# Cost Reduction in CCS

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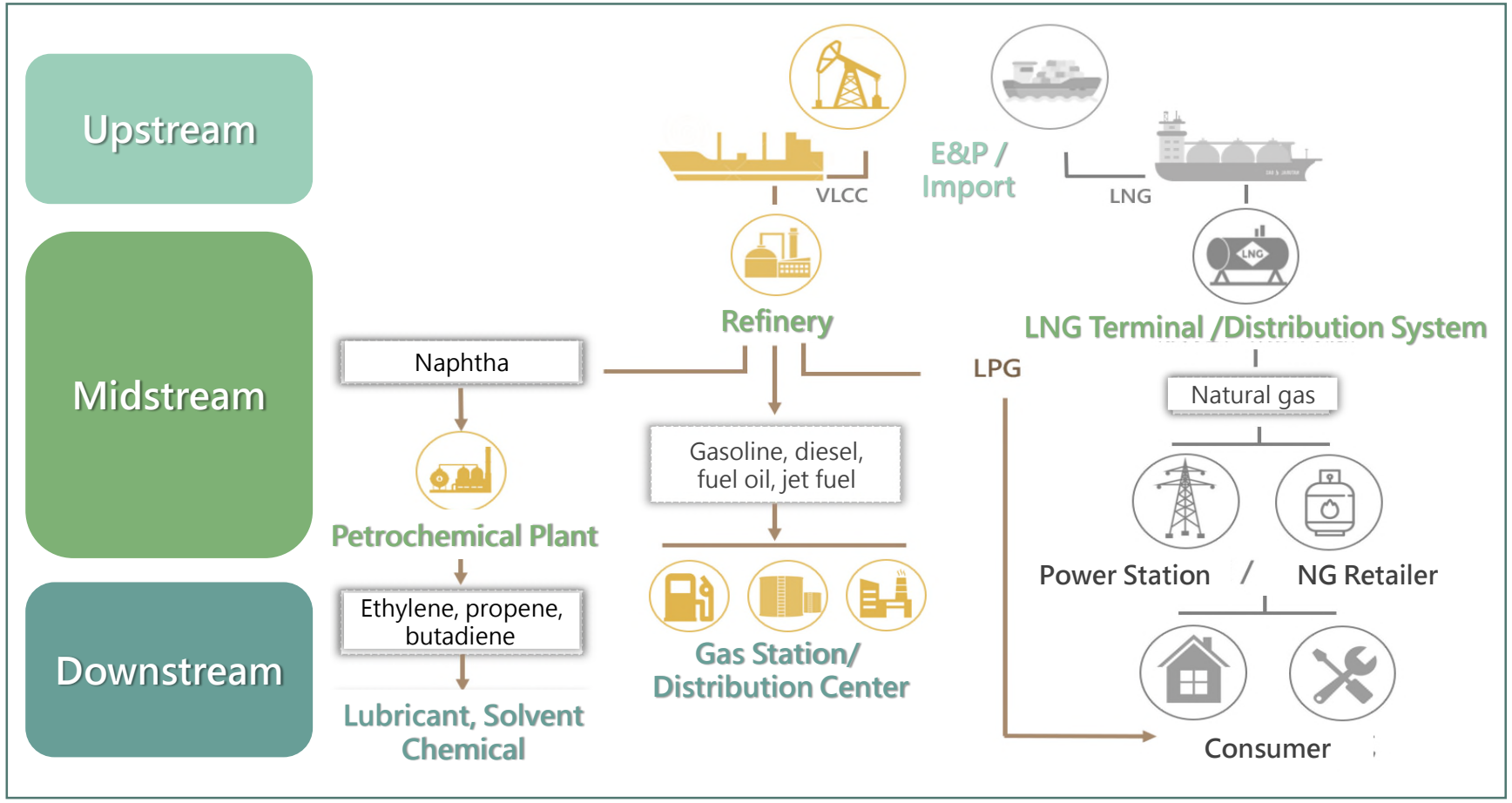
CPC
2024.04.23

- 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

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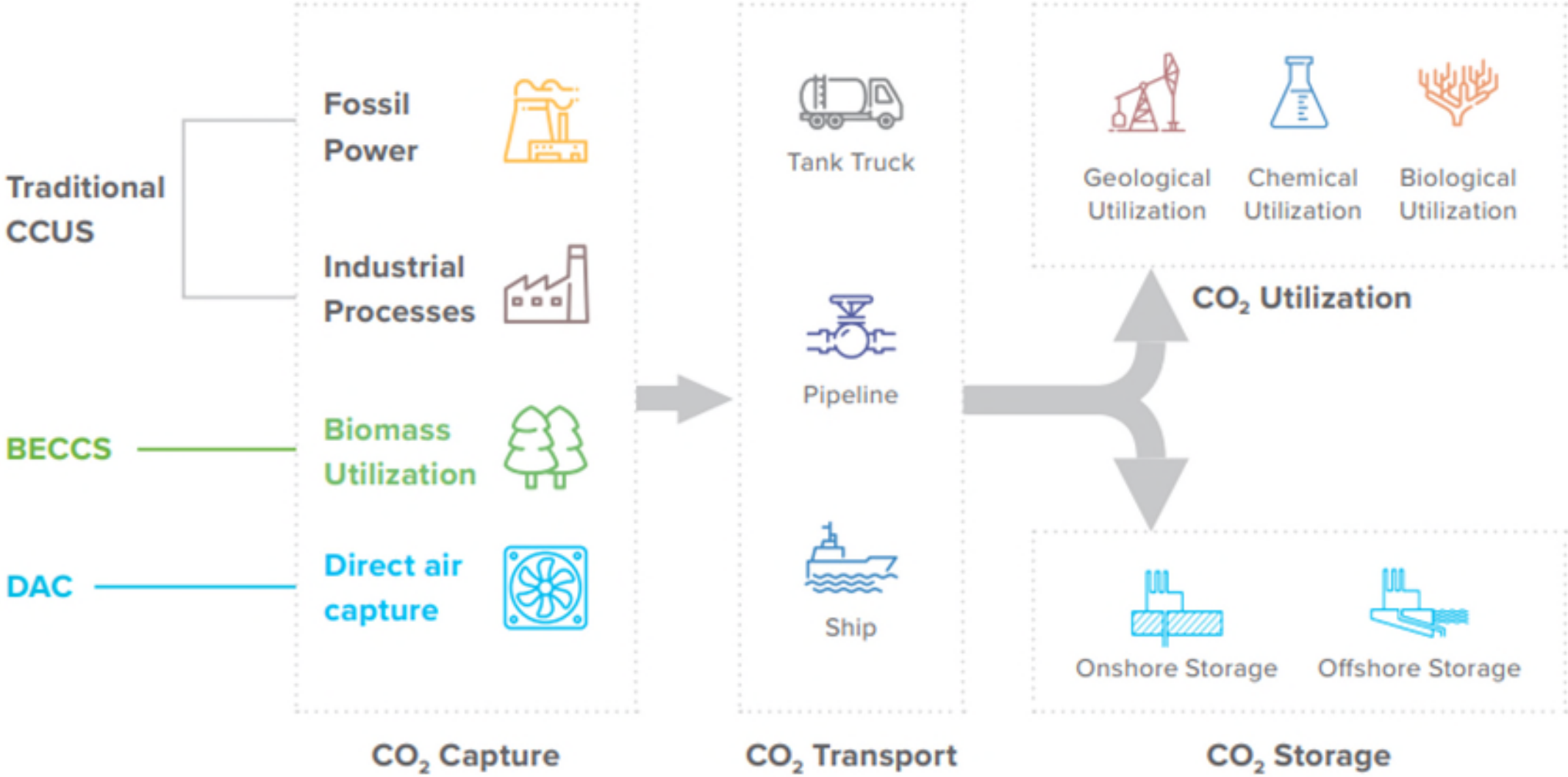



(GCCSI, 2023)

