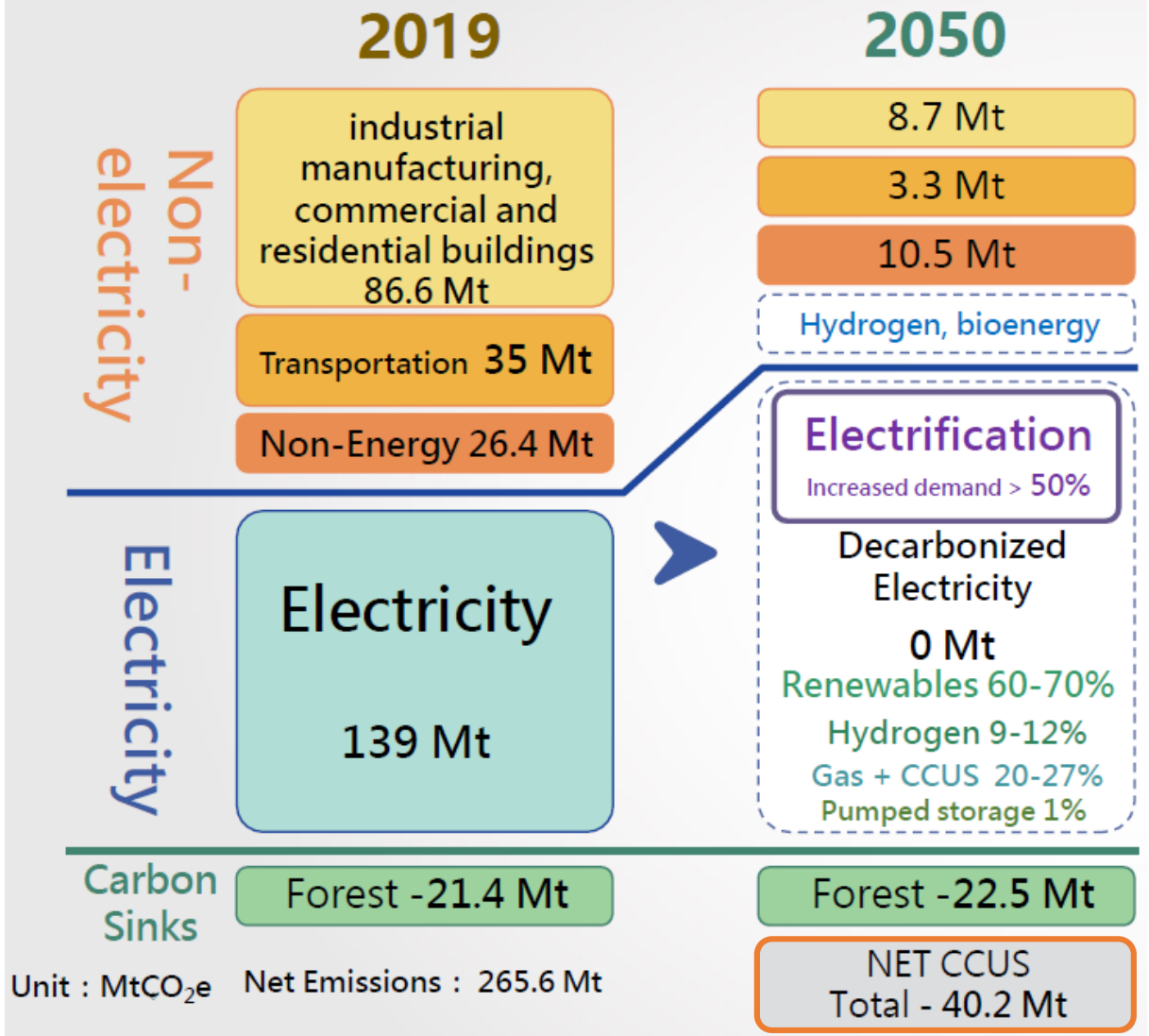
CCUS in Net Zero Pathway

CCUS in Net Zero Pathway





(https://www.ndc.gov.tw/en/Content_List.aspx?n=B154724D802DC488)

