

# INDUSTRIAL CCS

Symposium on Climate Change, Green Growth and CCUS

Peking University Public Policy Forum International

Peking University

20 November 2018

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GLOBAL CCS  
INSTITUTE

# Industrial processes can not be switched out of the global economy

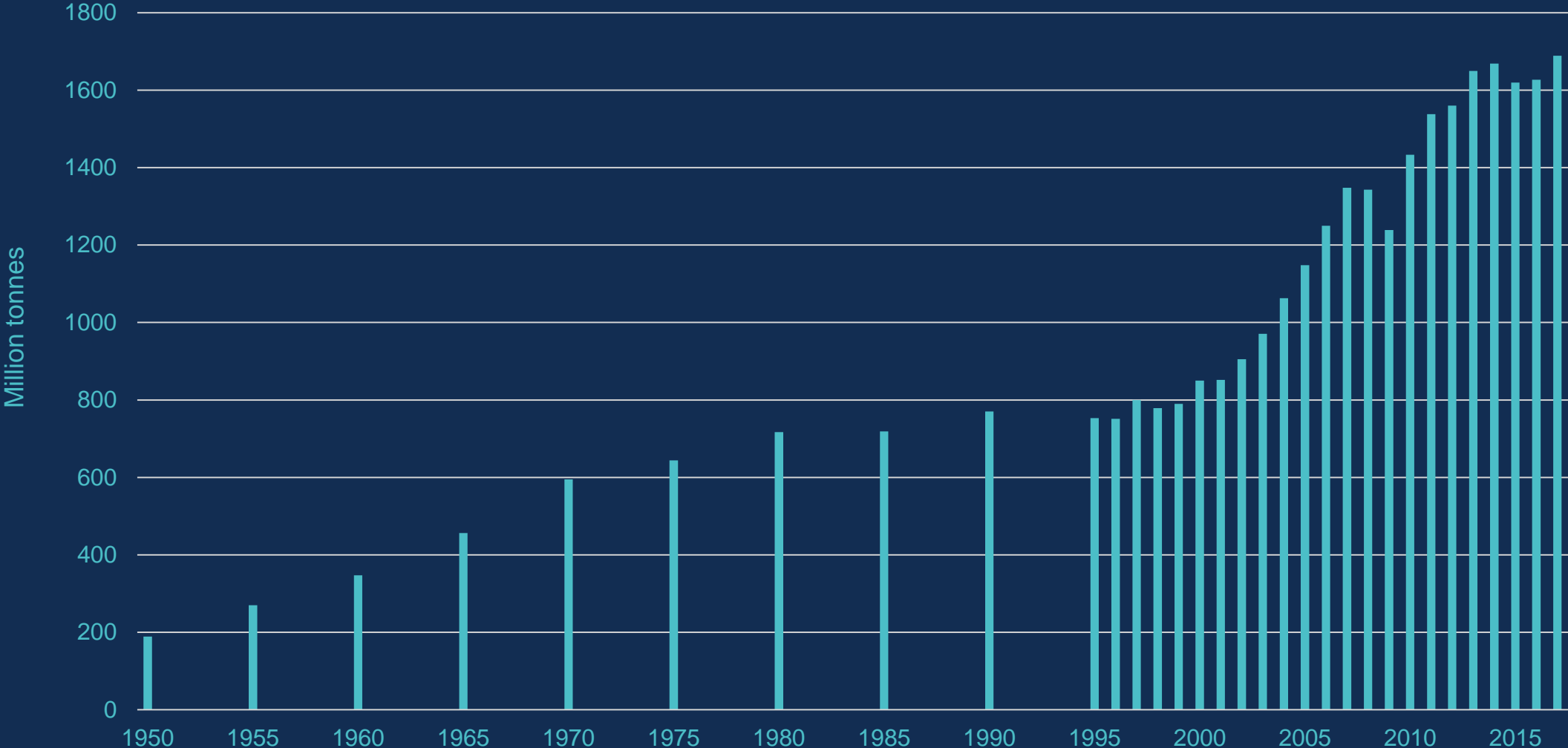
Industrial processes produce the building blocks of modern society

- Steel, cement, fertiliser, various chemicals from coal (CTX), plastics, methane production, oil refining, hydrogen production
- Demand for these products will continue to grow through to the middle of this century. By 2060:
  - Global population to increase by 45%
  - Global GDP to increase by 245%

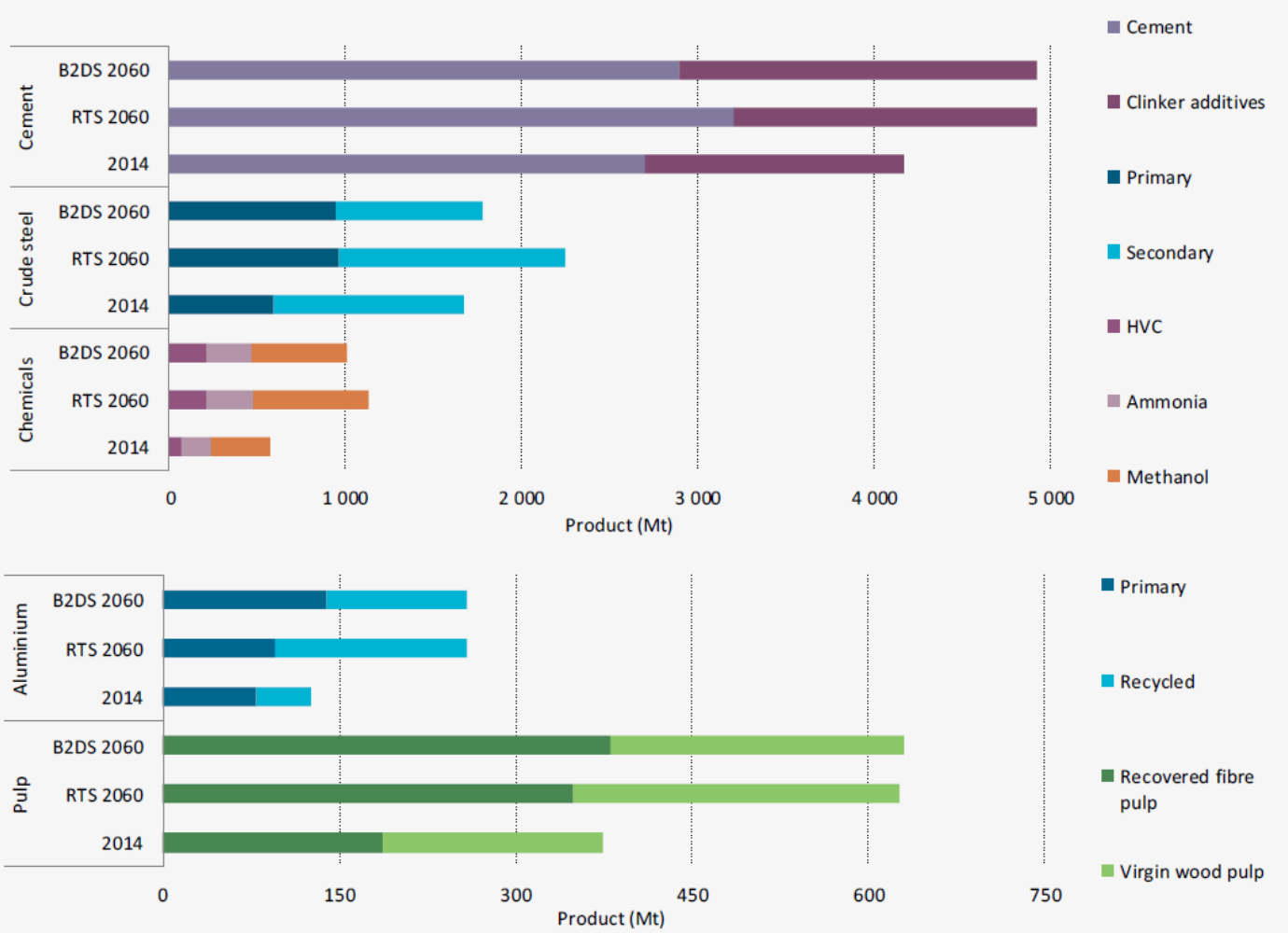
Industrial products are necessary inputs to the transition to a lower emissions energy system



# Growth in steel production



# Demand for industrial products grows under all climate mitigation scenarios



Crude steel production in 2060 is projected to be:

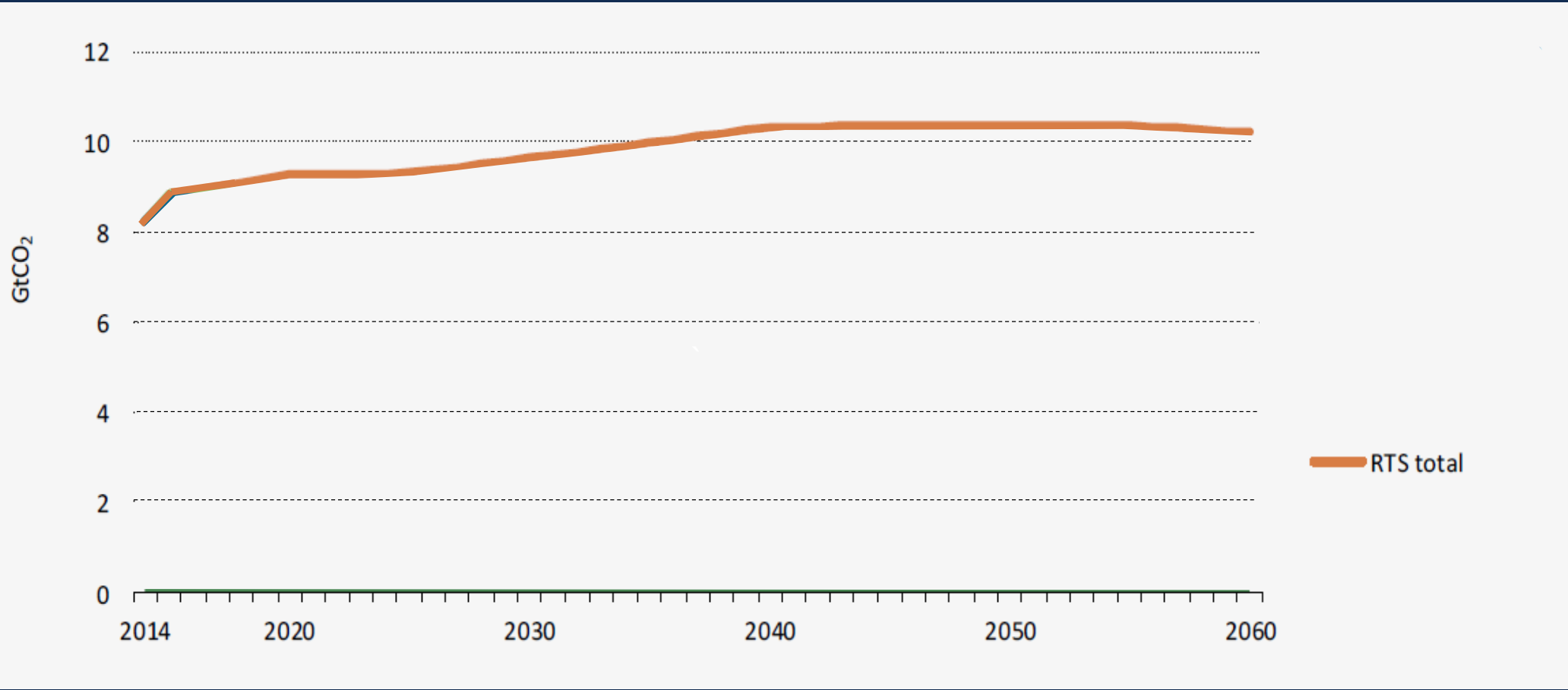
- ~2200Mtpa in the Reference Scenario
- ~1800Mtpa in the Beyond 2 degree Scenario