# Content

## Cost Reduction in CCS

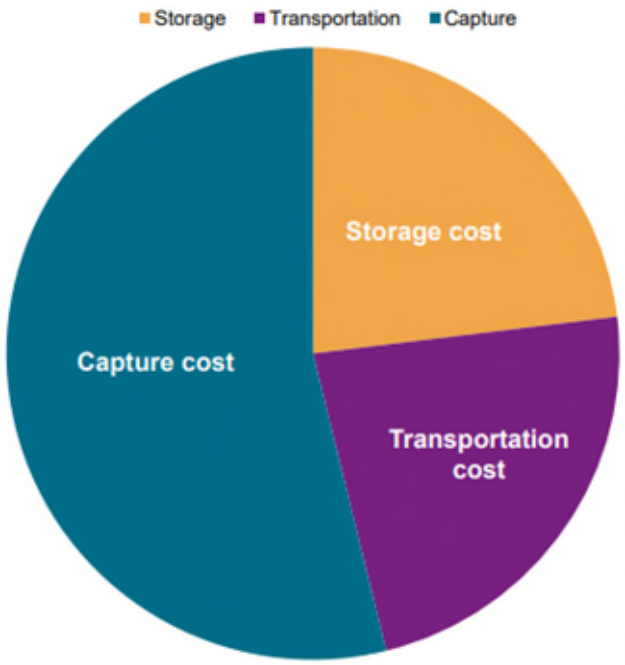
# CCS Cost Composition

**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

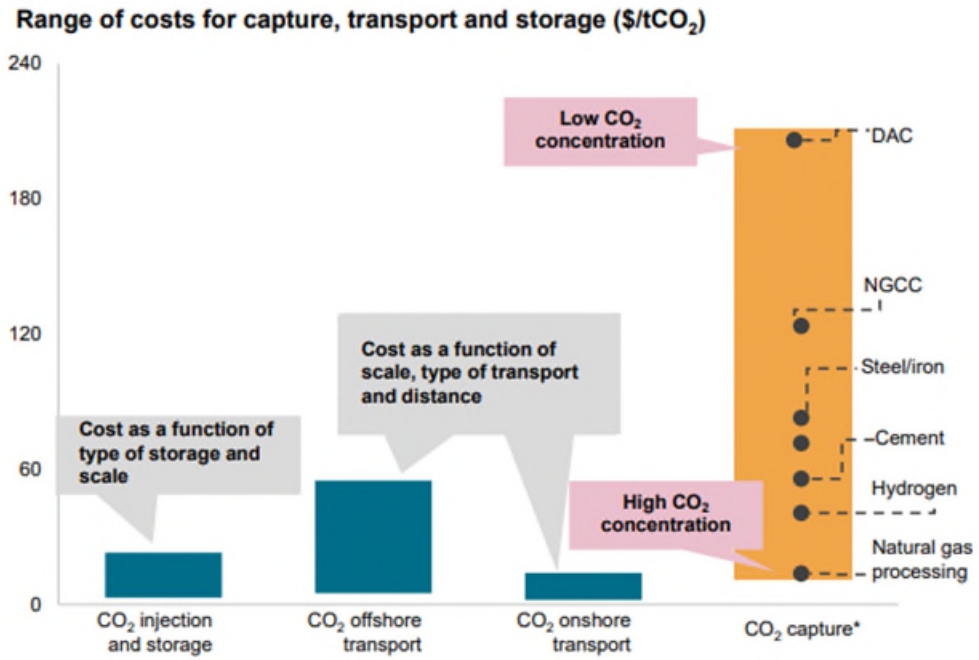
**Volume**
- Volume of $CO_2$ stored

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

**Location**
- Location/risk factor
- Distance to storage site

**Volume**
- Volume of $CO_2$ stored

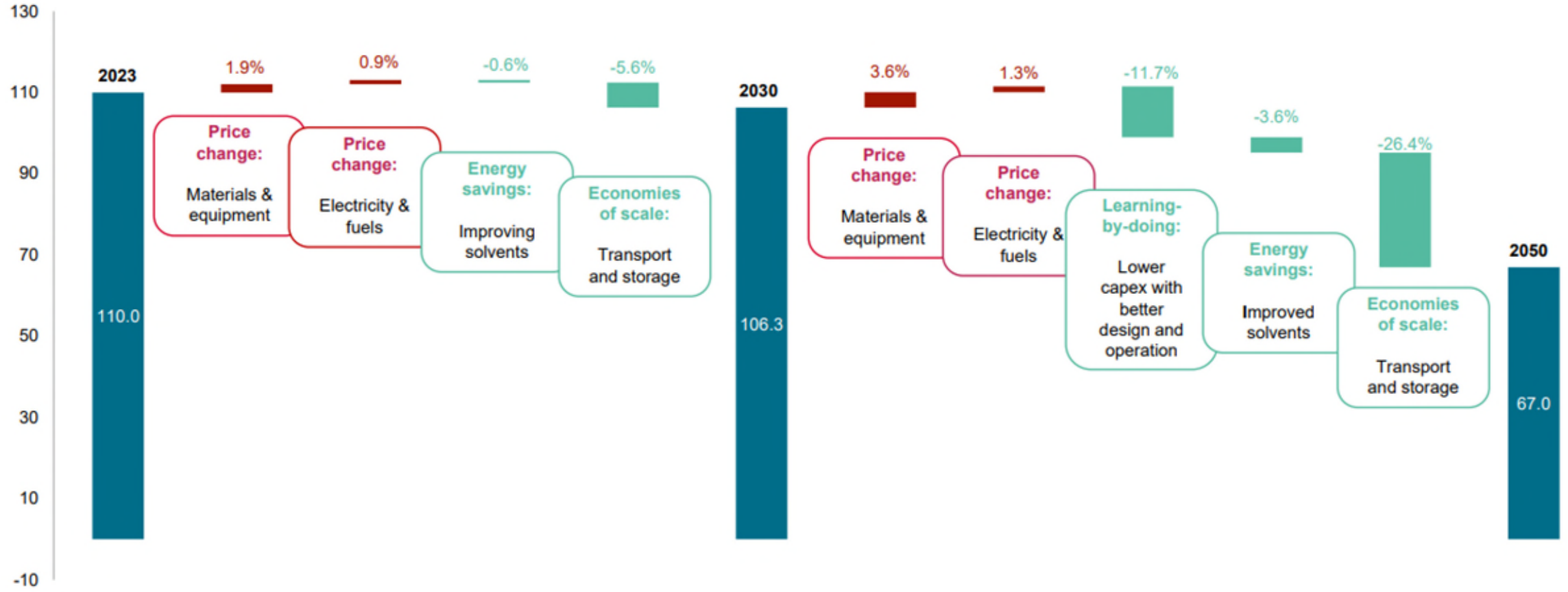
**Type of transportation**
- Pipeline
- Ship
- Truck or rail




(S&P Global, 2024)

# Key Factors Driving the CCS Cost

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

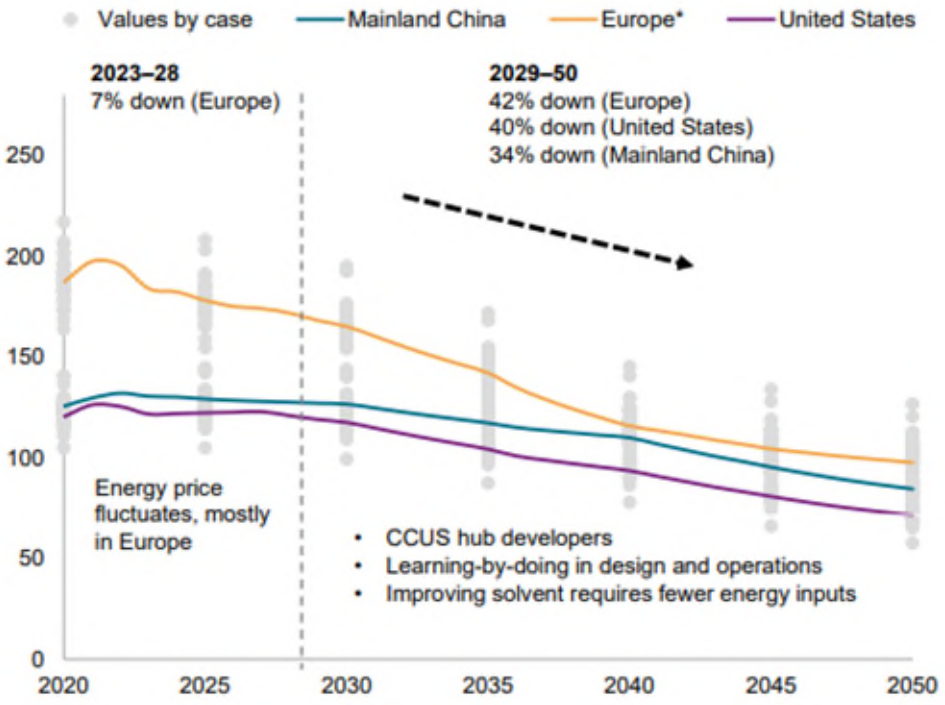


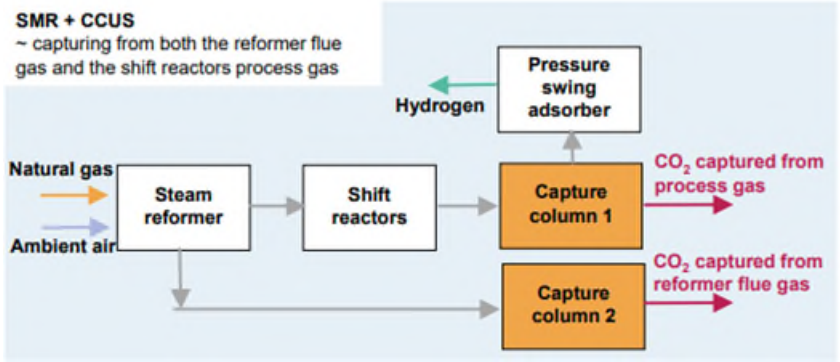

Data compiled March 5, 2024.
The numbers in the figure refer to the LCCA of cement in the United States.
Source: S&P Global Commodity Insights.