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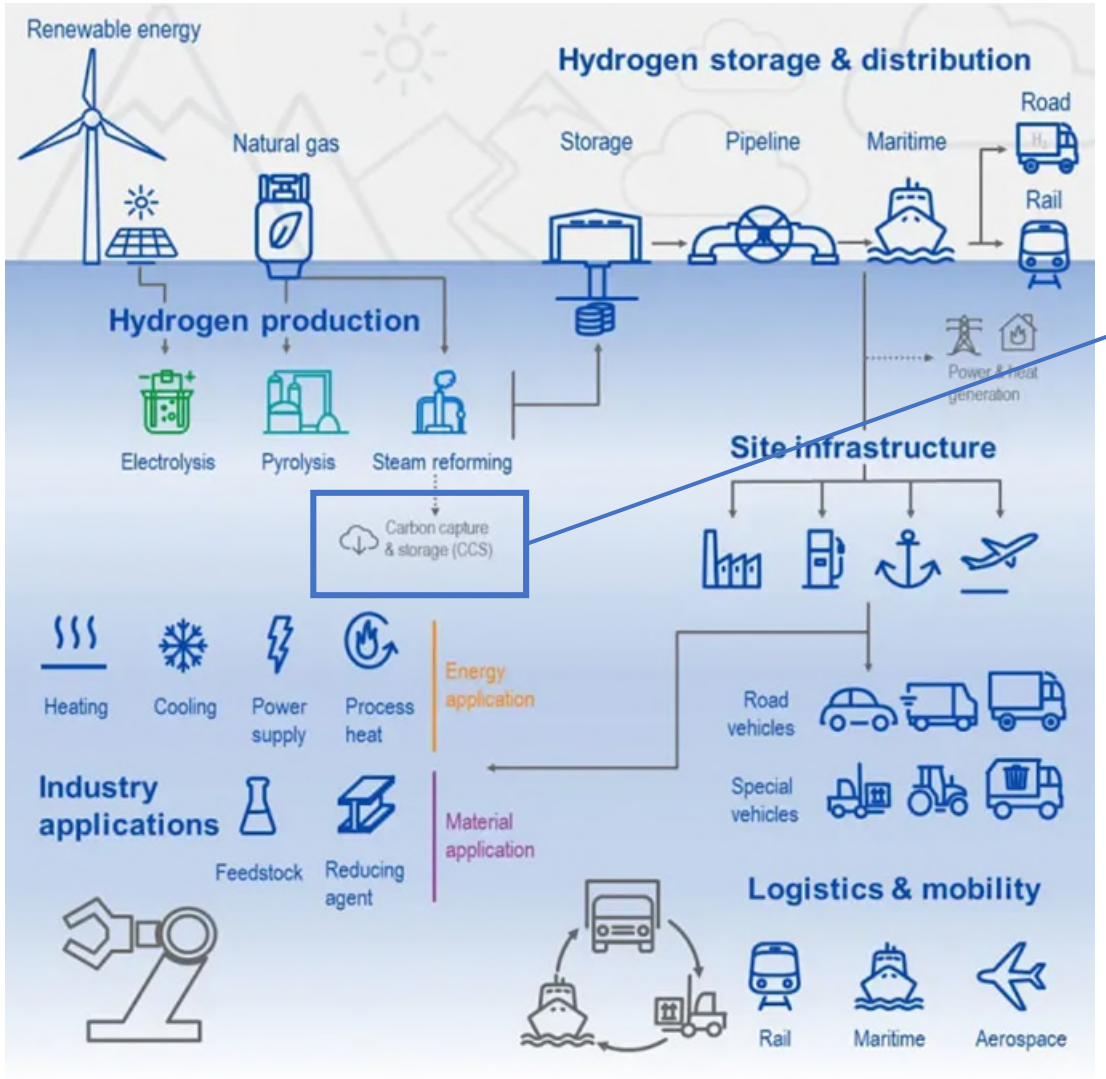