...compared to ~1700Mtpa in 2017

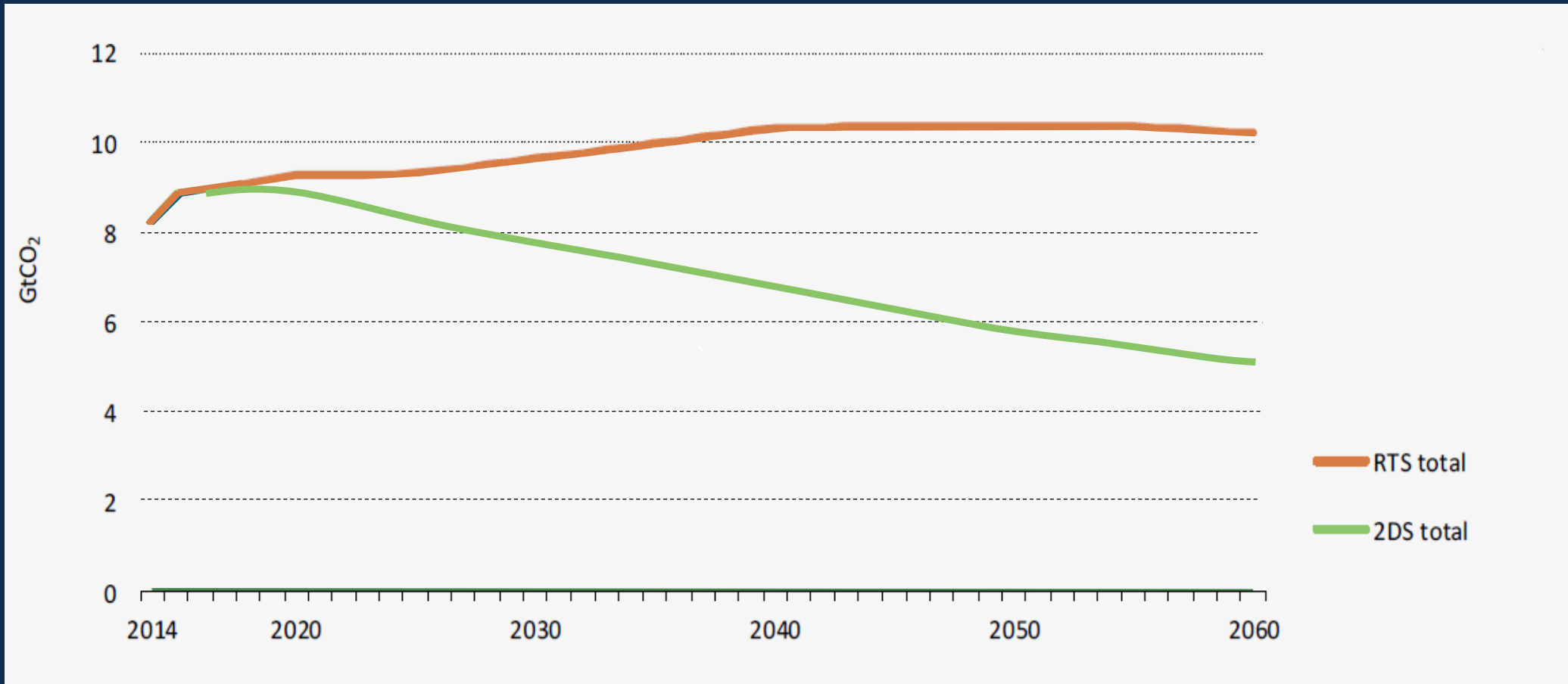
Notes: HVC = high-value chemicals. HVC refer to ethylene, propylene and BTX (benzene, toluene and xylene). Crude steel and aluminium production levels are expressed in liquid metal terms.



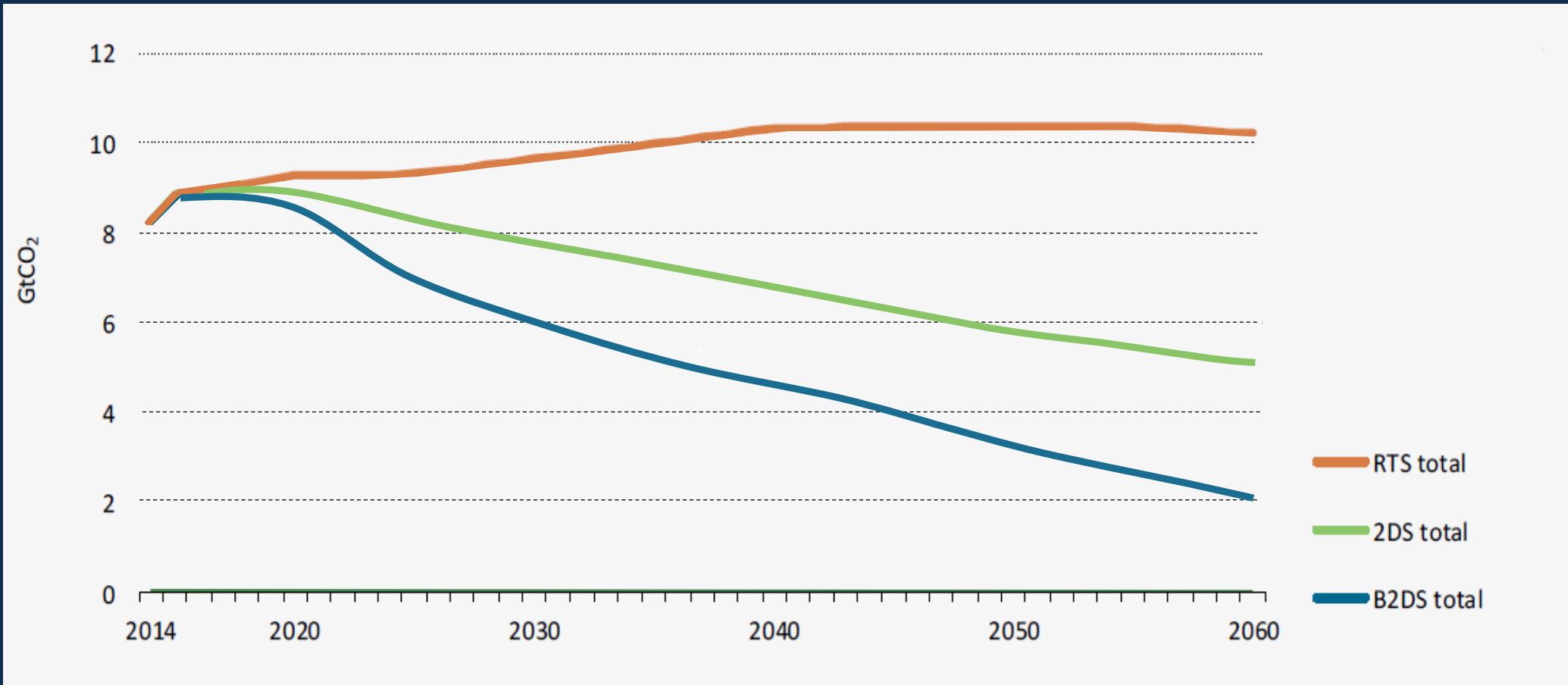
# Reference Scenario: industrial emissions exceed 10Gt CO<sub>2</sub> by 2040



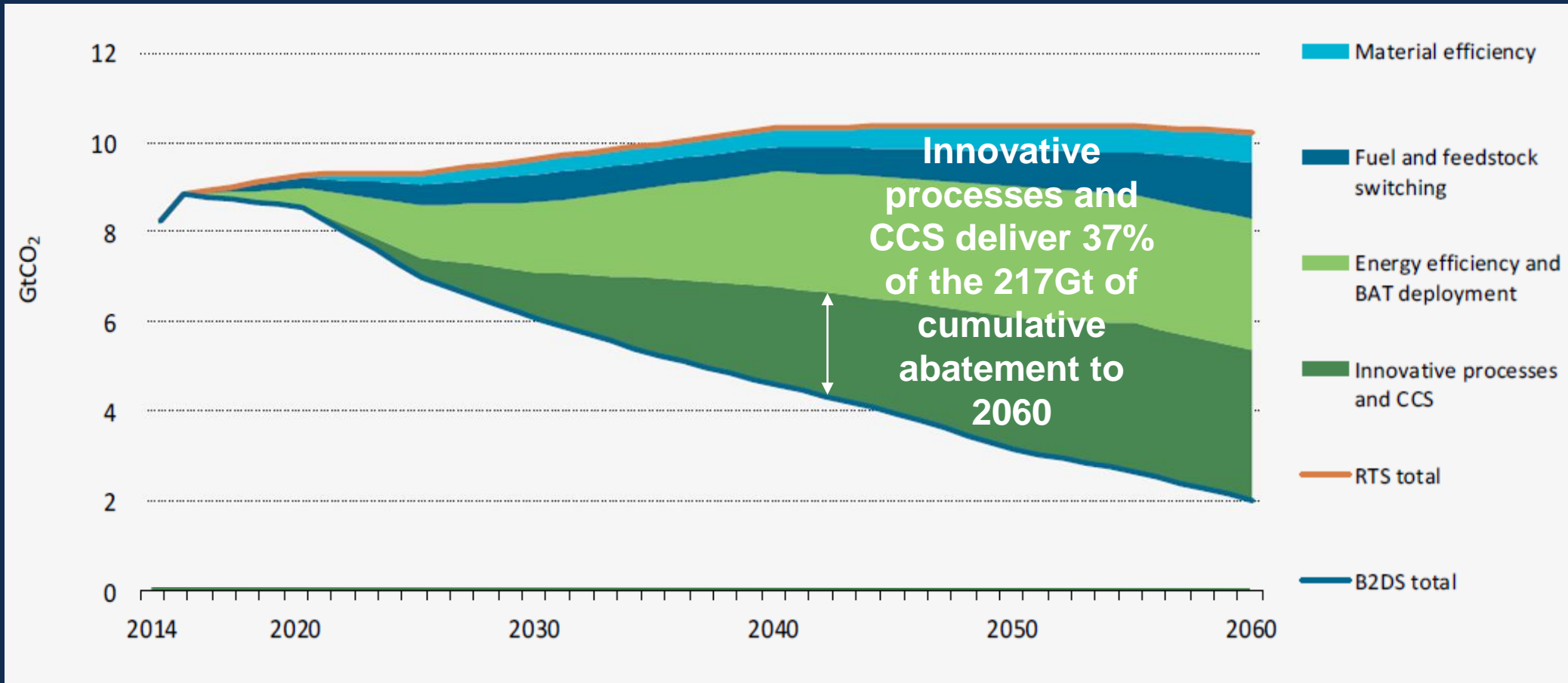
## 2 Degree Scenario: industrial emissions reduce to approximately 5Gt CO<sub>2</sub> by 2060