(S&P Global, 2024)

# SMR v.s. ATR

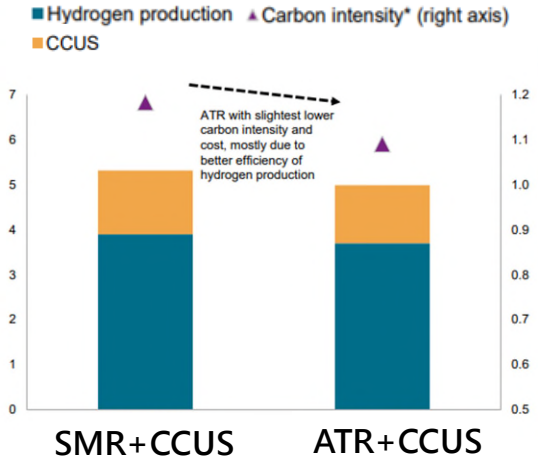
## SMR: $CO_2$ avoidance cost outlook(2023$/t$CO_2$)



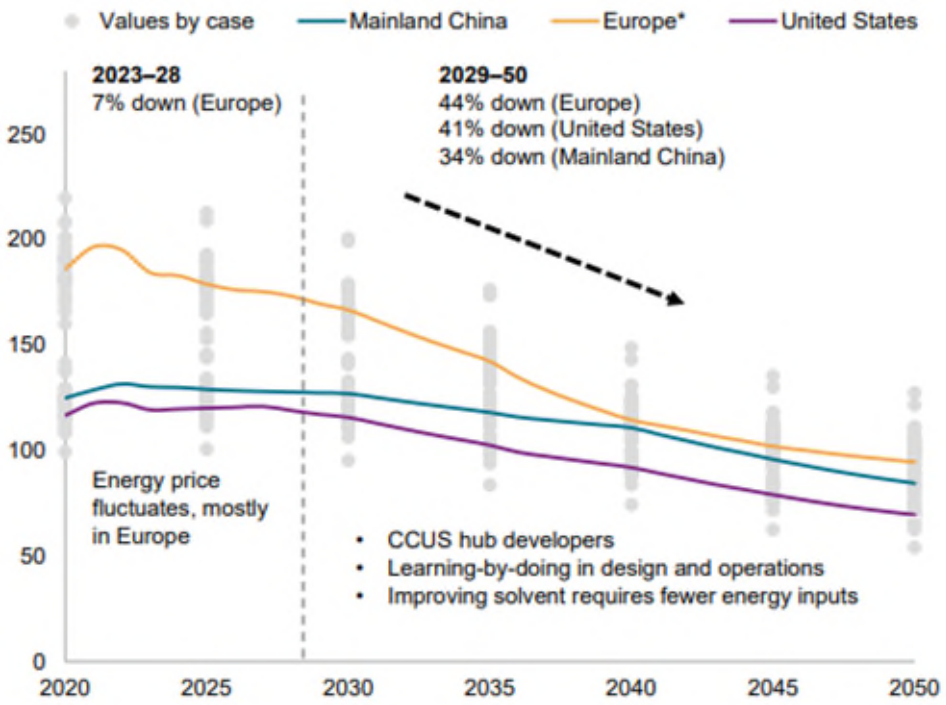

## Levelized cost of Hydrogen production

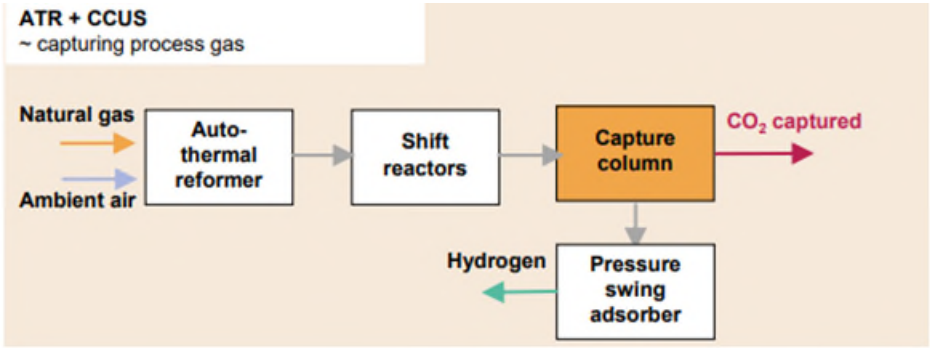
(left: 2023$/kg$H_2$, right: kg$CO_2$/kg$H_2$)




(S&P Global, 2024)

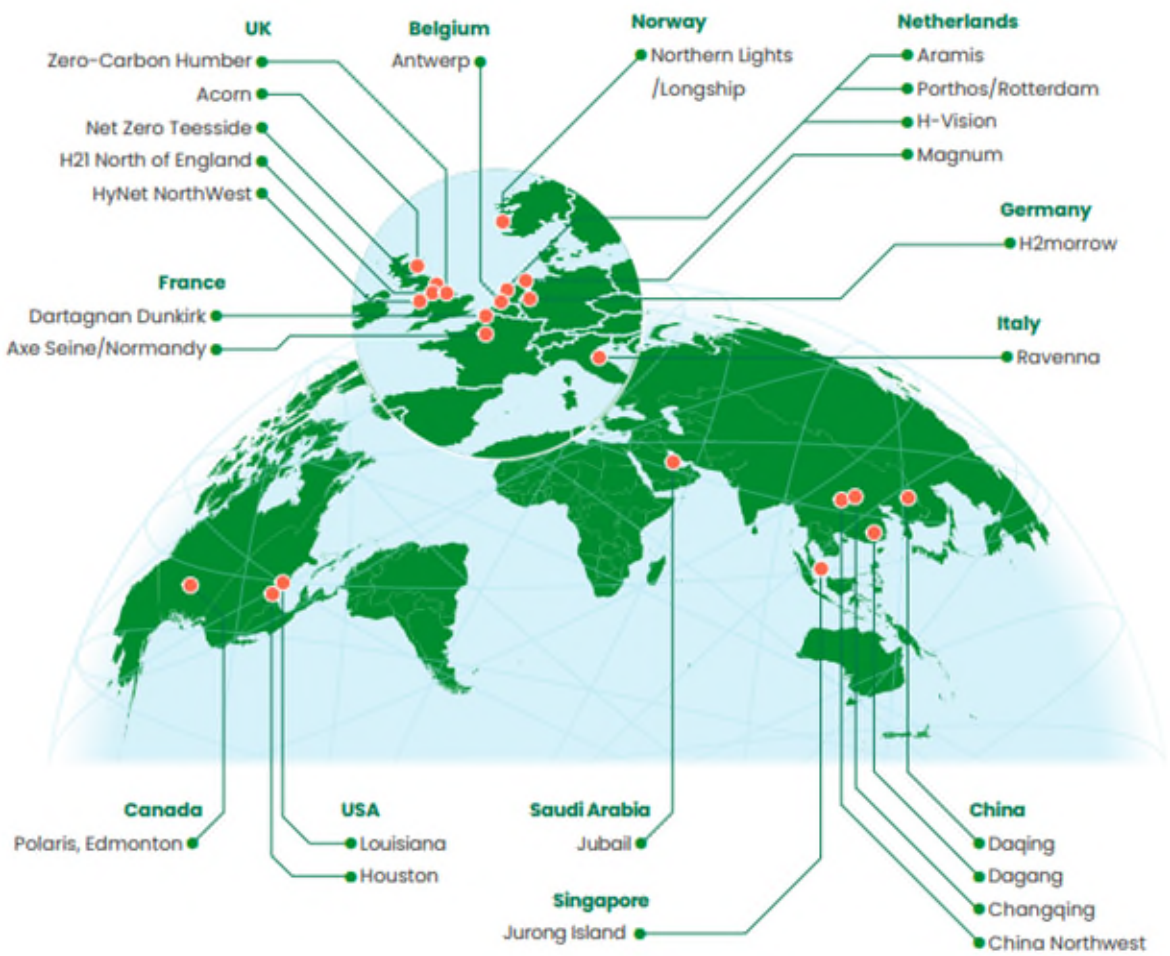
## ATR: $CO_2$ avoidance cost outlook(2023$/t$CO_2$)