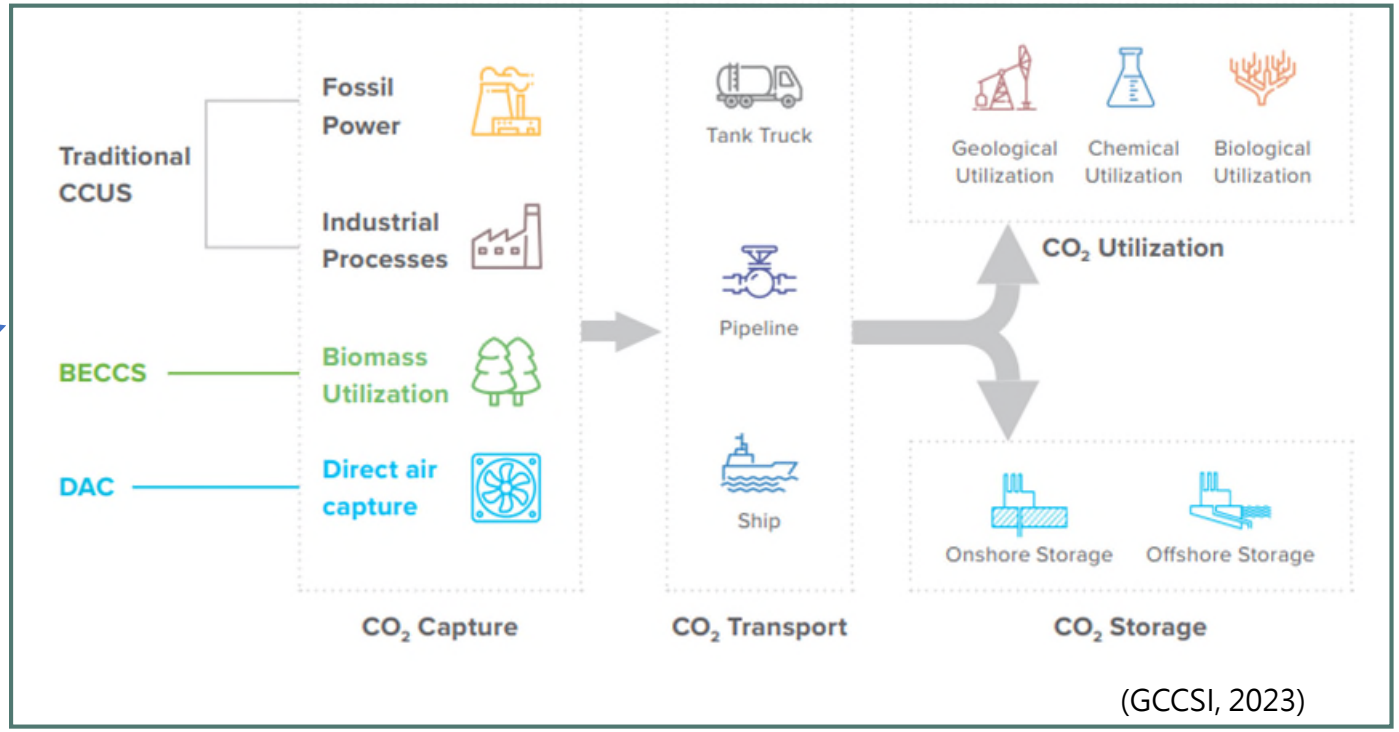
The Way Forward