# Beyond 2 Degree Scenario: industrial emissions reduce to approximately 2Gt CO<sub>2</sub> by 2060

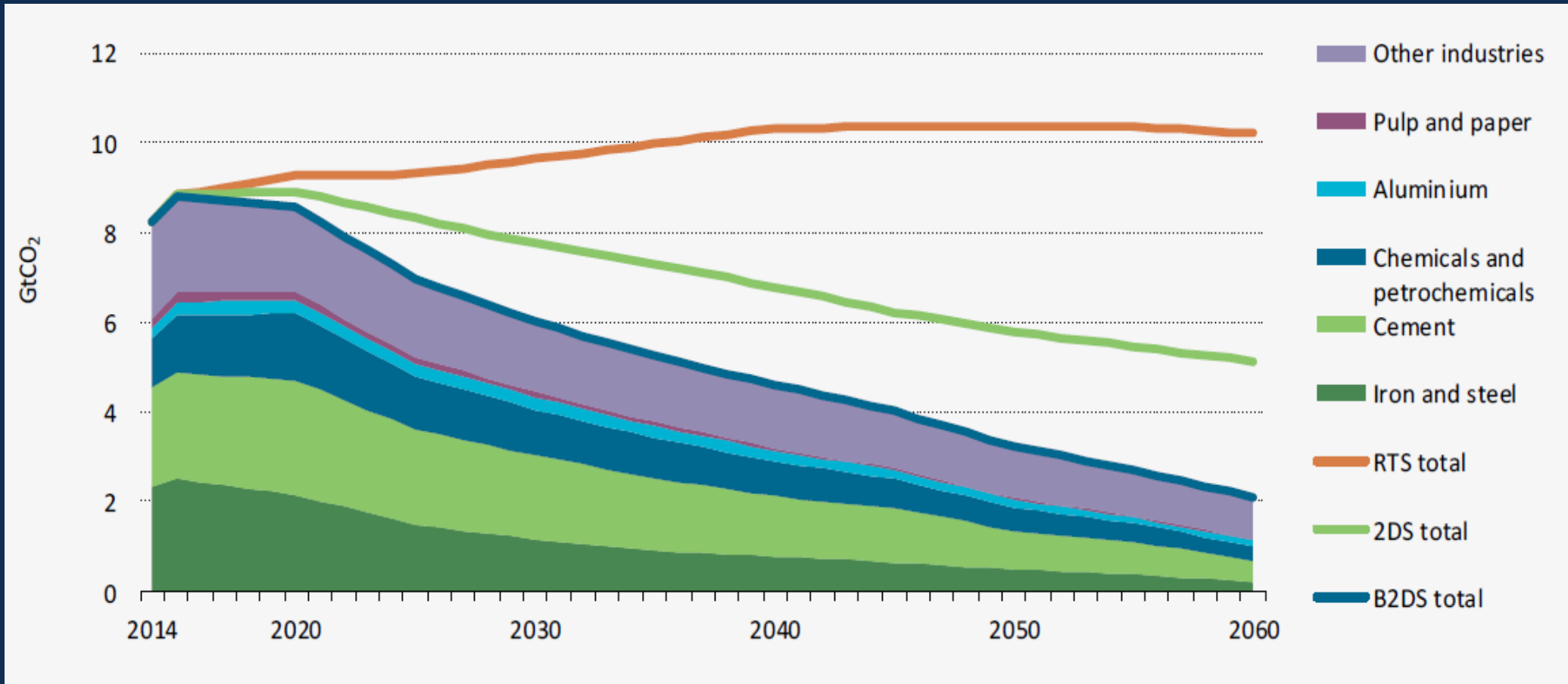


# Beyond 2 Degree Scenario: industrial emissions reduce to approximately 2Gt CO<sub>2</sub> by 2060

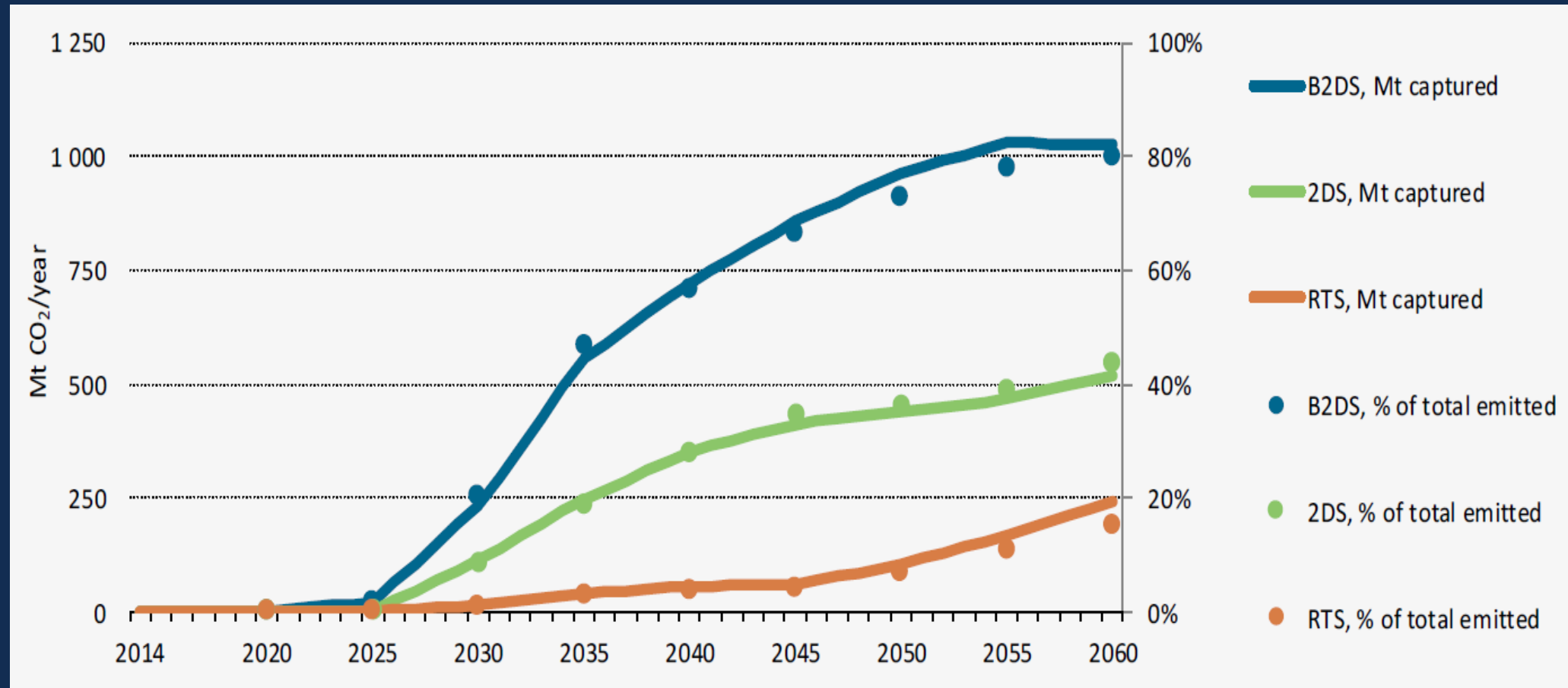




# Beyond 2 Degree Scenario: Fe & steel emissions reduce to 208Mt CO<sub>2</sub> by 2060, 9% of current levels

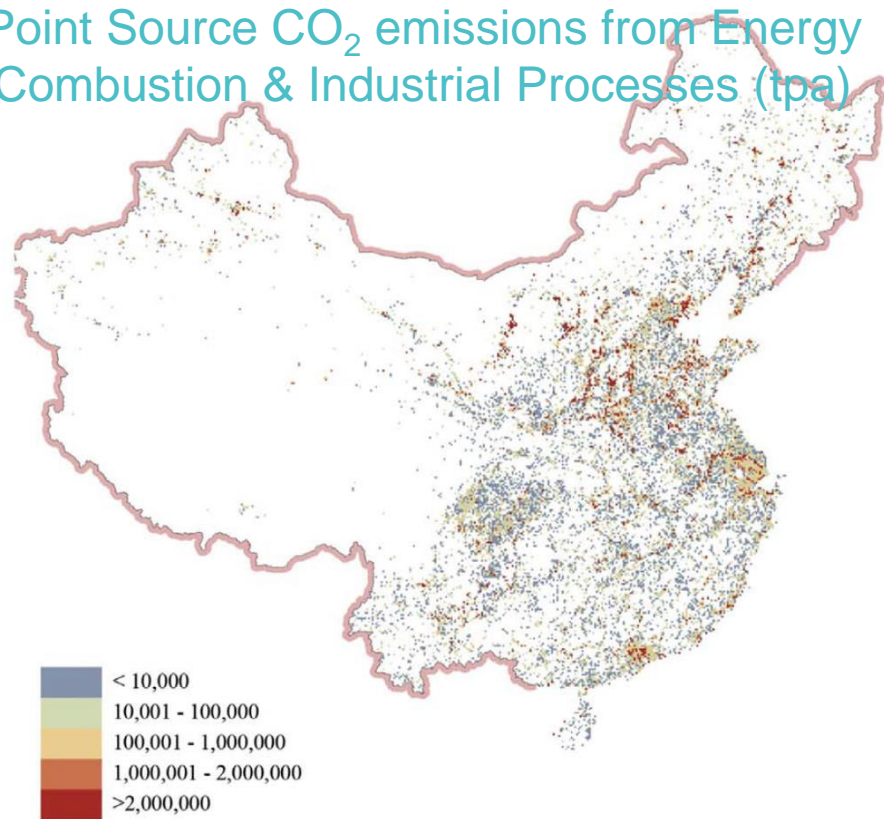


# Beyond 2 Degree Scenario: CCS delivers 26Gt cumulative abatement in Fe & steel sector to 2060



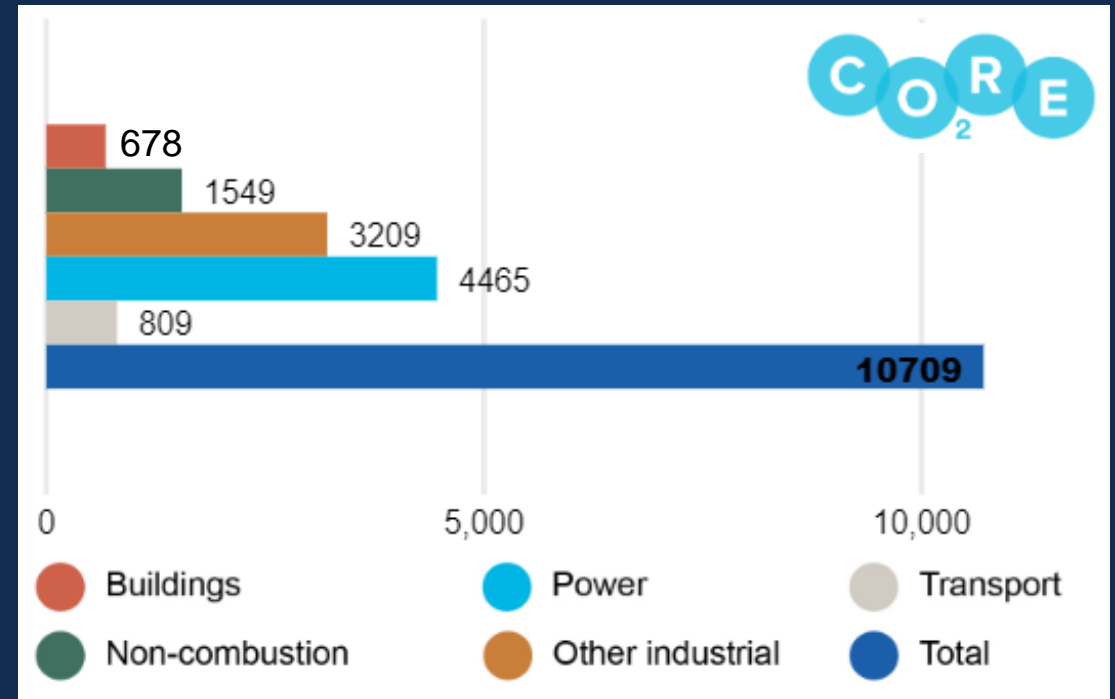
# CCS will be essential for Chinese industry

Point Source CO<sub>2</sub> emissions from Energy Combustion & Industrial Processes (tpa)



Source: Cai et.al 2018, China high resolution emission database (CHRED) with point emission sources, gridded emission data, and supplementary socioeconomic data, Resources, Conservation & Recycling, 129, pp232-239

Total Chinese CO<sub>2</sub> emissions by Sector in 2016 (Mtpa)



Source: Global CCS Institute CO<sub>2</sub>RE Database



# Industrial CCS compared to Power Generation CCS



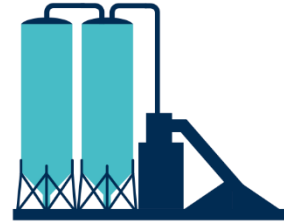
STEEL PLANT



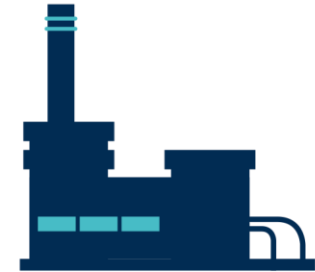
STEAM METHANE REFORMER



GASIFICATION PLANT



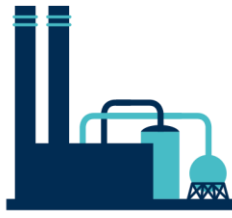
CEMENT PLANT



FUTURE POWER GENERATION



REFINERY



NATURAL GAS PLANT



FERTILISER PLANT



BIOMASS

- Can't eliminate via substitution with nuclear/renewable energy sources
- Often a more concentrated CO<sub>2</sub> stream
- Smaller capture cost
- Tends to be higher margin business

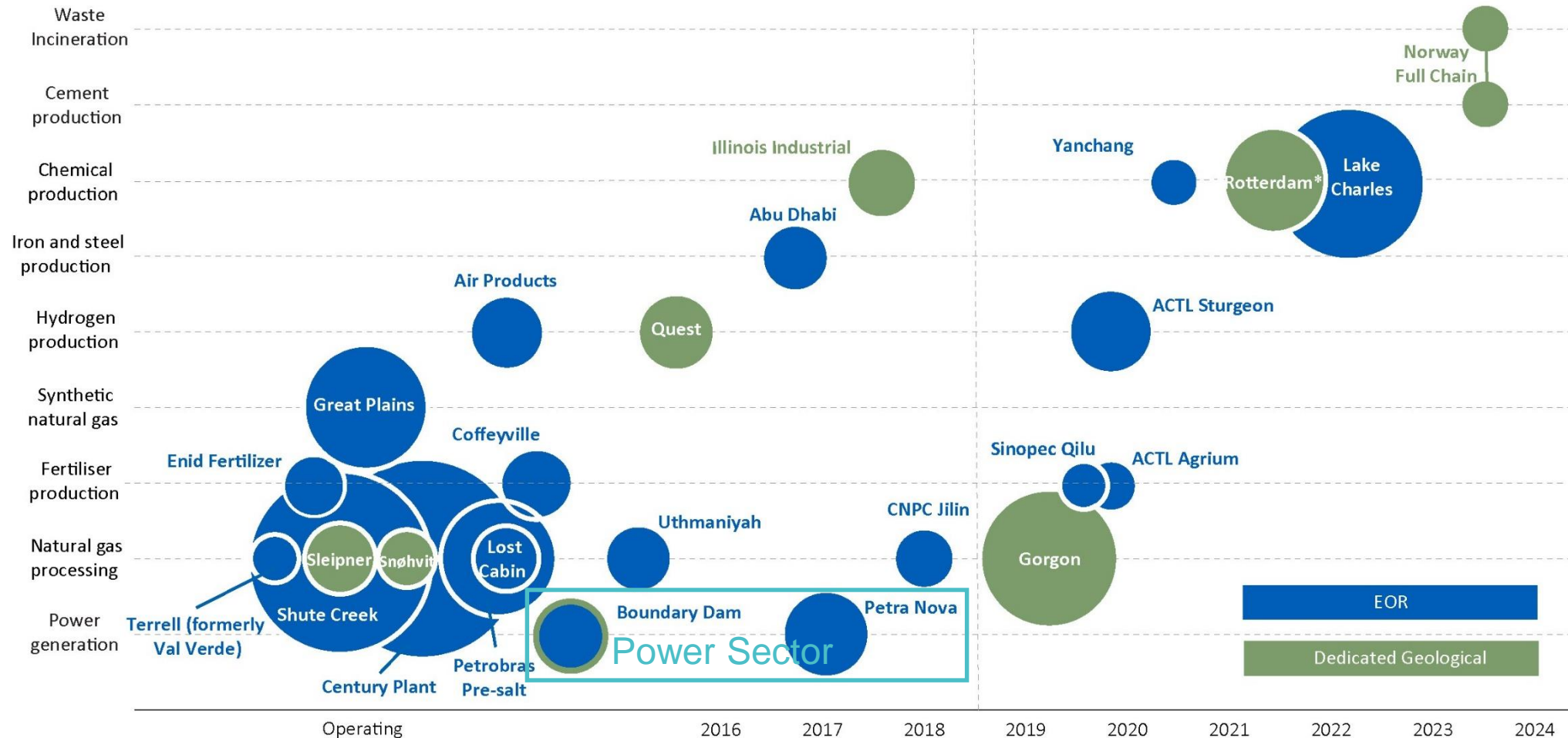
- Can substitute nuclear/renewable
- Dilute CO<sub>2</sub> stream
- Larger capture cost
- Tends to be lower margin business



**Smaller commercial challenge**

**Larger commercial challenge**

# Actual and expected operation dates to 2024 for large scale CCS facilities by industry – only 2 in the power sector



 = 1Mt/yr of CO<sub>2</sub> (area of circles proportional to capacity)



