Carbon Capture and Sequestration in ASEAN: An Industry Perspective

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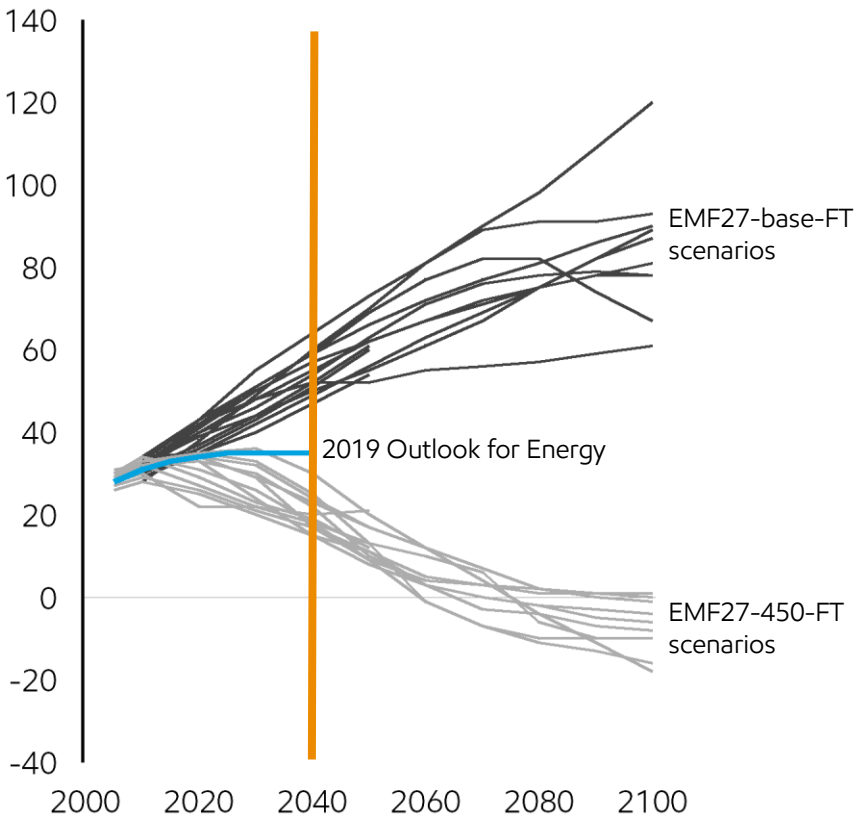
Carbon Capture and Sequestration Required in 2°C Scenarios