H_2 and CCS Value Chain Combination



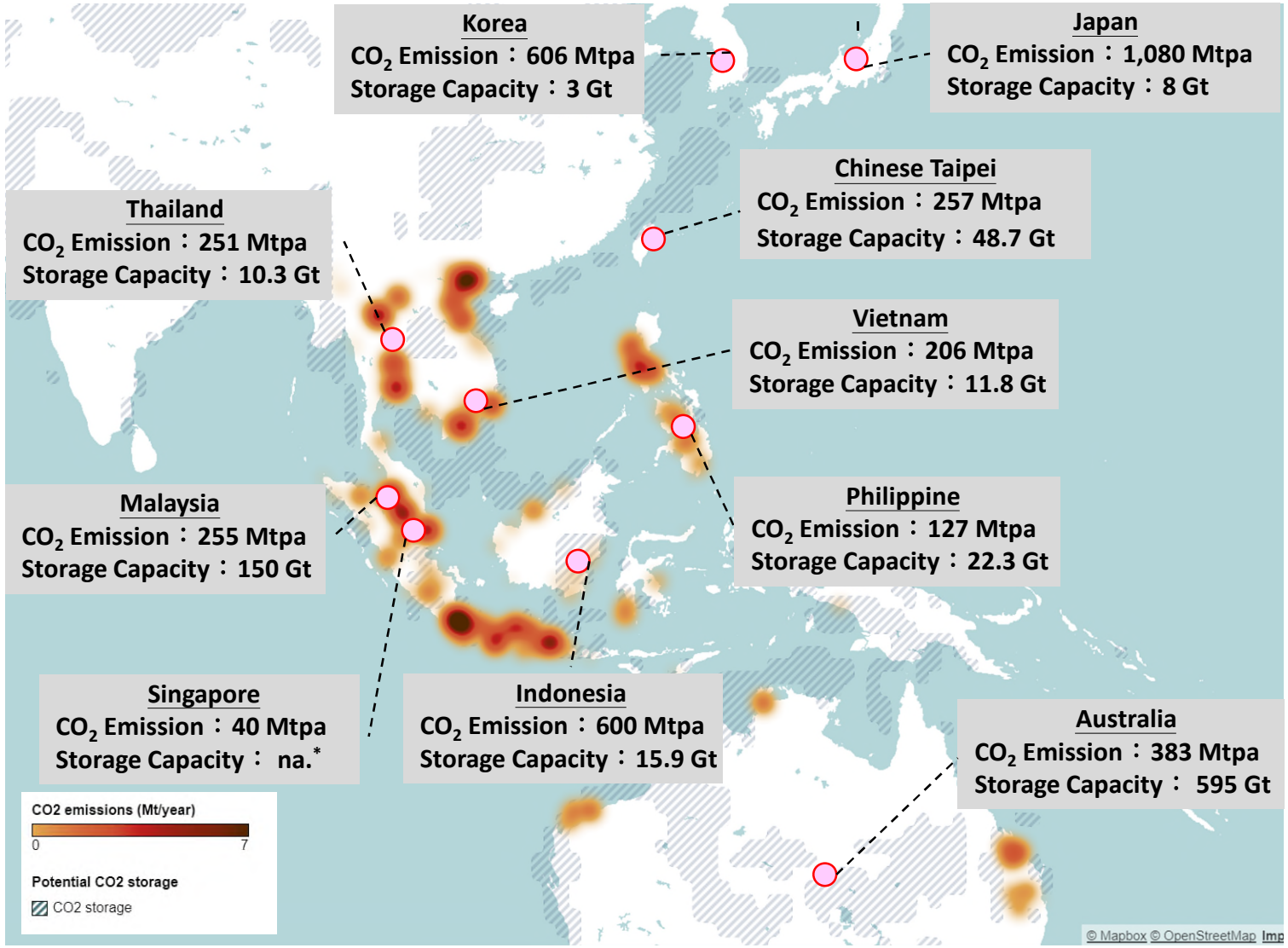


(GCCSI, 2023)

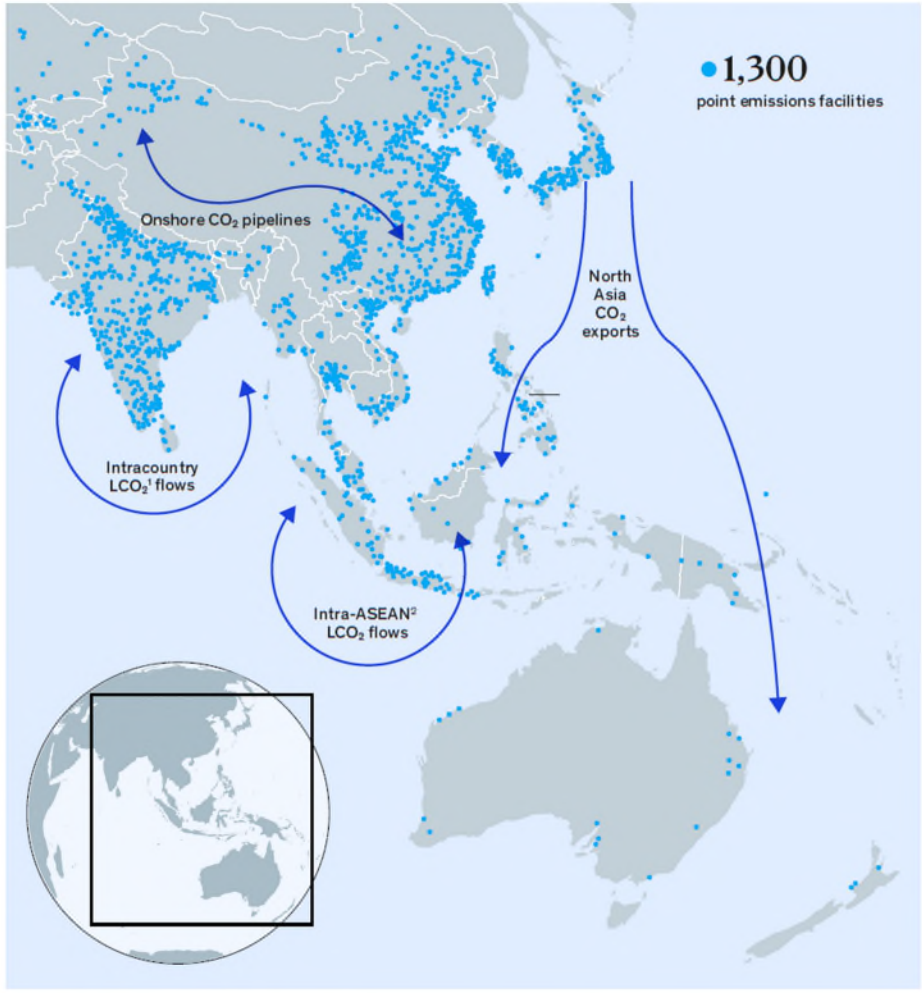
- Identify the demand of each emission facilities (H_2 or CCS)
- Evaluate the capacity of a CCS hub and H_2 Production Unit(HPU)
- Optimized the source-sink mapping through a value chain study.