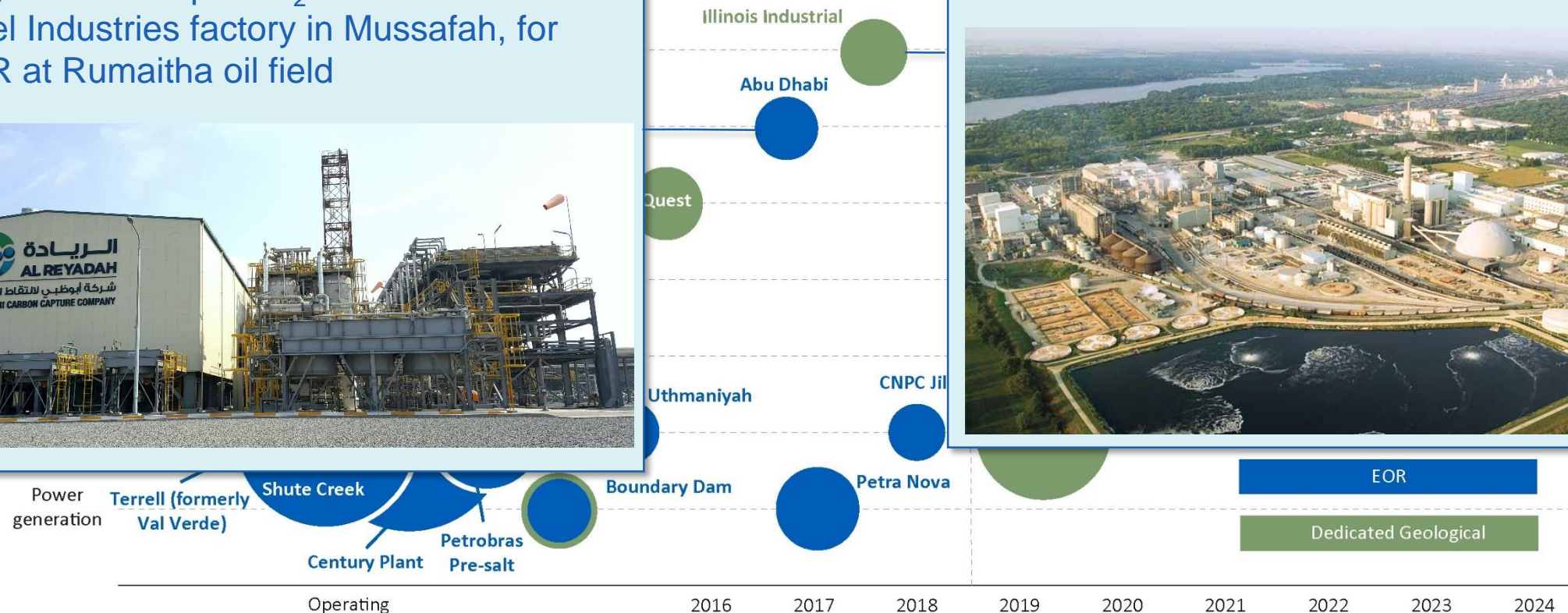
## Al Reyadah CCS Project

- DRI Steel production
- Amine chemical absorption process
- JV between Abu Dhabi National Oil Company and Abu Dhabi Future Energy Company
- 800,000 tonnes pa CO<sub>2</sub> from the Emirates Steel Industries factory in Mussafah, for EOR at Rumaitha oil field



## Illinois Industrial CCS

- CO<sub>2</sub> capture from Archer Daniels Midland corn to ethanol plant
- Decatur, Illinois
- 1,000,000 tonnes pa CO<sub>2</sub> – dedicated storage



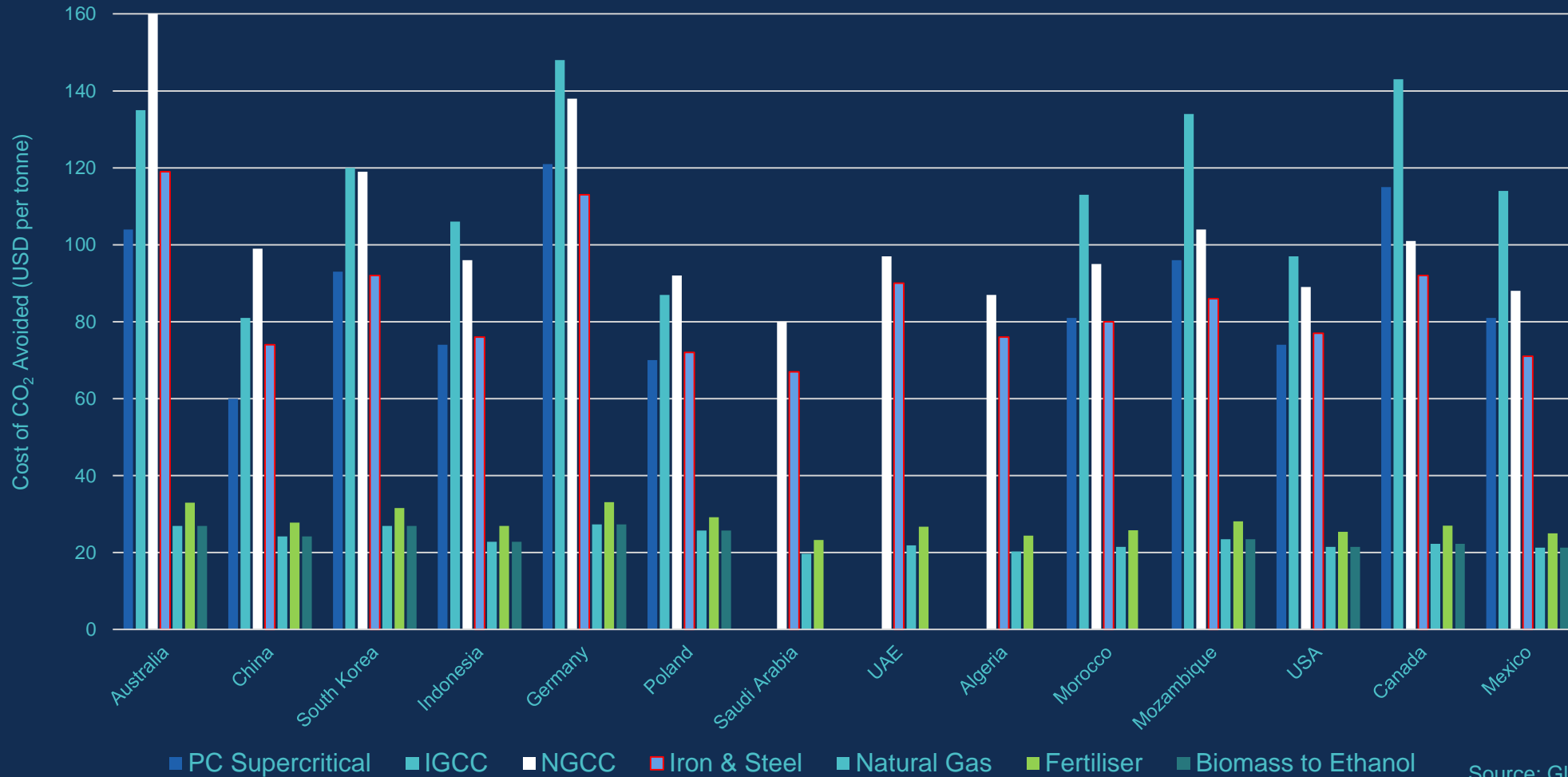
= 1Mtpa of CO<sub>2</sub> (area of circles proportional to capacity)



# First of a kind CO<sub>2</sub> avoided costs for CCS

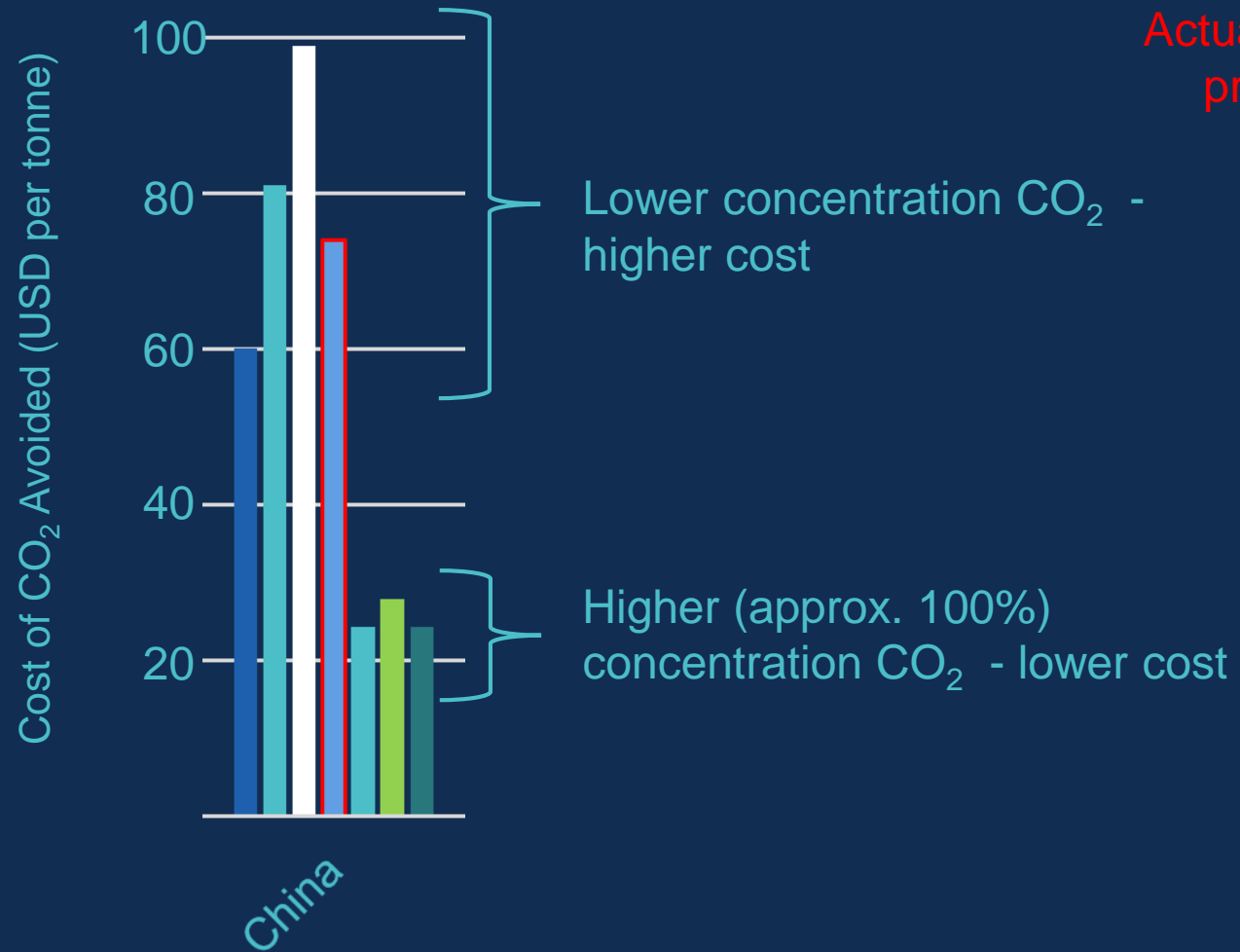
Cost of CO<sub>2</sub> Avoided by County and Industry for CCS