# Economies of Scale – CCUS Hub

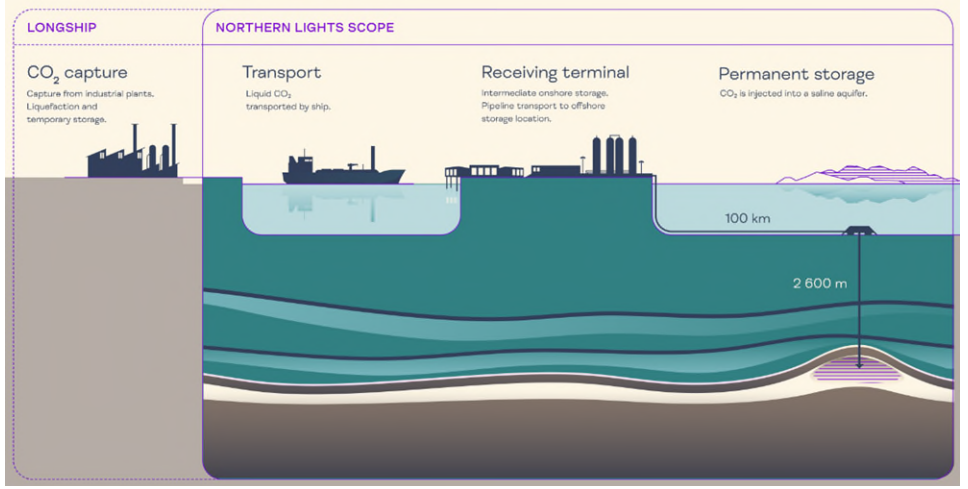
A CCUS hub takes carbon dioxide from several emitting sources, and then transports and stores it using common infrastructure.




- **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)

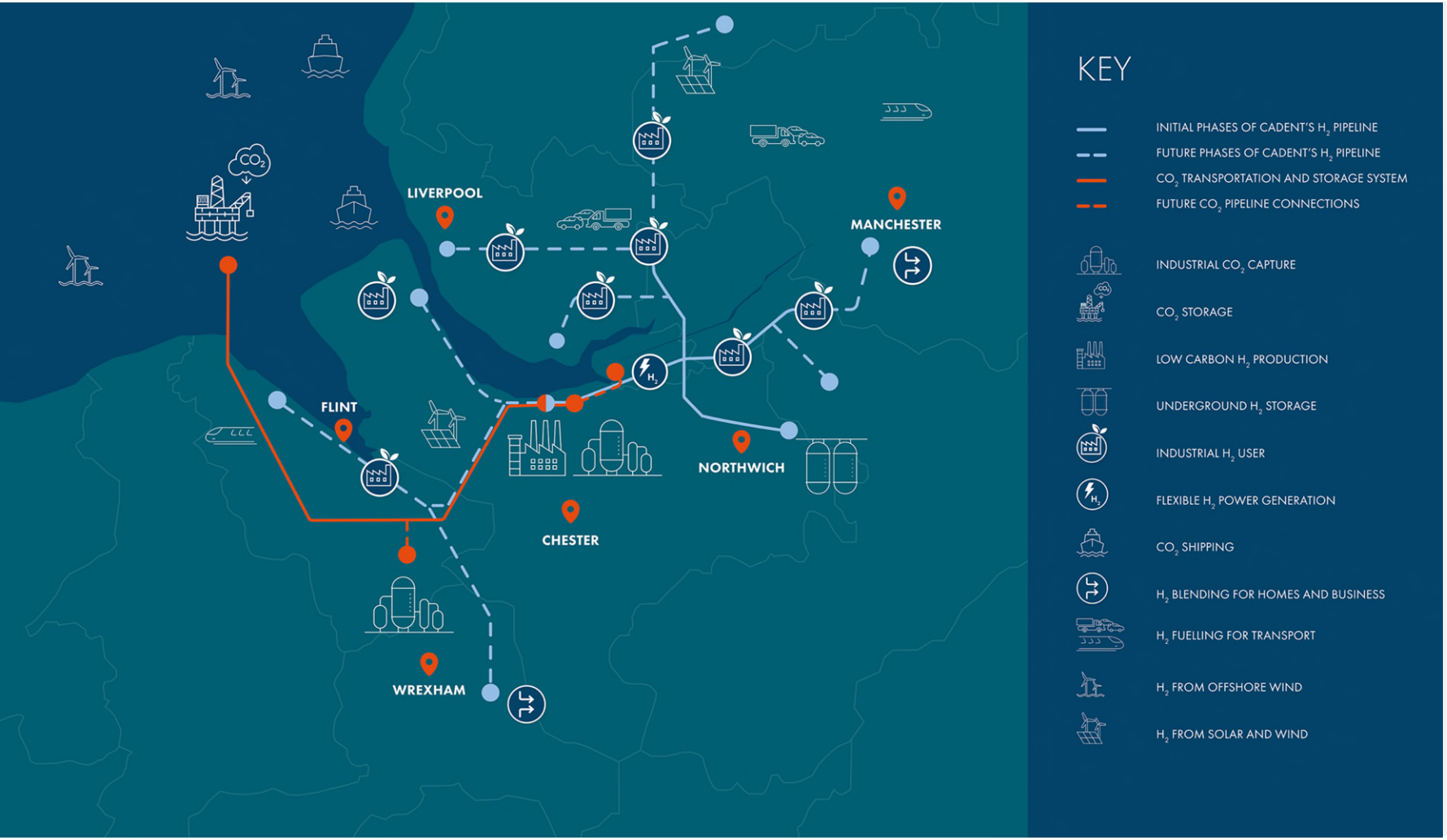
- Yara' s ammonia plant in Sluiskil: **0.8 Mtpa**。

## 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/)

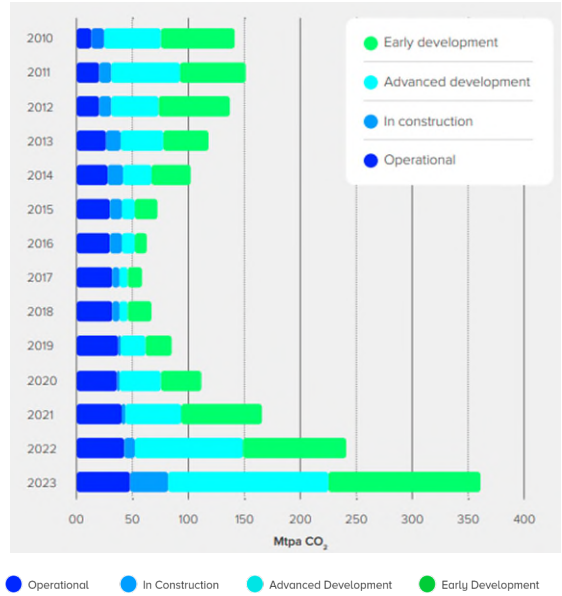
# Government Support

## Supportive CCS Policies in Key Regions

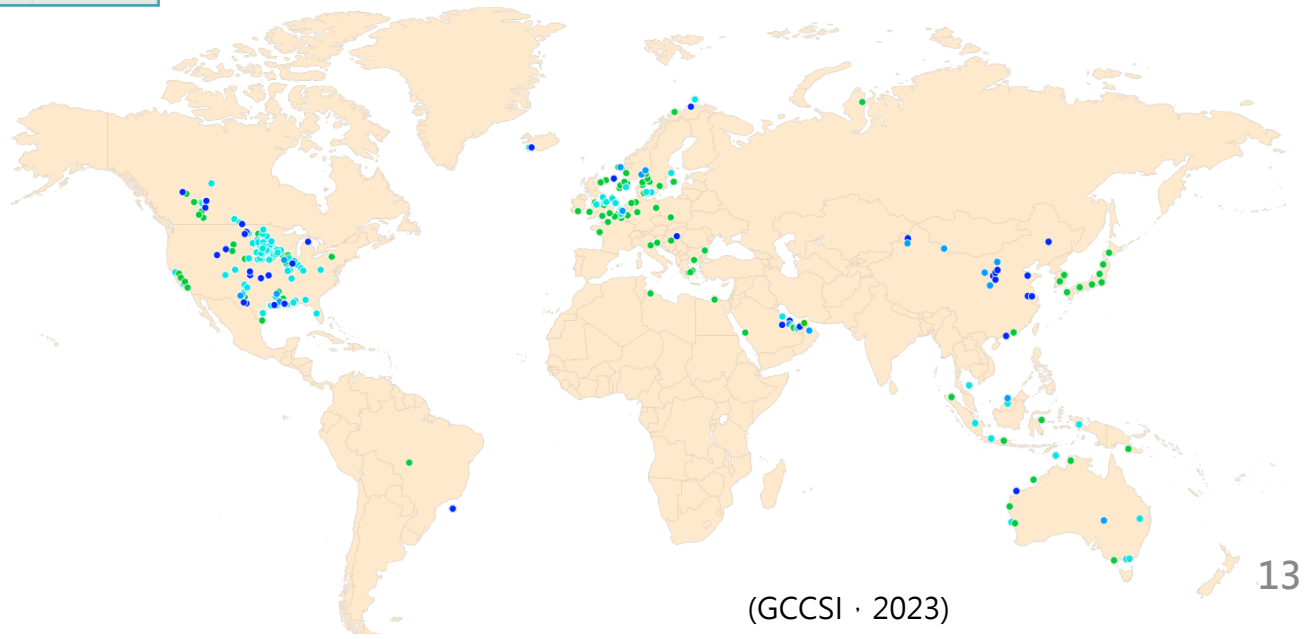
(S&P, 2024)