(https://www.tuvsud.com/en/themes/hydrogen/explore-the-hydrogen-value-chain)

International Cooperation – Source-Sink Mapping



Potential CCS network

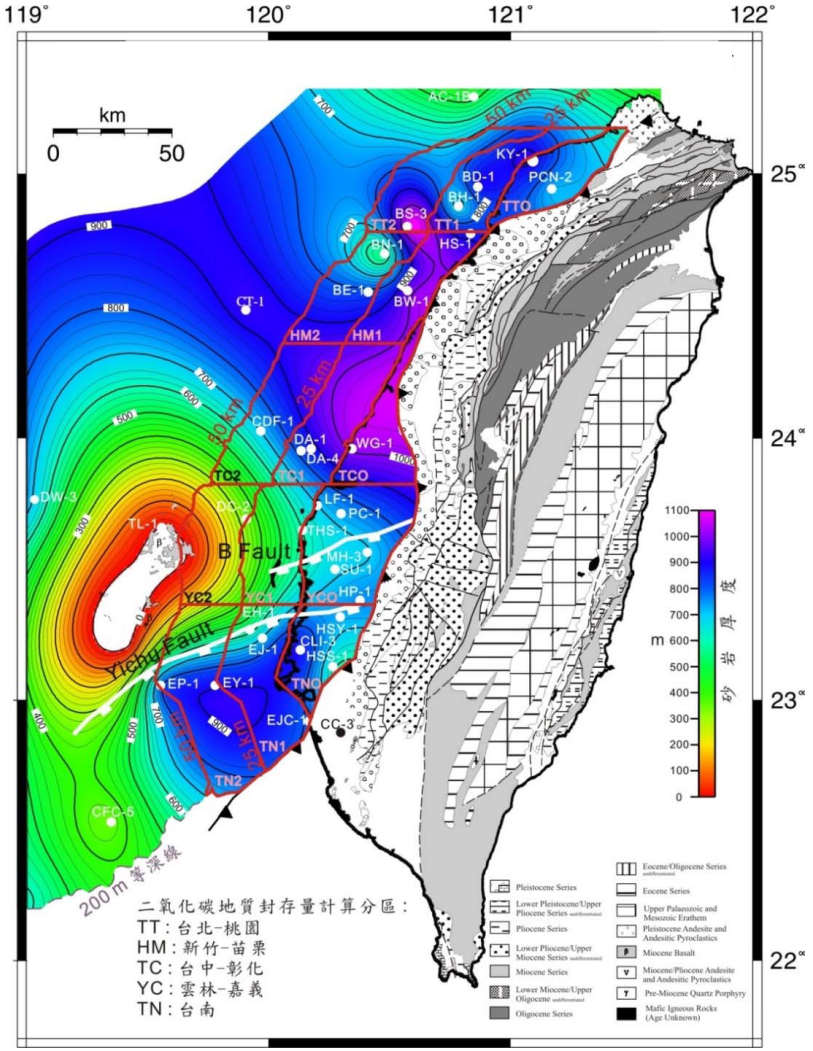


(Lu, 2008; Lin, 2014; Kearns, 2017; IEA, 2021; OGCI, 2022; McKinsey & Company, 2023)