**CAUTION**  
Actual cost is always project specific



# First of a kind CO<sub>2</sub> avoided costs for CCS in China

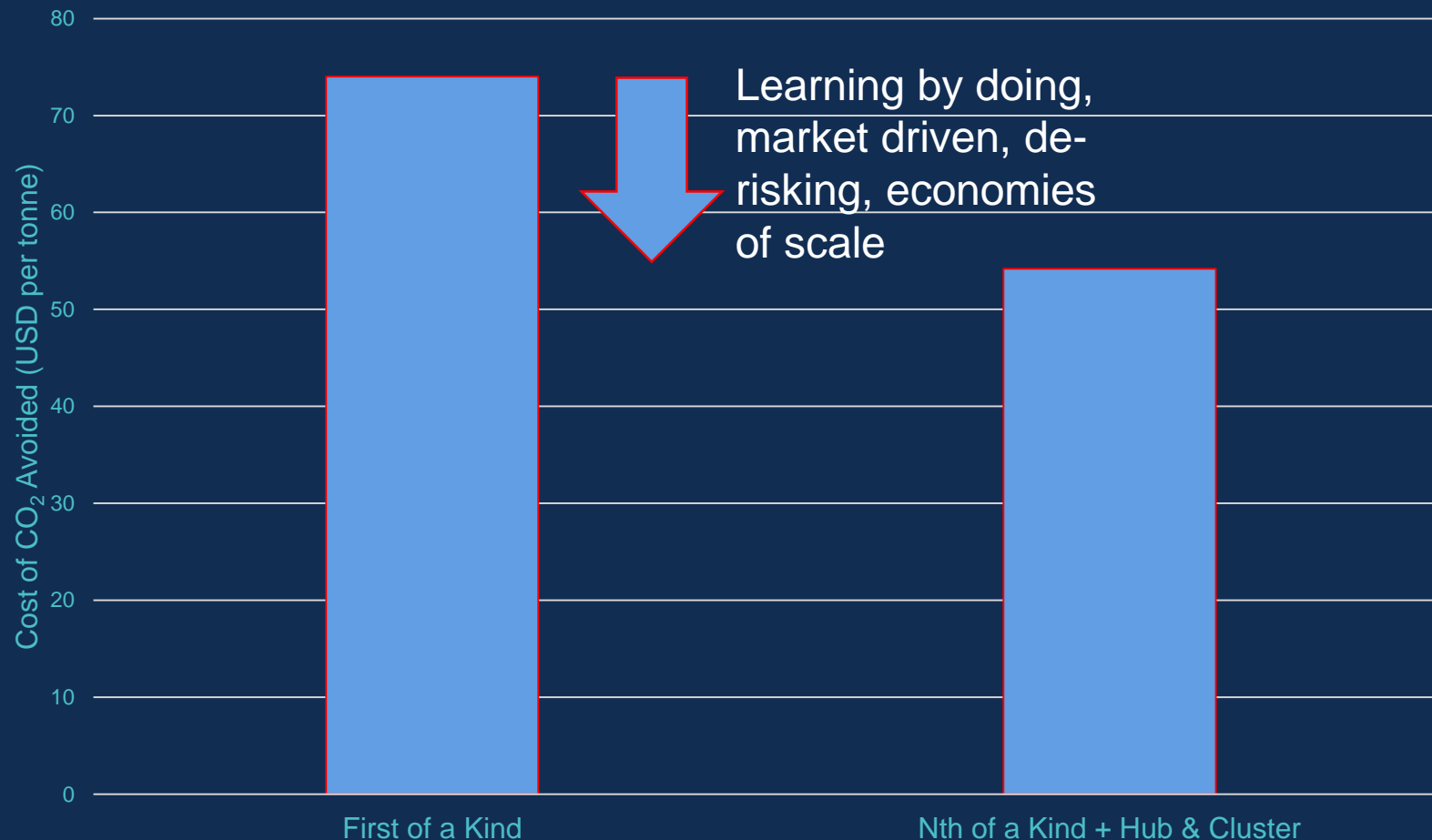
**CAUTION**  
Actual cost is always  
project specific





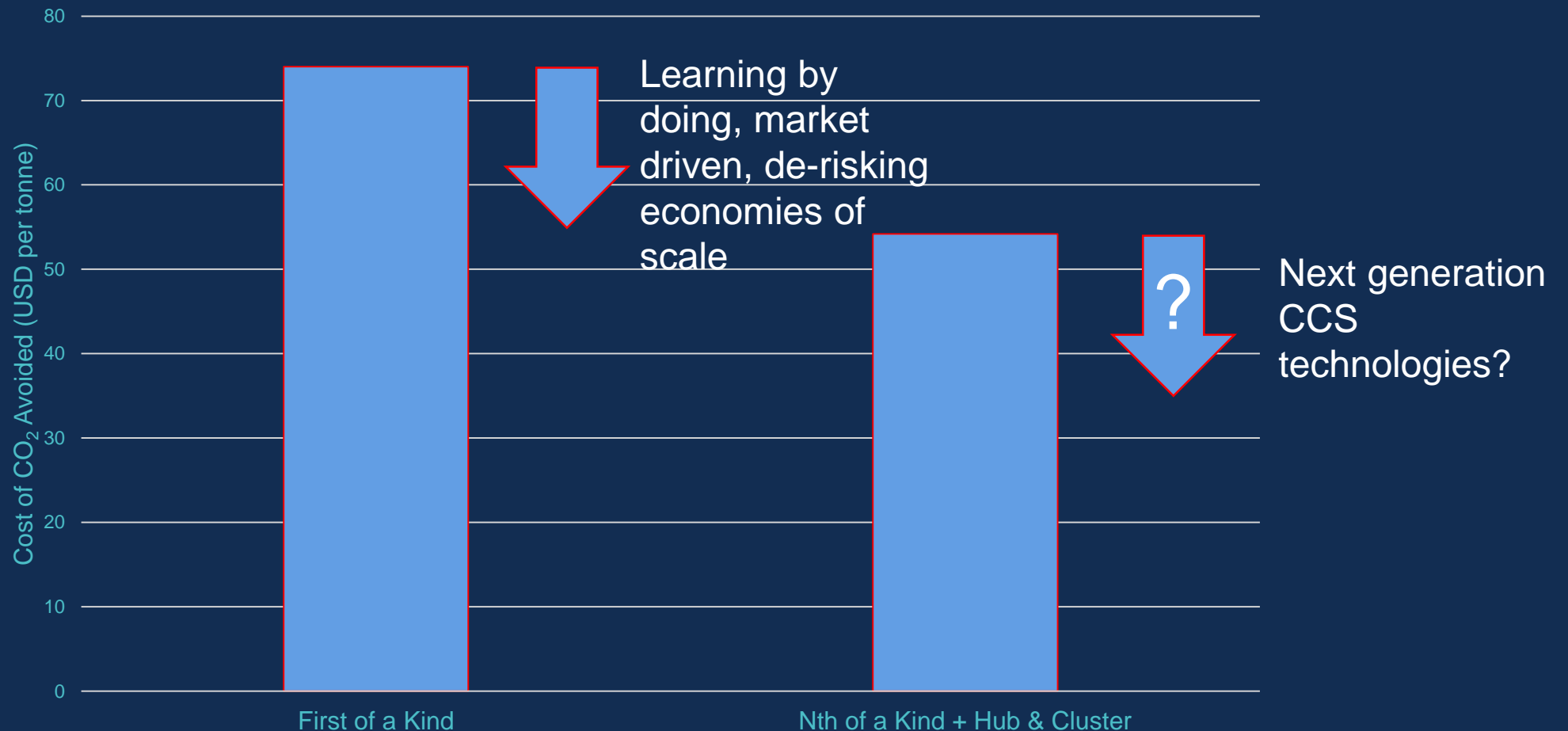
# Nth of a Kind – current technology with Hub and Cluster in China CO<sub>2</sub> avoided costs for CCS on Steel Production

Cost of CO<sub>2</sub> Avoided for CCS on Steel Production in China



# What cost reductions will next generation technologies deliver?

Cost of CO<sub>2</sub> Avoided for CCS on Steel Production in China

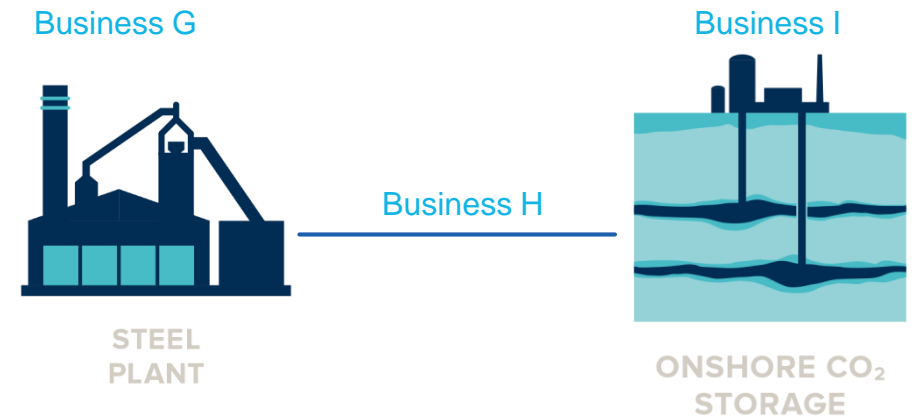


# Single source – single sink models create risk and cost

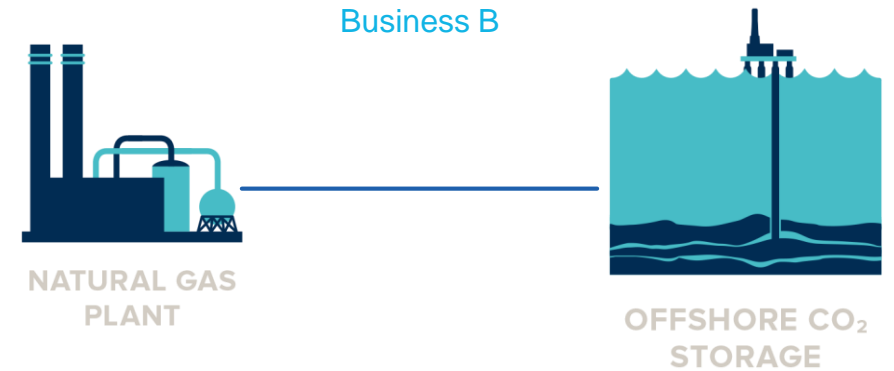
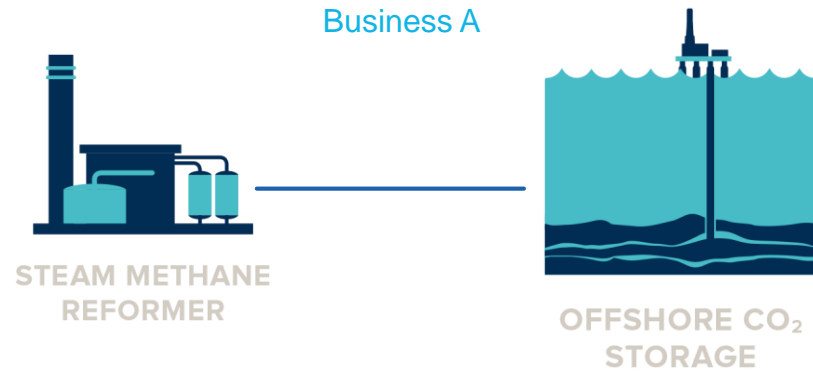


## Disaggregated business model

- Storage operator depends on one customer
- CO<sub>2</sub> source depends on one storage operator
- Pipeline operator depends on one CO<sub>2</sub> source and one storage operator
- Significant counterparty risk
- Lower utilization of assets
- Higher cost of capital

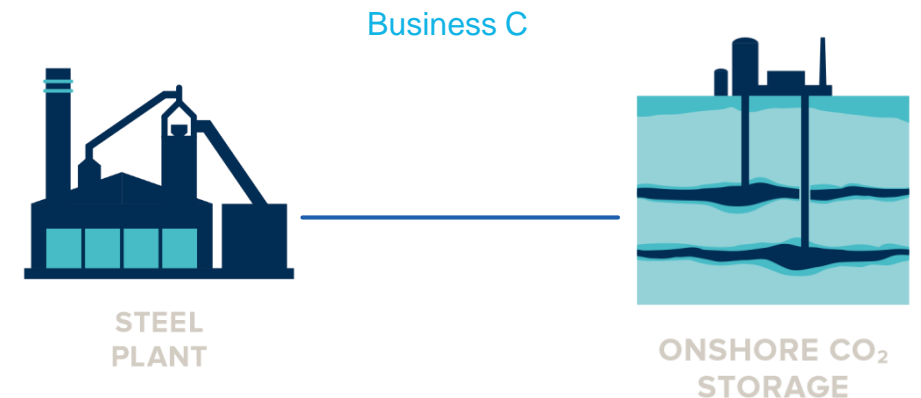


# Single source – single sink models create risk and cost



## Vertically integrated business model

- Lost opportunity to reduce cost through economies of scale
- Lost opportunity to reduce cost and risk through specialization
- Broad competency requirements increases risk
- Higher cost of capital