| 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

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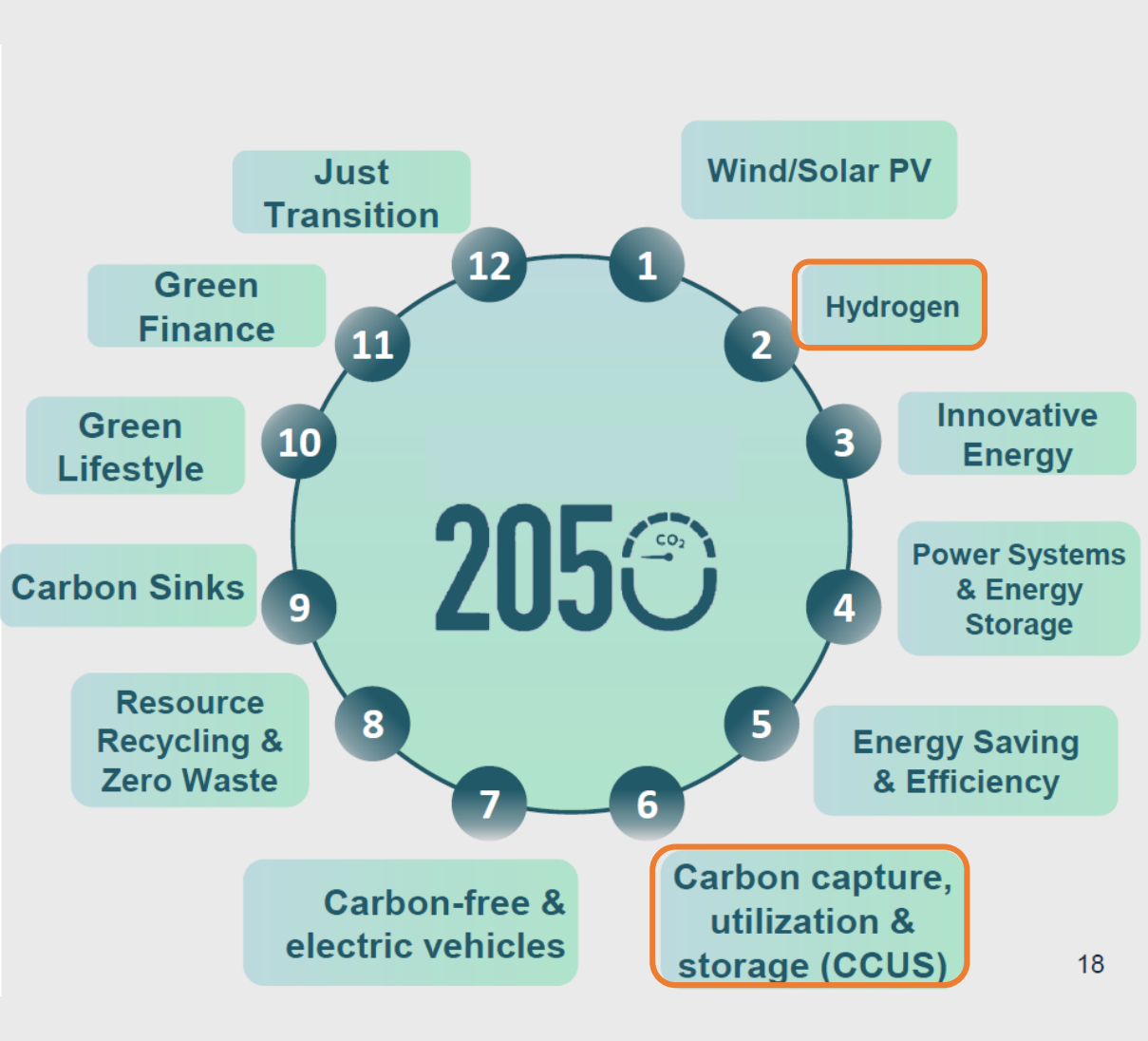


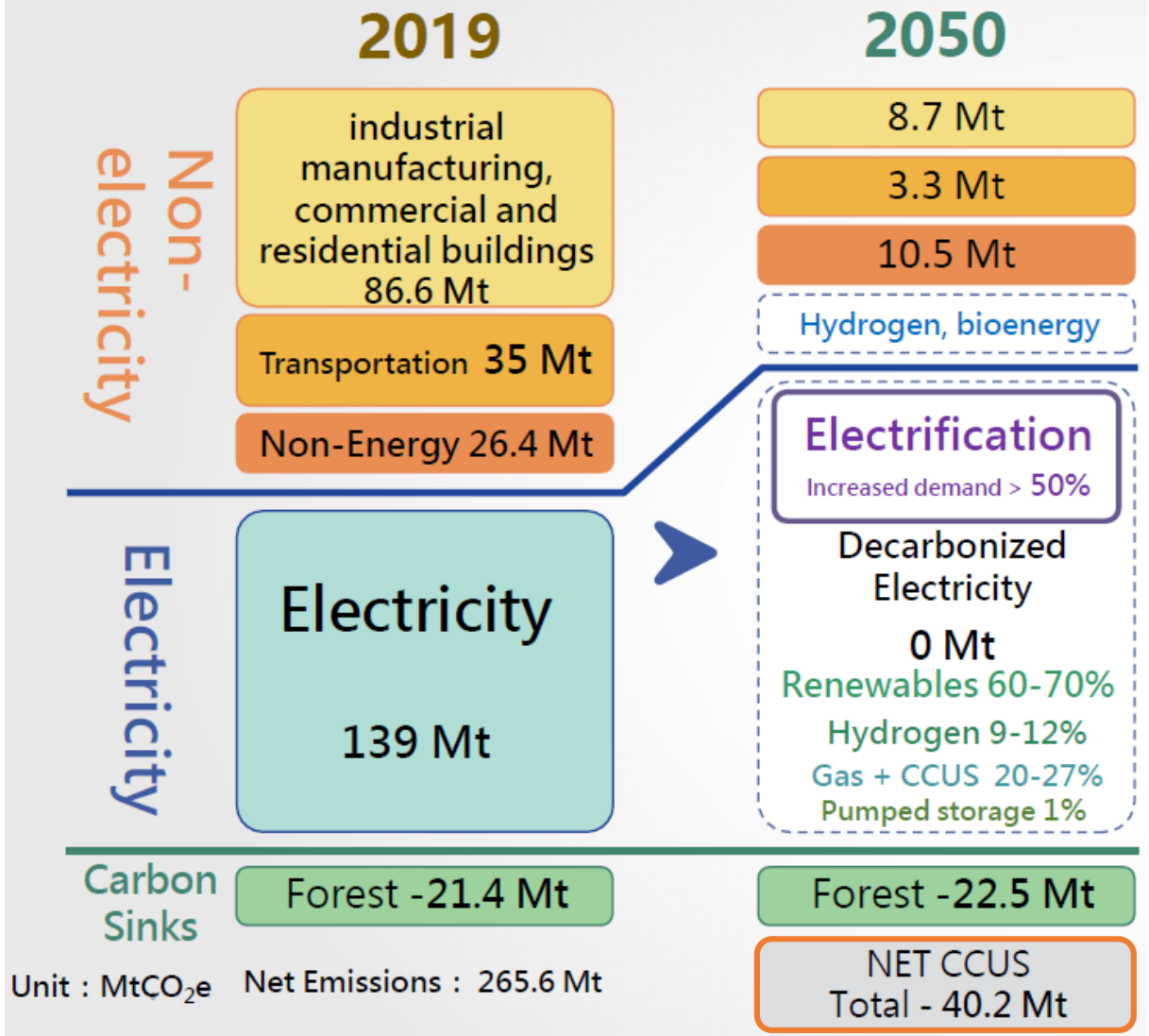


(https://www.ndc.gov.tw/en/Content_List.aspx?n=B154724D802DC488)