Storage Potential and Primary Point Emission Facilities

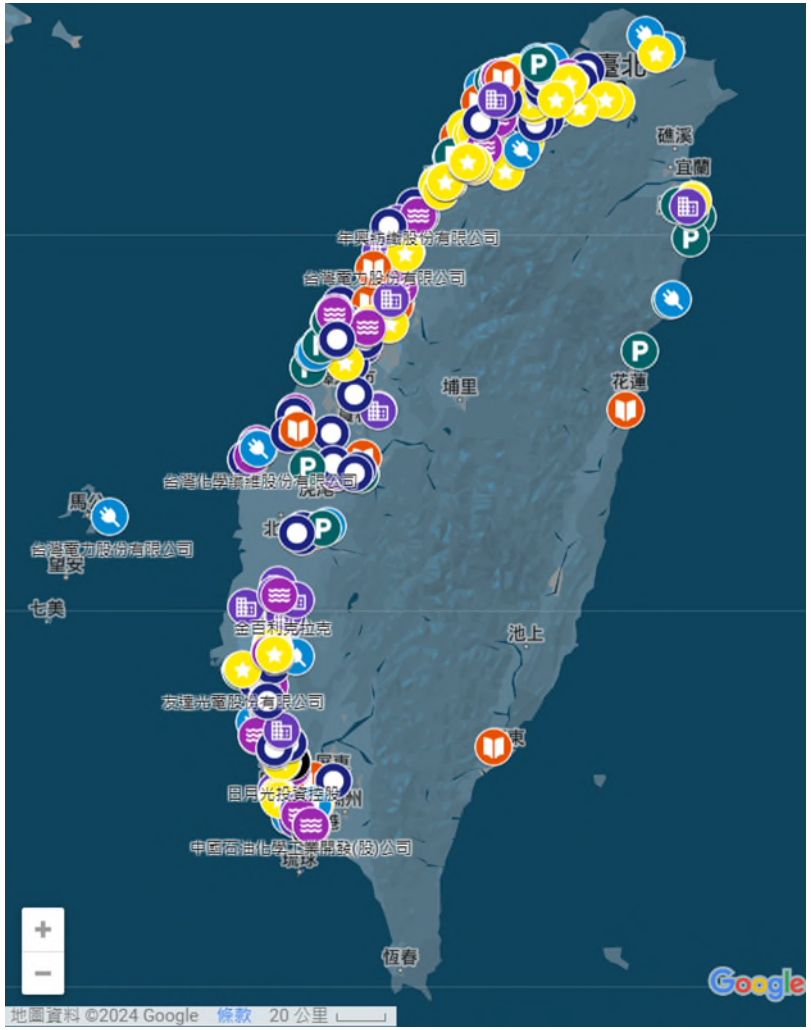
Onshore (2.8 Gt)

(Lu, 2008)



Plain, nearshore and offshore (45.9 Gt)