# Industrial clusters

Business A



Business B



Business C

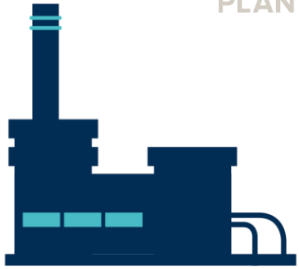


Business D



Business I

STEEL  
PLANT



STEAM METHANE  
REFORMER

GASIFICATION PLANT

CEMENT  
PLANT

FUTURE POWER  
GENERATION

Business E



Business H



Business G



Business F



BIOMASS

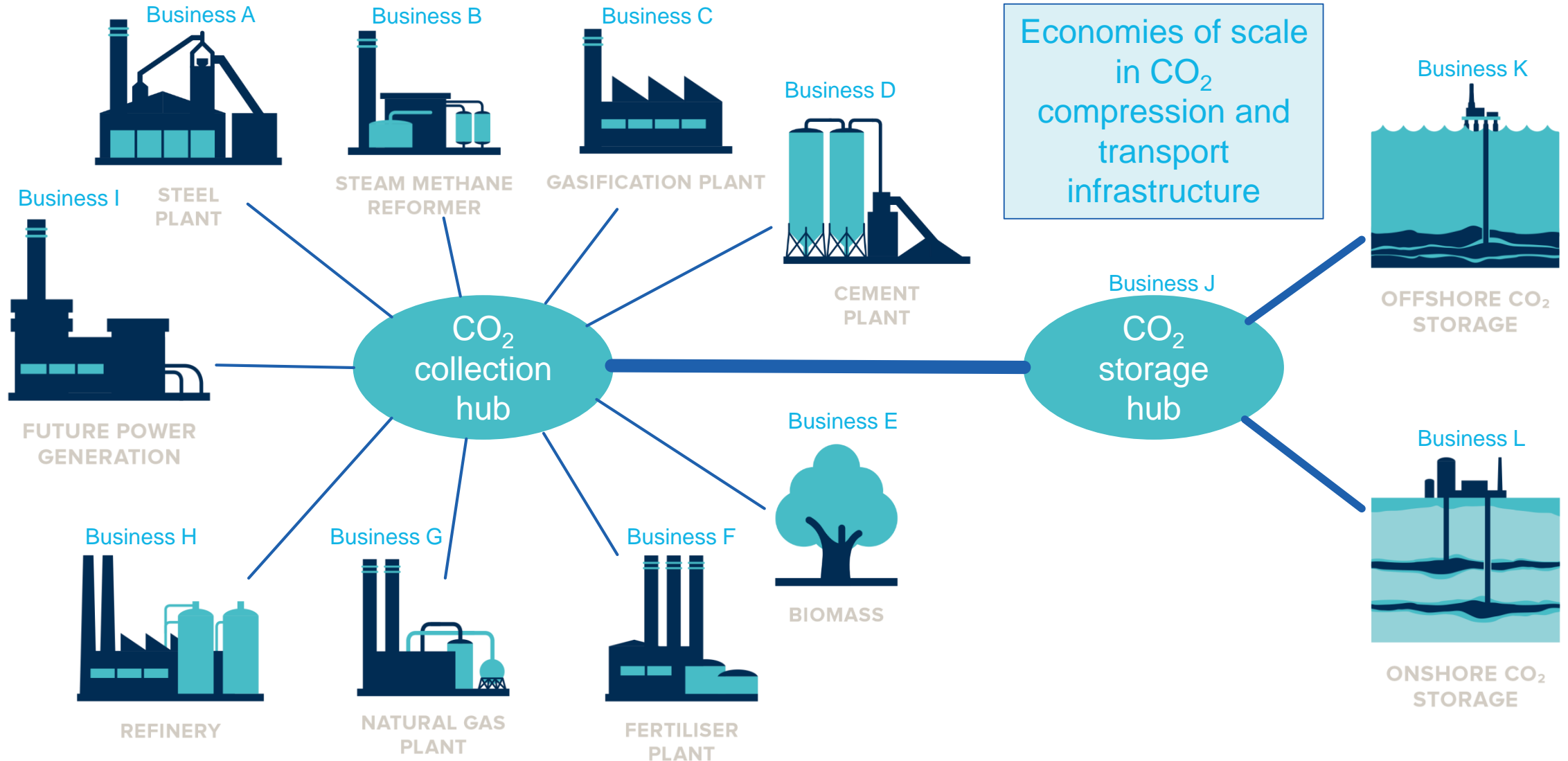
REFINERY

NATURAL GAS  
PLANT

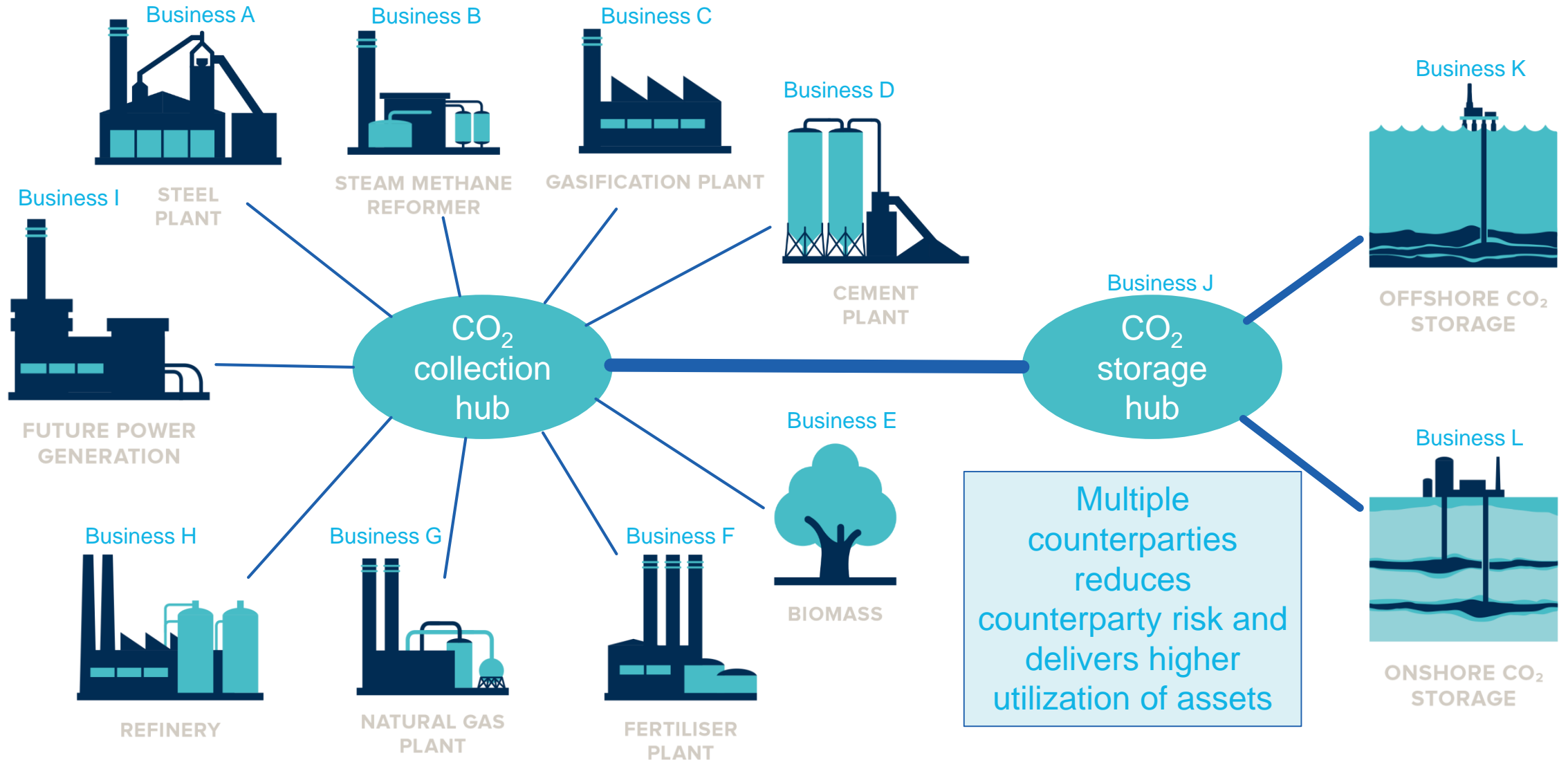
FERTILISER  
PLANT



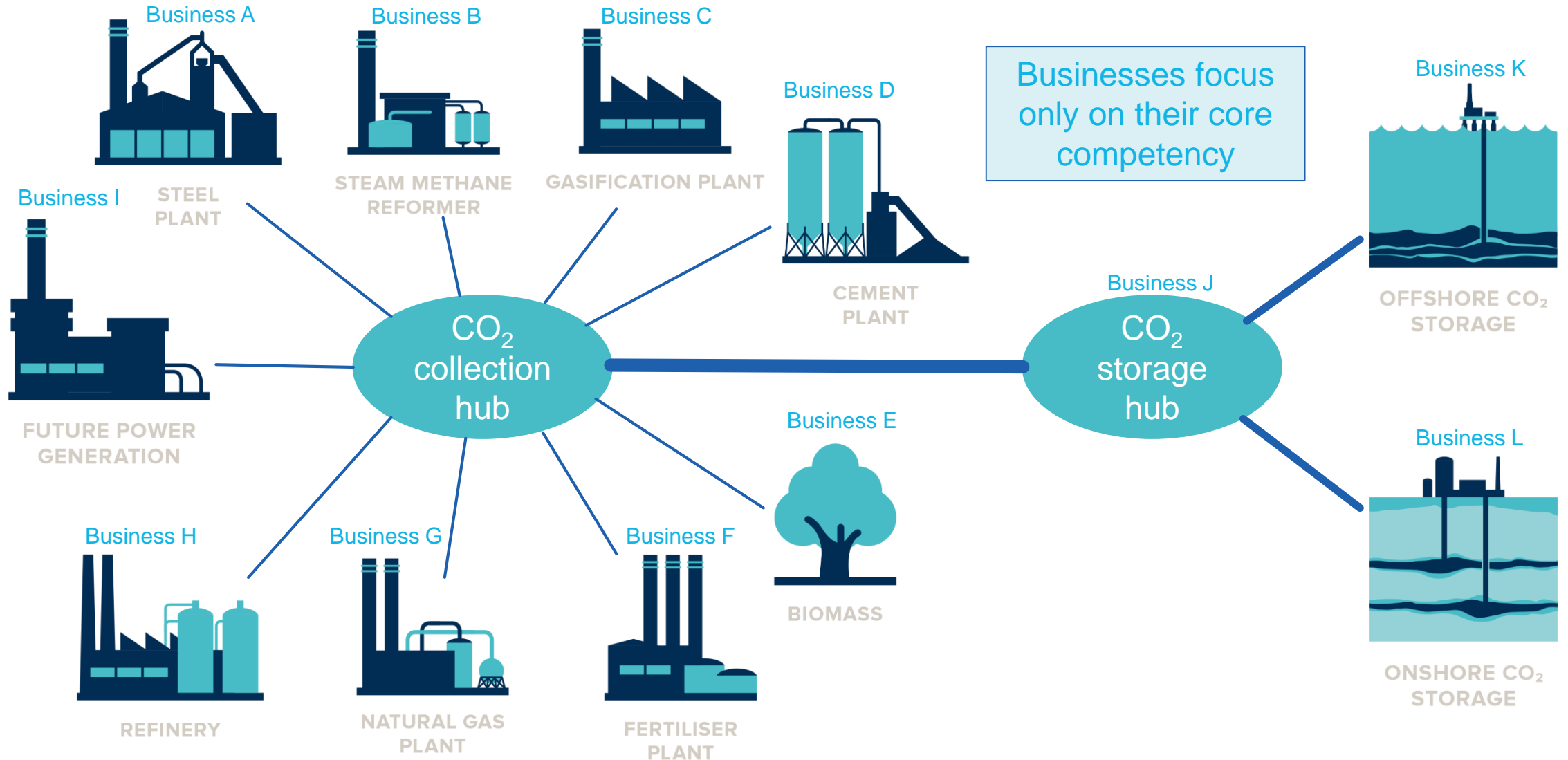
# Hubs and clusters – reduce cost and risk of CCS



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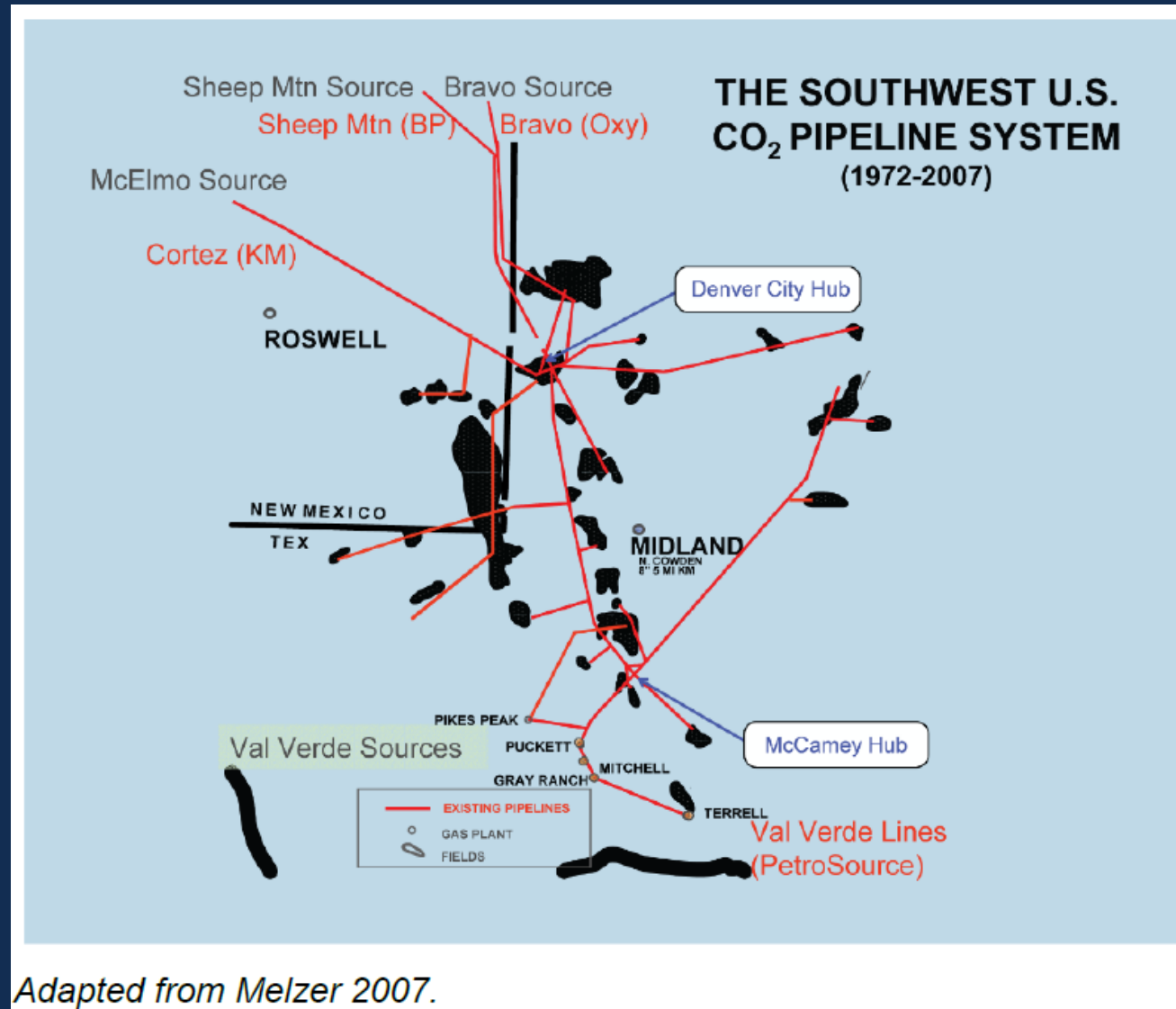