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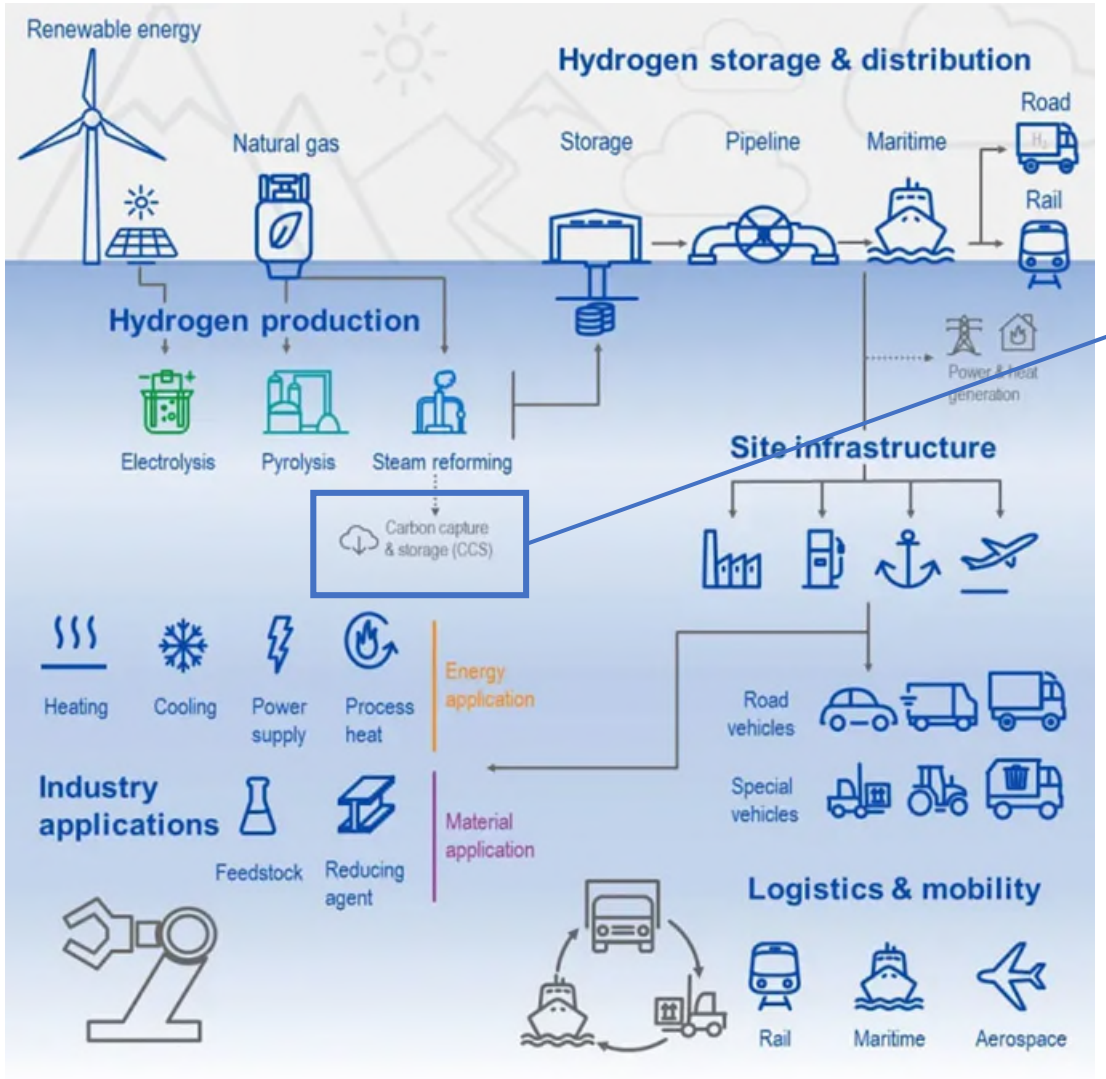
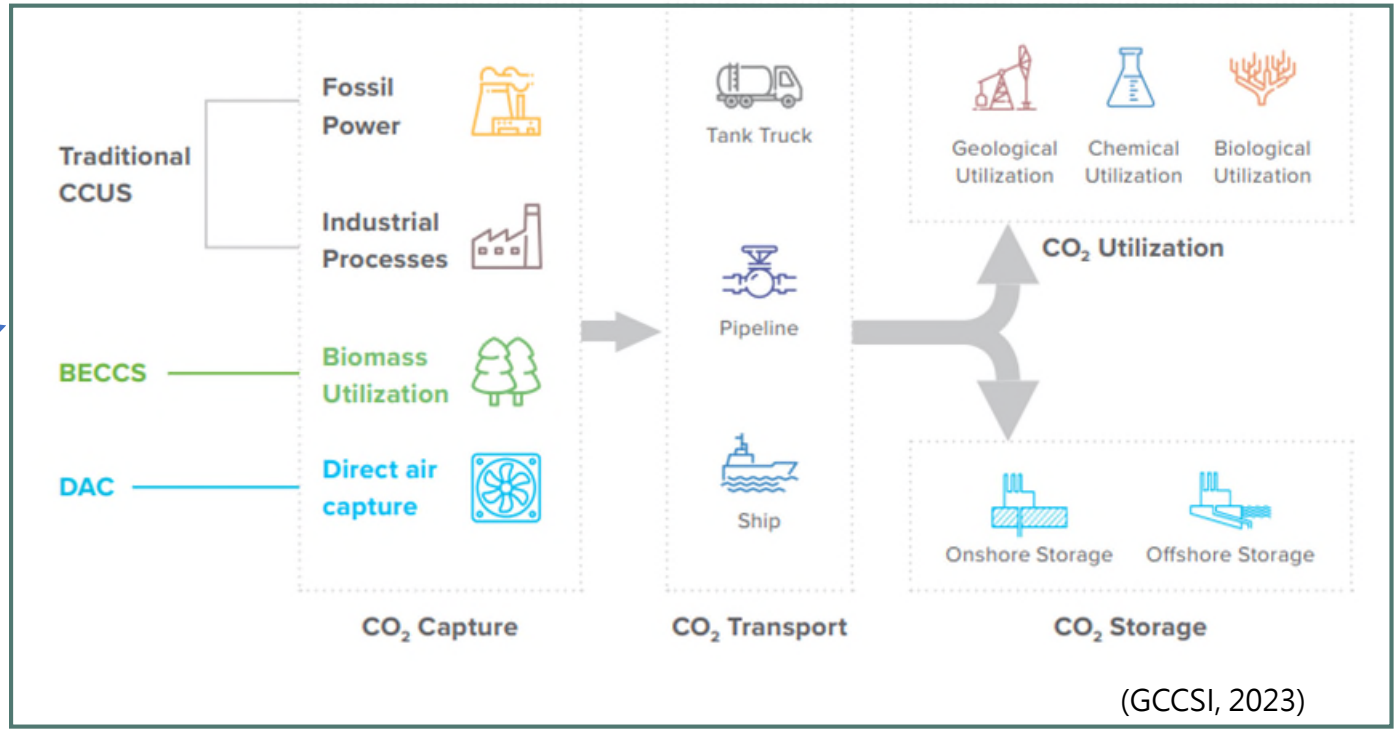
## The Way Forward