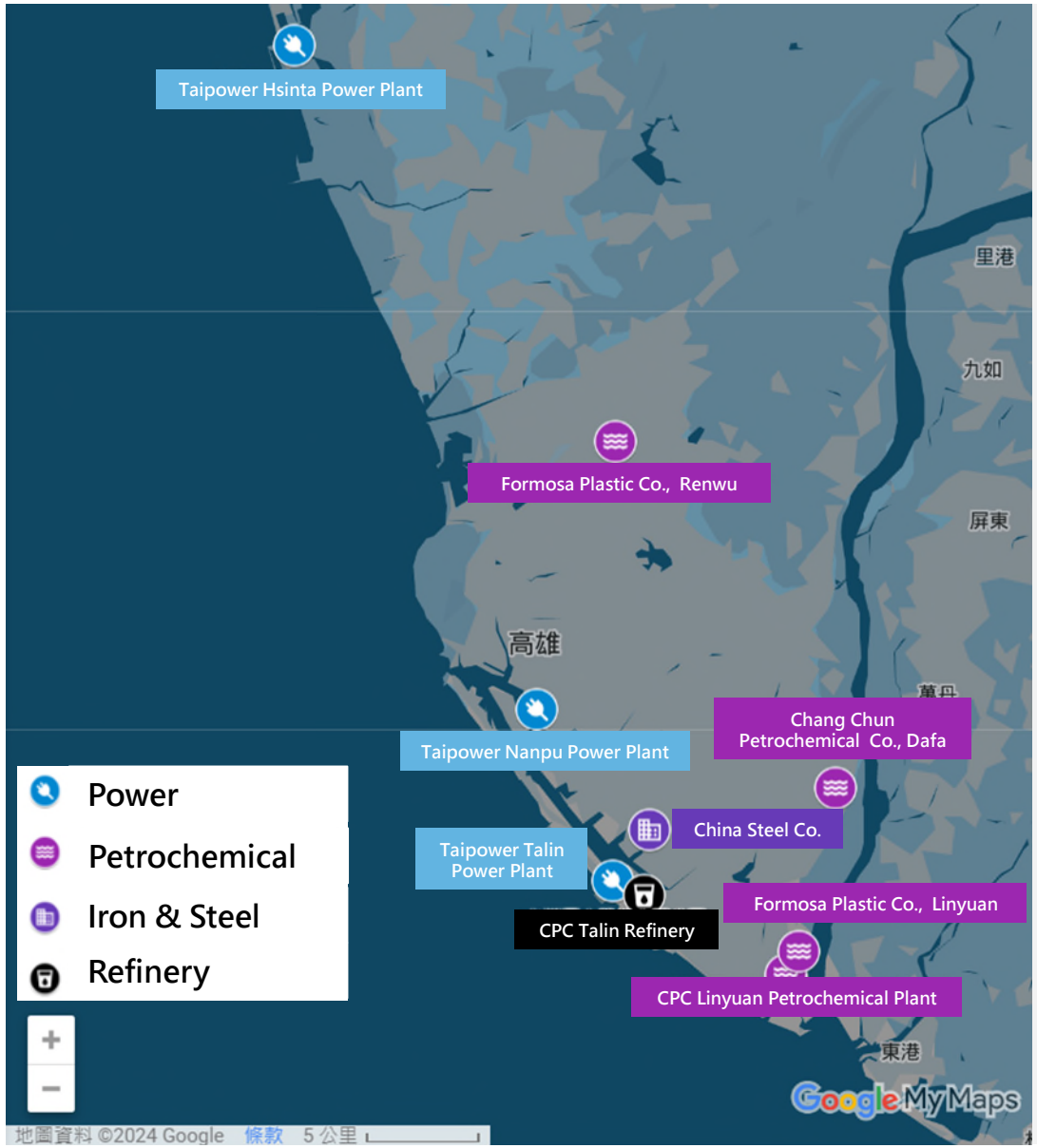
(Lin, 2014)

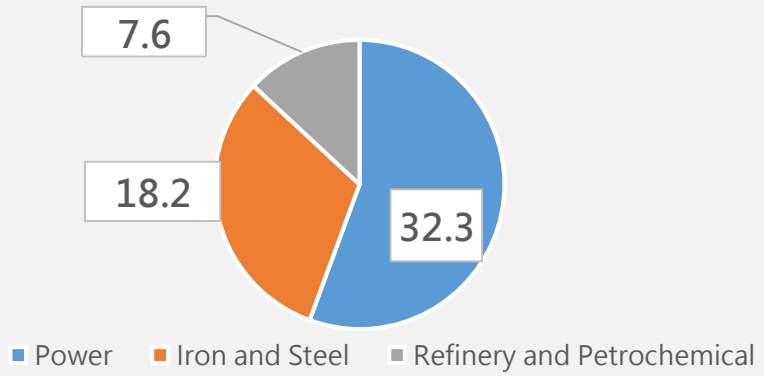


Primary point emission facilities
(42 facilities direct GHG emission>0.5Mtpa)

(Chang., 2023)

Low Carbon City - Kaohsiung





- Nine facilities with direct GHG emissions larger than 0.5 Mtpa, accounting for 85% of the total GHG emissions of all emission facilities in Kaohsiung, including:
  - 3 power plants
  - 1 iron and steel mill
  - 1 refinery
  - 4 petrochemical plants

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Conclusion

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Attract more players to reduce CCS cost

- Invest in R&D to improve the capture technologies.
- Integrate H_2 and CCS into one business model and optimize the capacity design and the source-sink mapping through the value chain analysis.
- Develop a cross-domain strategic alliance and establish a CCS hub to lower the cost and investment risk.
- Call for government support for common infrastructure.

Raise public acceptance through outreach and engagement

- Address public concerns by providing honest and transparent information.

Thanks for your attention

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