# Hubs and clusters – reduce cost and risk of CCS





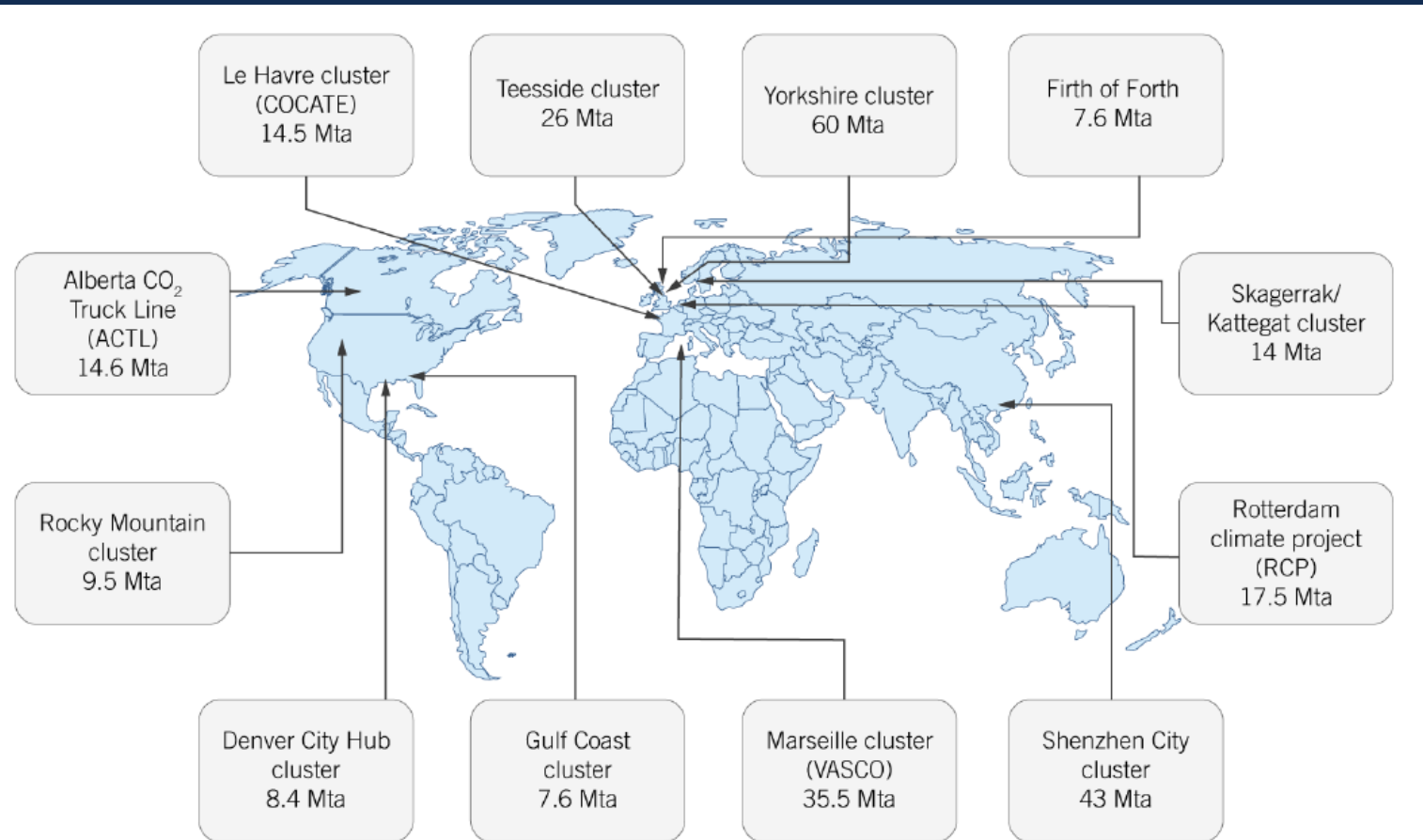
# Southwest USA CO<sub>2</sub> Pipeline System



Adapted from Melzer 2007.



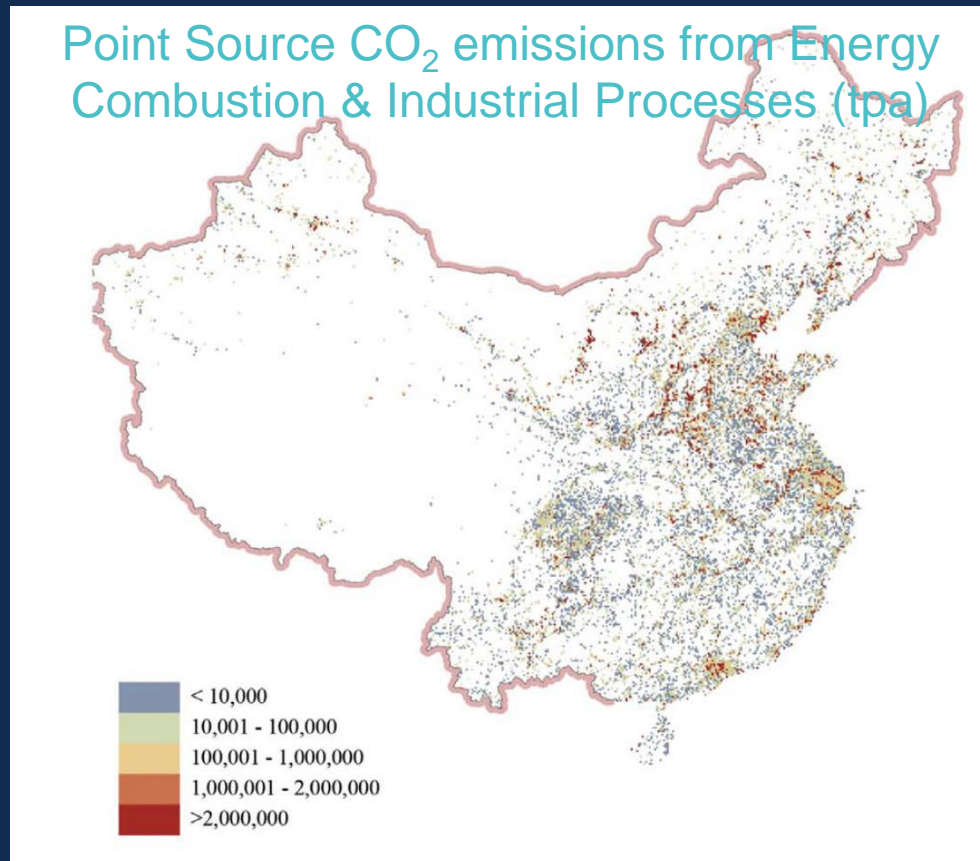
# Major CCS Clusters – Proposed or in Development



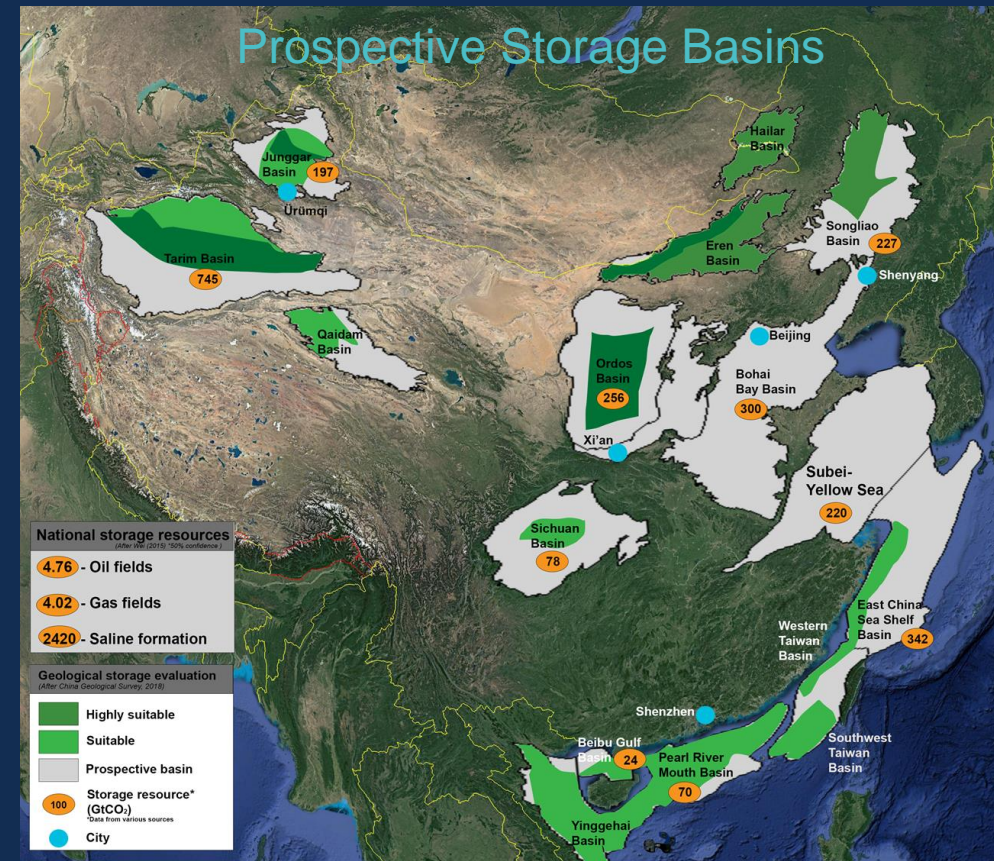
*Adapted from IEAGHG 2015a and ZEP 2014 data. Figure 1 identifies existing industrial clusters with estimated annual CO<sub>2</sub> emissions. CCS infrastructure exists in some of the clusters identified in the figure. The figure is illustrative only.*



# China – a significant opportunity for CCS hubs and clusters



Source: Cai et.al 2018, China high resolution emission database (CHRED) with point emission sources, gridded emission data, and supplementary socioeconomic data, Resources, Conservation & Recycling, 129, pp232-239



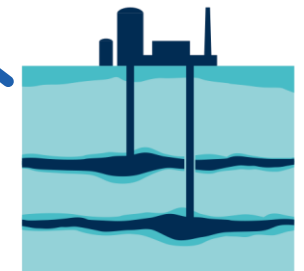
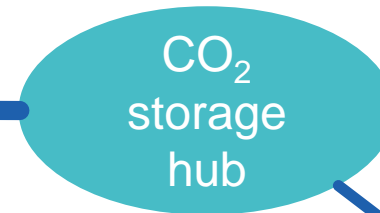
Source: Global CCS Institute Analysis



# Initial investment is risky



STEEL  
PLANT



ONSHORE CO<sub>2</sub>  
STORAGE

- All the risks and costs of a single source – single sink business model
- Larger capital cost and lower asset utilization of pipeline infrastructure that is oversized to accommodate future demand as the hub grows.



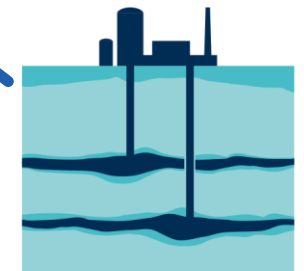
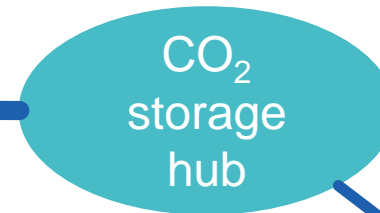
# Option – initial investment by government