# $H_2$ 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

**Republic of Korea**
$CO_2$ Emission：636 Mtpa
Storage Capacity：3 Gt

**Japan**
$CO_2$ Emission：1,083 Mtpa
Storage Capacity：8 Gt

**People's Republic of China**
$CO_2$ Emission：12,667 Mtpa
Storage Capacity：403 Gt

**Chinese Taipei**
$CO_2$ Emission：276 Mtpa
Storage Capacity：48.7 Gt

**Thailand**
$CO_2$ Emission：282 Mtpa
Storage Capacity：10.3 Gt

**Vietnam**
$CO_2$ Emission：328 Mtpa
Storage Capacity：11.8 Gt

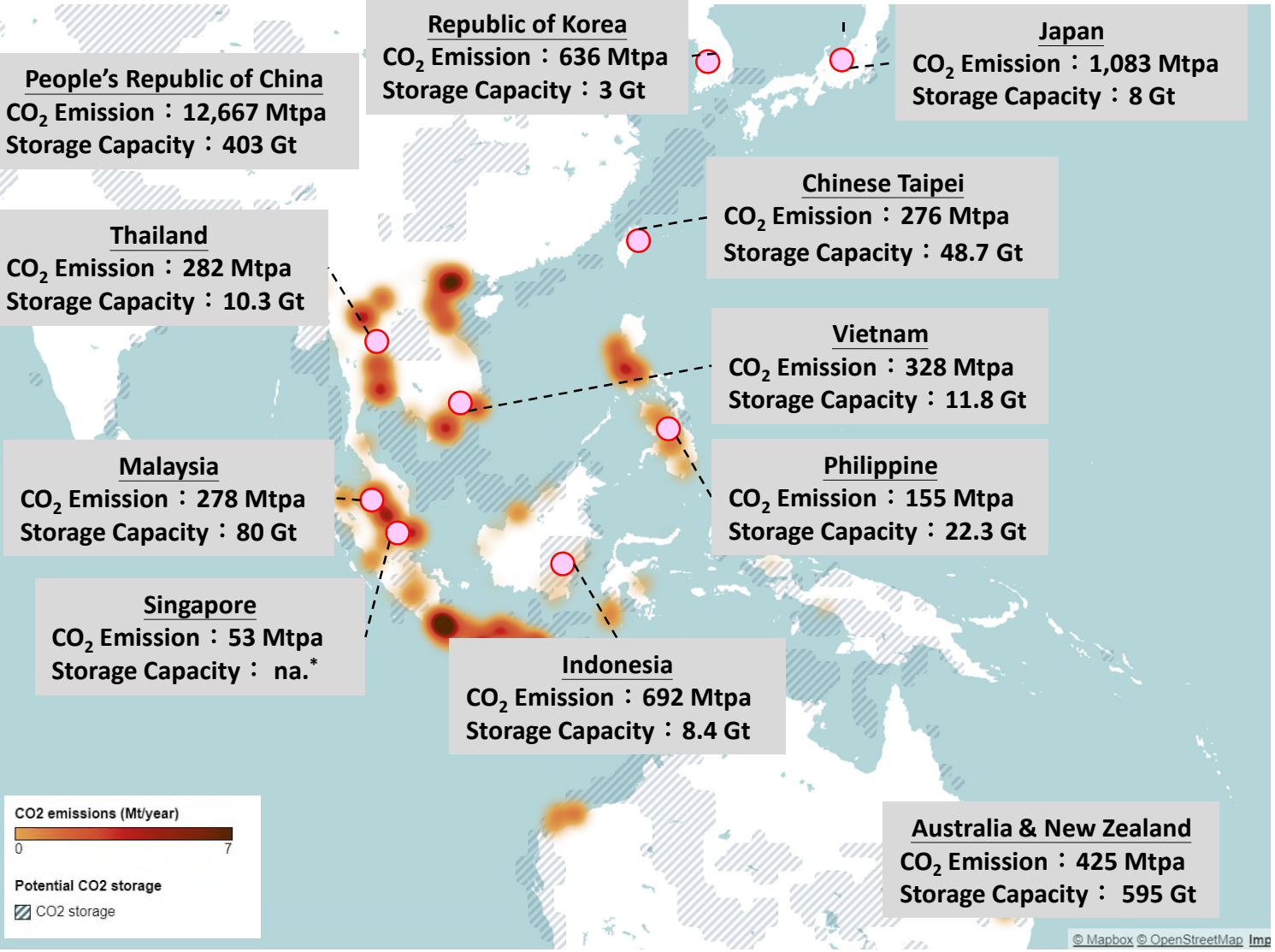
**Malaysia**
$CO_2$ Emission：278 Mtpa
Storage Capacity：80 Gt

**Philippine**
$CO_2$ Emission：155 Mtpa
Storage Capacity：22.3 Gt

**Singapore**
$CO_2$ Emission：53 Mtpa
Storage Capacity： na.*

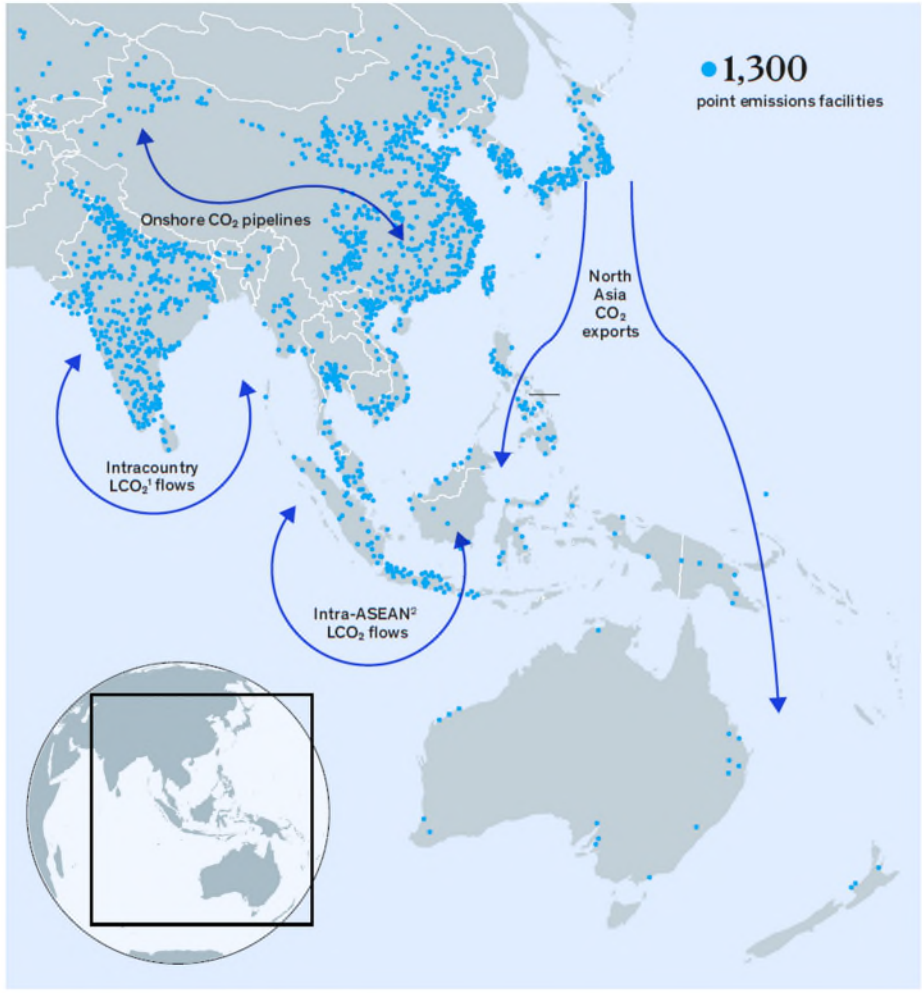
**Indonesia**
$CO_2$ Emission：692 Mtpa
Storage Capacity：8.4 Gt

**Australia & New Zealand**
$CO_2$ Emission：425 Mtpa
Storage Capacity： 595 Gt




(Lu, 2008; Lin, 2014; Kearns, 2017; IEA, 2021; EDGAR, 2022)

## Potential CCS network

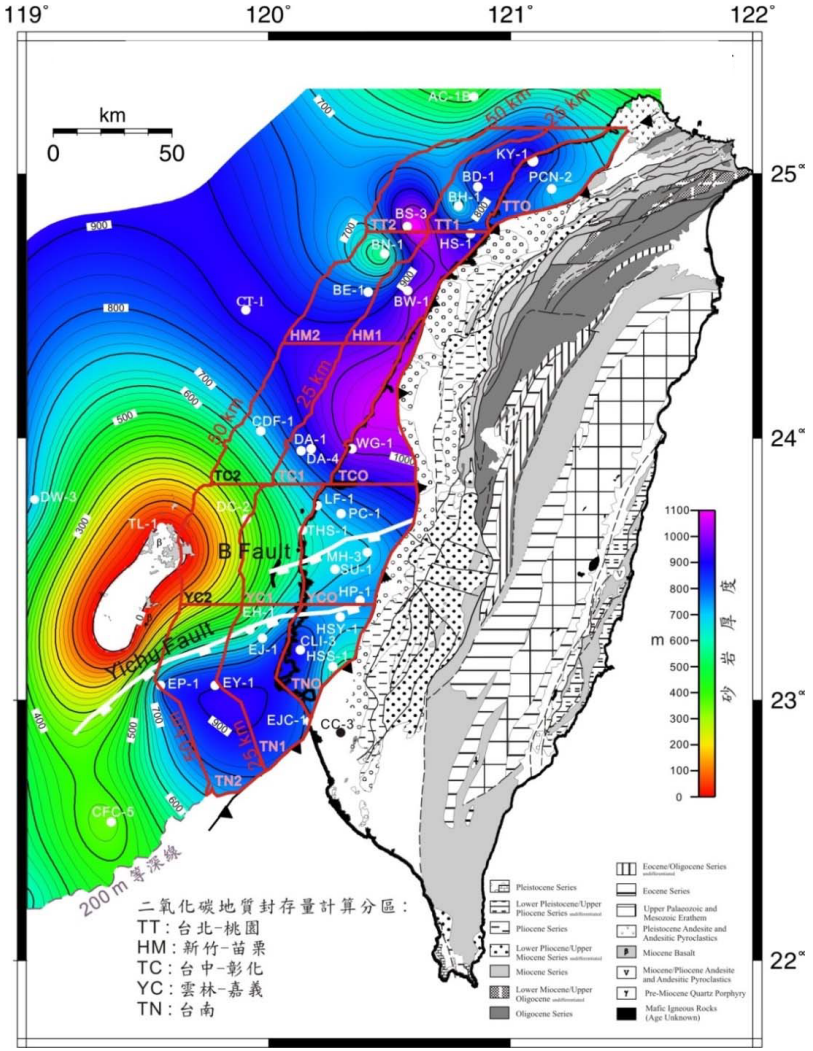



(McKinsey & Company, 2023)

# Storage Potential and Primary Point Emission Facilities

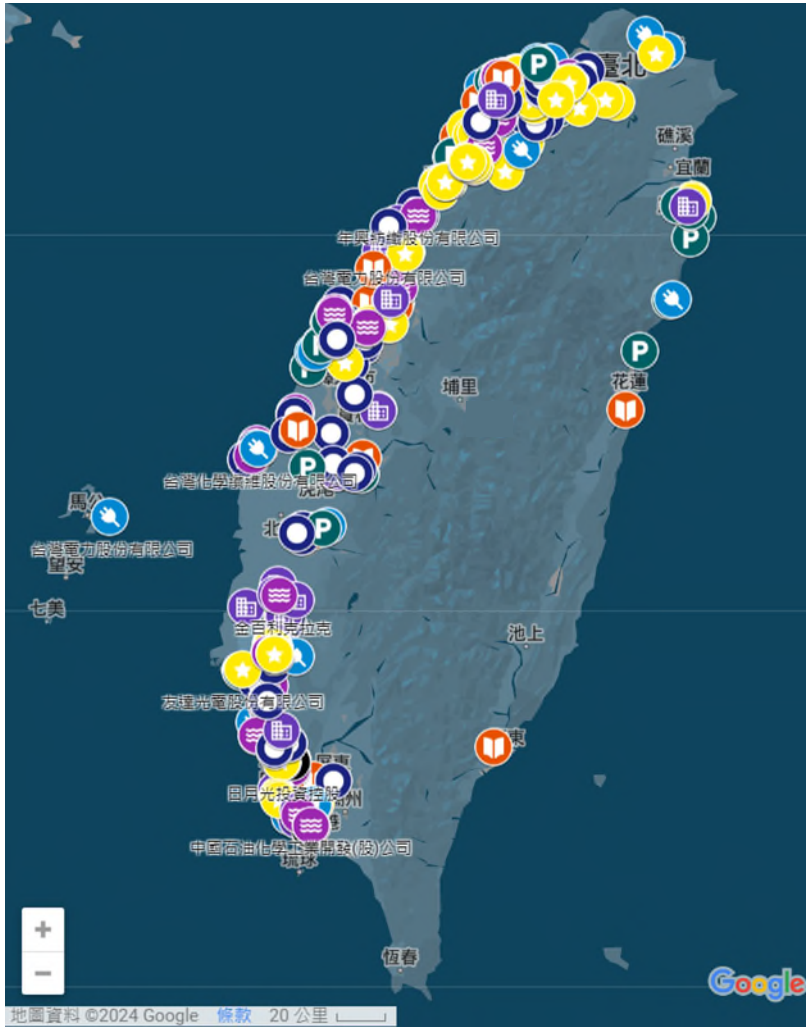

Onshore (2.8 Gt)

(Lu, 2008)




Plain, nearshore and offshore (45.9 Gt)

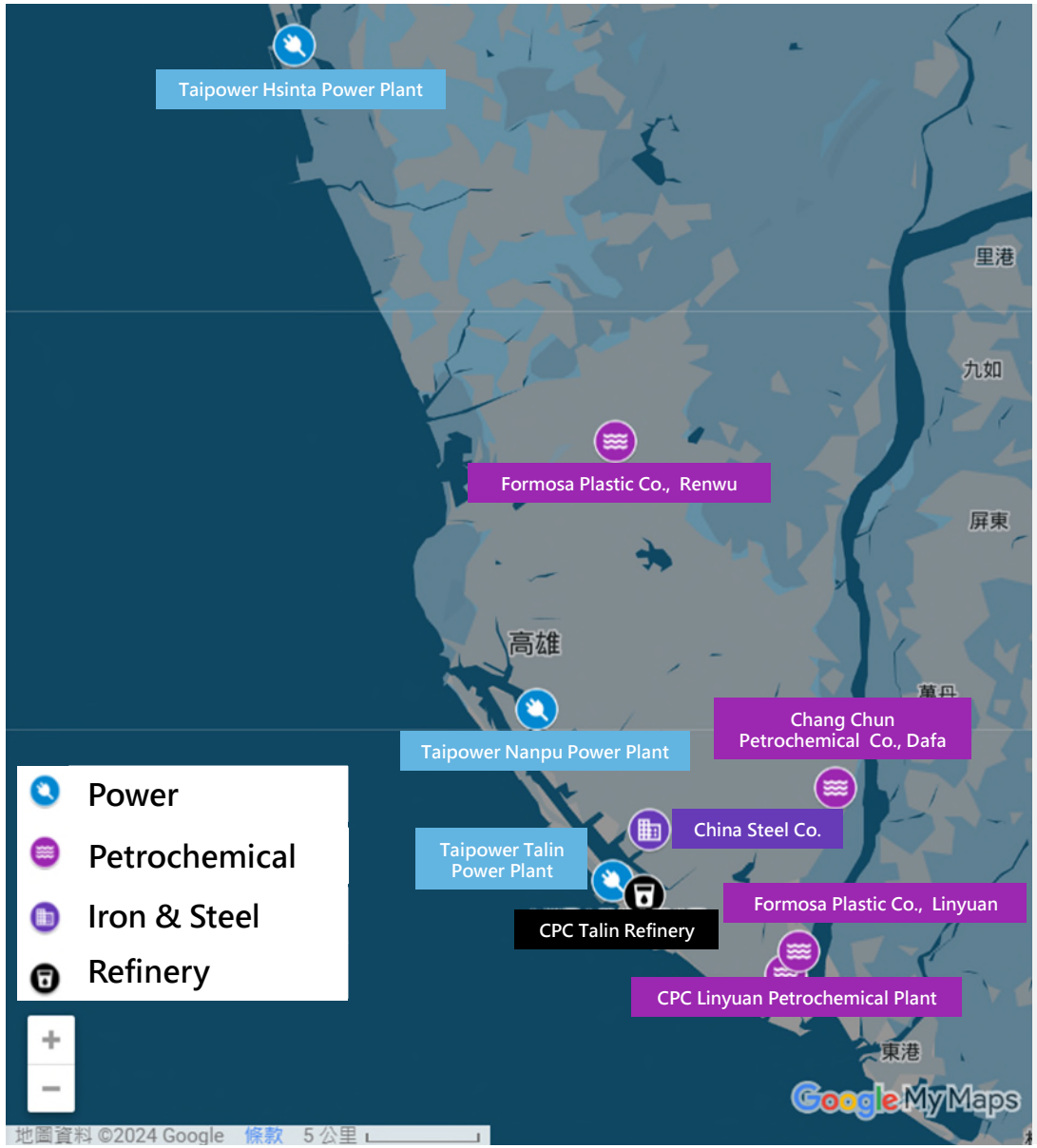
(Lin, 2014)

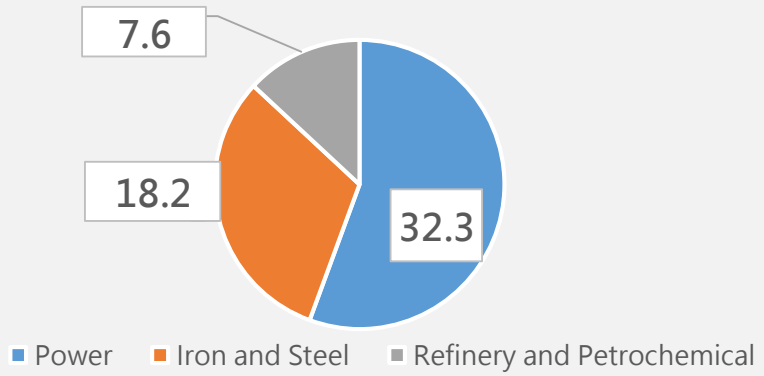



Primary point emission facilities
(42 facilities direct GHG emission>0.5Mtpa)

(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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