STEEL PLANT



Government owned & operated

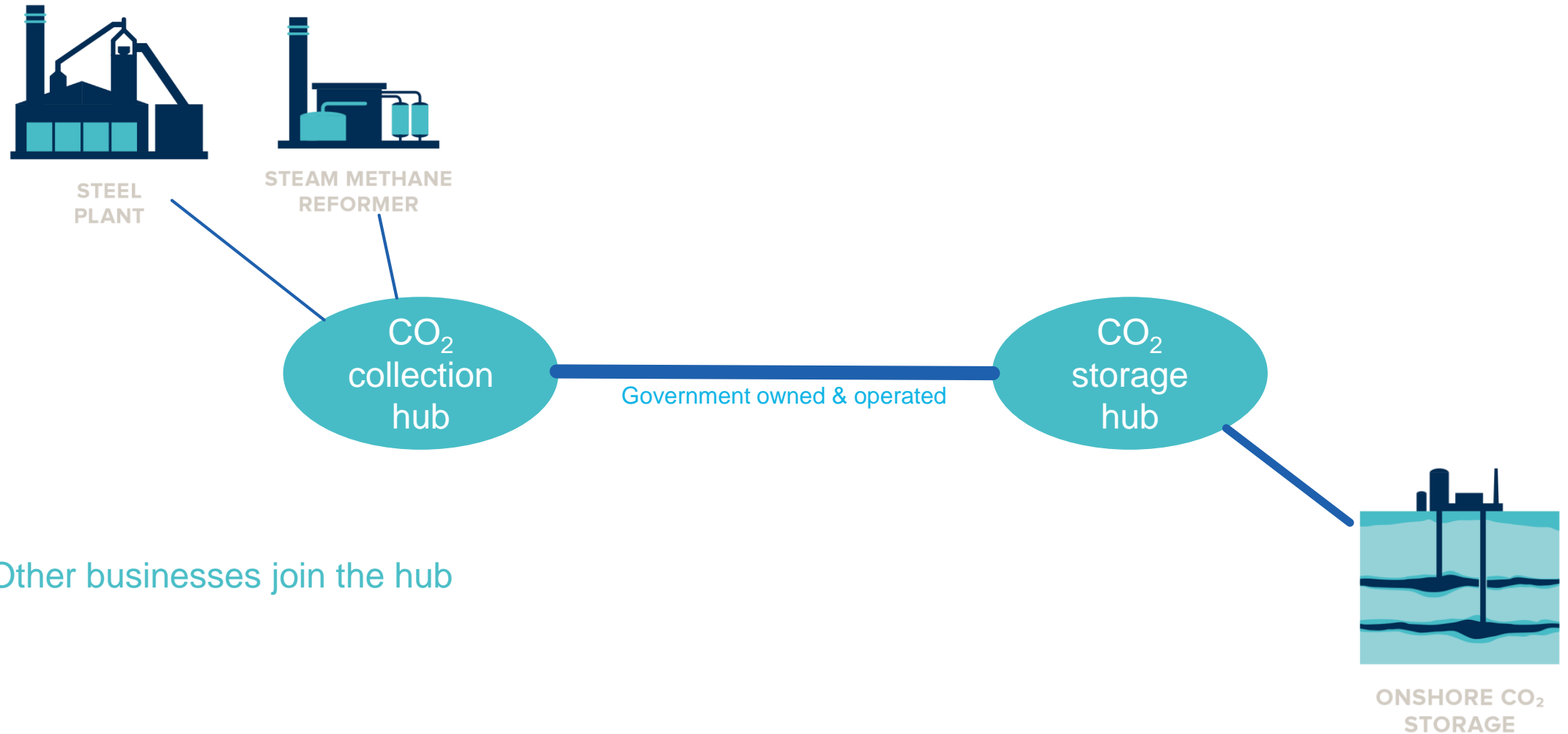


ONSHORE CO<sub>2</sub> STORAGE

- Government owns and operates initial CO<sub>2</sub> pipeline and compression infrastructure after securing an “Anchor customer”



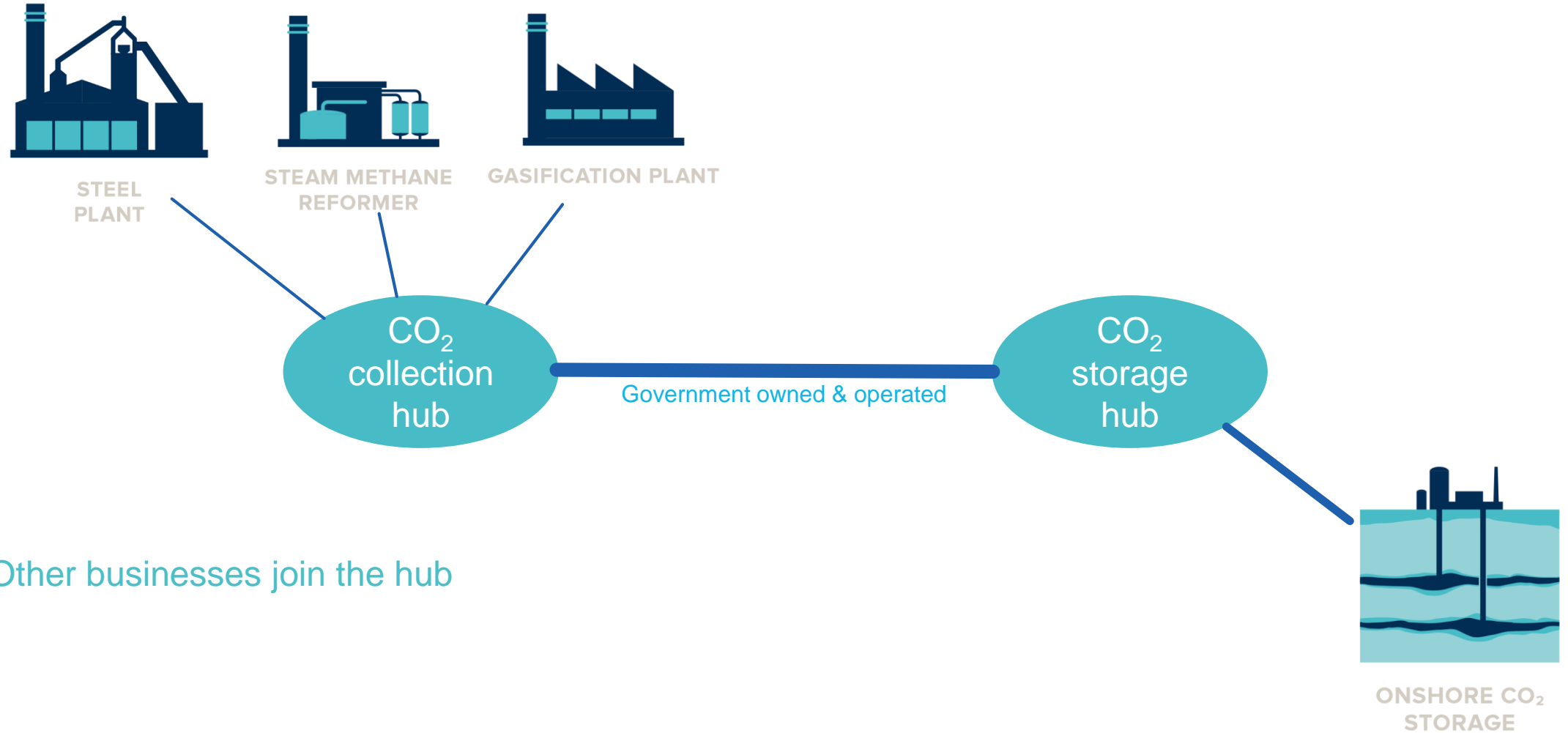
# Option – initial investment by government



- Other businesses join the hub



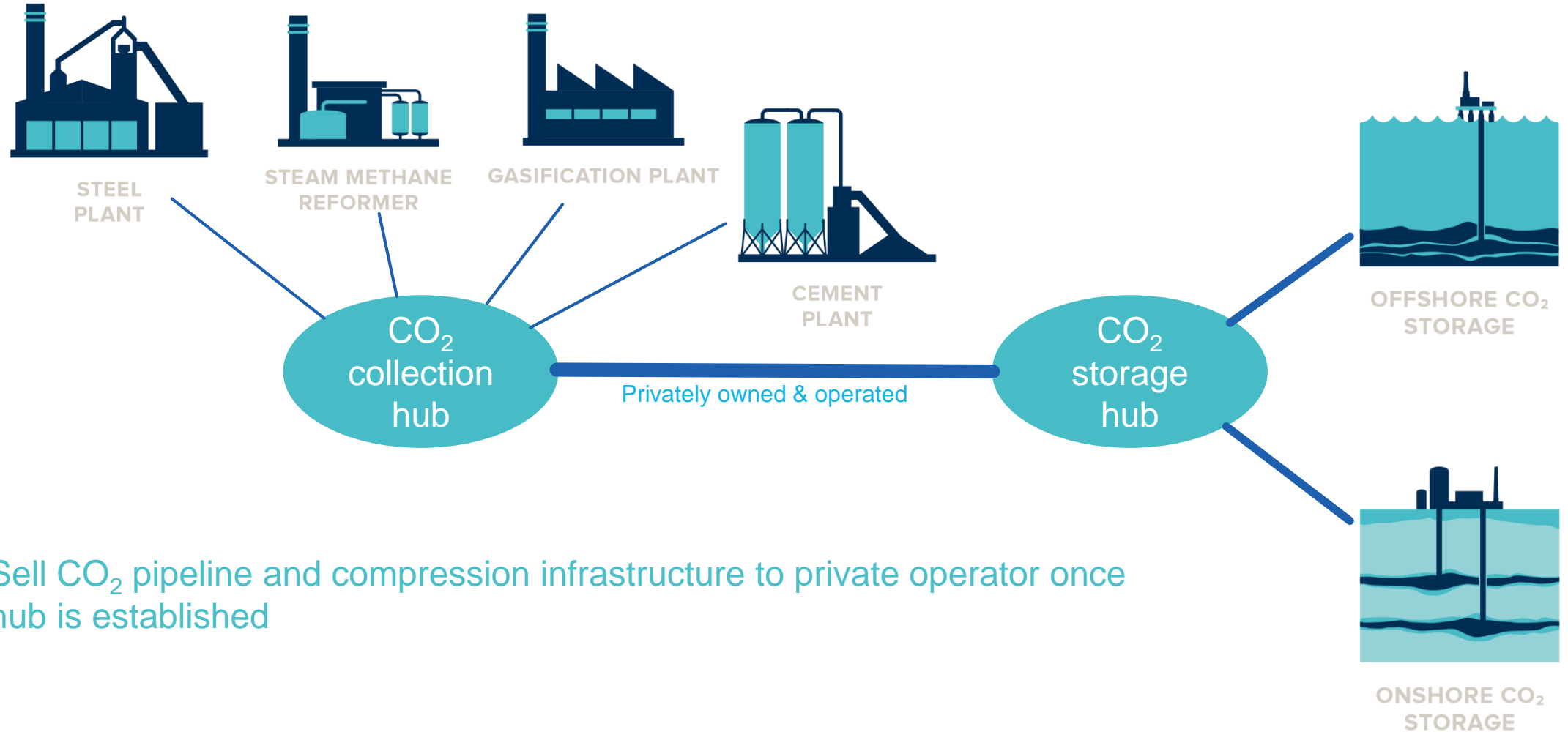
# Option – initial investment by government



- Other businesses join the hub



# Option – divest to private operator

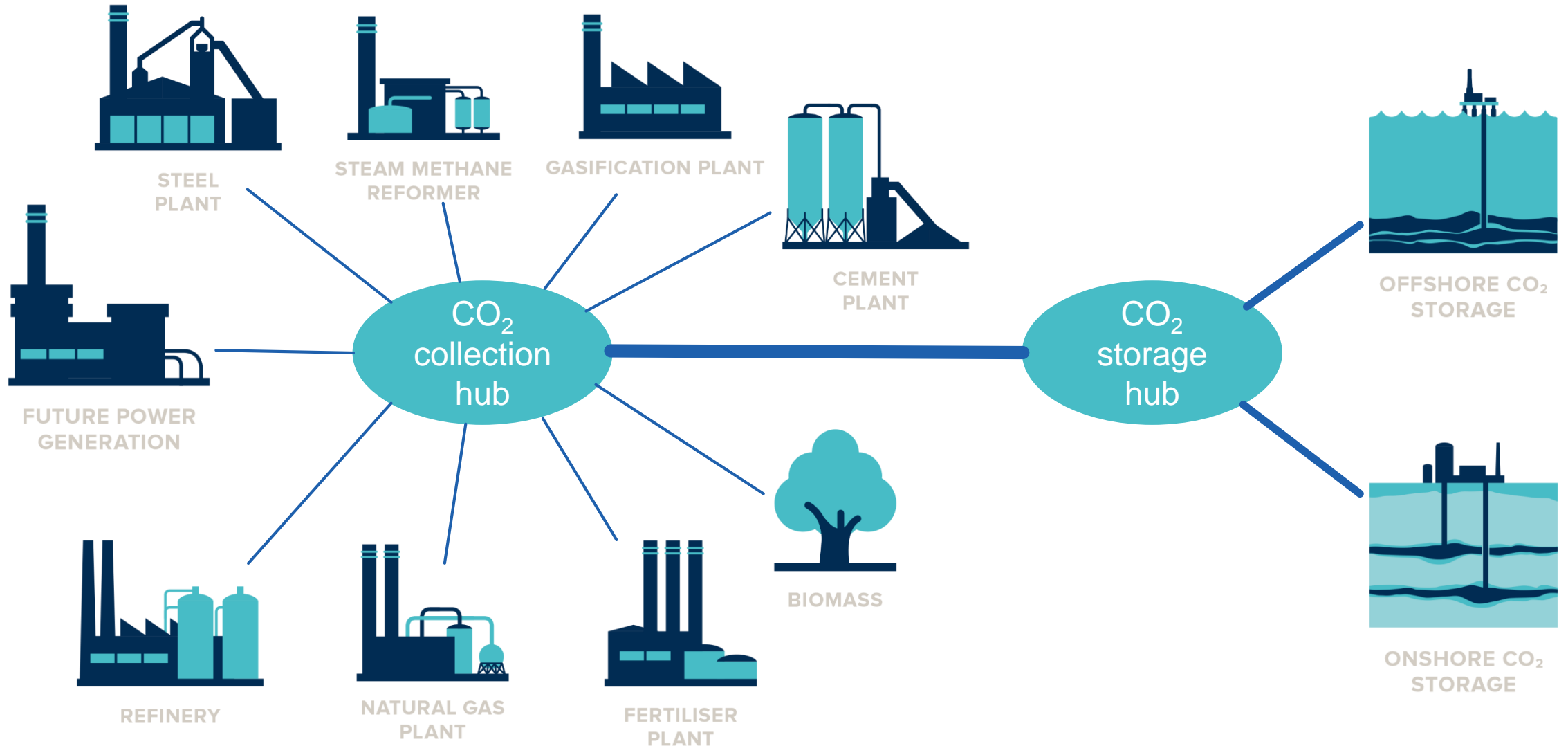


- Sell CO<sub>2</sub> pipeline and compression infrastructure to private operator once hub is established





# Low emissions industry of the future



# THANK YOU

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