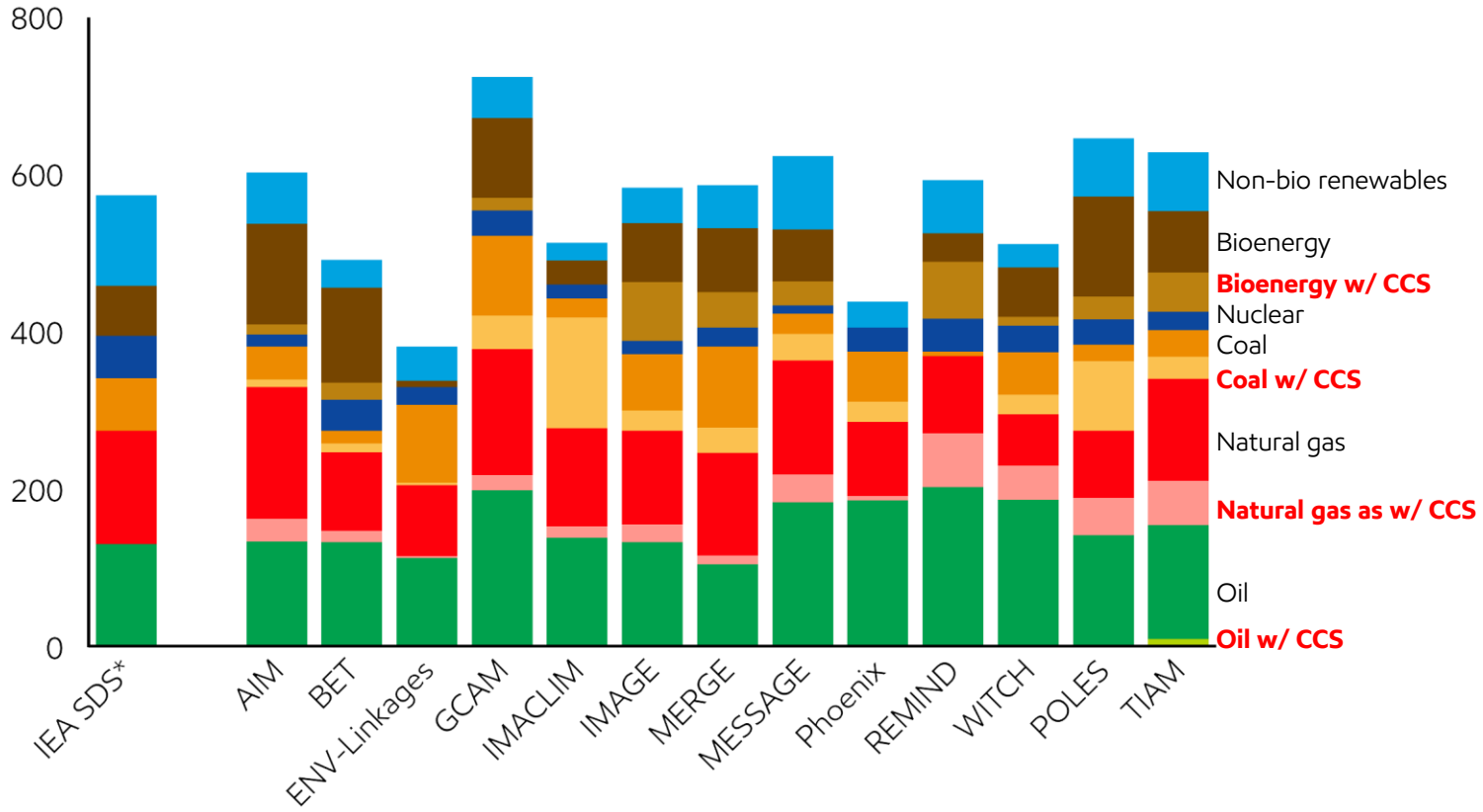
Global energy-related CO_2 emissions

Billion tonnes



2040 global demand by energy type from assessed 2°C scenarios

Exajoules



EMF27 full technology scenarios data downloaded from: https://secure.iiasa.ac.at/web-apps/ene/AR5DB

*IEA WEO 2018 SDS includes CCS but breakdown by energy type is not readily identifiable

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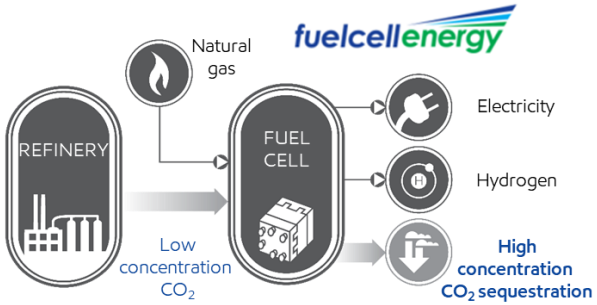
ExxonMobil Focus on CCS R&D with Partners



- Progressing design of carbonate fuel cell for CO_2 capture at Rotterdam refinery
  - Joint development with FuelCell Energy
  - Demonstration of technology, supplying data to inform commercial-scale developments

mosaic materials

Georgia Tech

Berkeley UNIVERSITY OF CALIFORNIA Department of Chemistry

- Collaborating with partners on novel, high capacity materials
  - Combine ExxonMobil's materials and process expertise with external innovators

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NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

NUS National University of Singapore

- Advancing additional CCS technology-to-scale collaborations
  - Multiple technologies via energy centers and national laboratories
  - Direct air capture with Global Thermostat

- Evaluating regional sequestration options for Singapore/ASEAN through the Singapore Energy Centre

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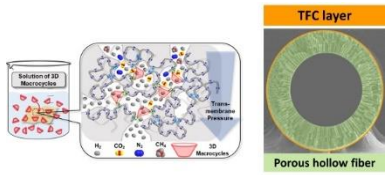
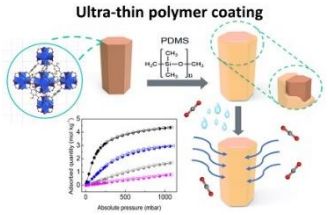
Singapore Energy Center – Example CCUS R&D Projects

Core Research Projects



Novel membranes for hydrogen separation and CO_2 capture. NUS.

CCU using incineration bottom ash and seawater desalination brine wastes. NTU.

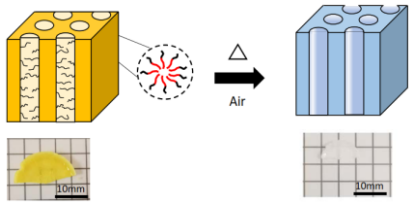


Develop Moisture-Resistant MOFs for CO_2 Capture. NUS.

From SgEC website:
https://sgec.sg/coreprojects/year-2019/

ExxonMobil Collaborative Topics

Develop Steam stable COFs for CO_2 capture. NUS.



Develop Hierarchical porous materials for CO_2 capture. NTU.

Develop regional geologic CO_2 sequestration options with subsurface, transport, and policy risks. NUS.

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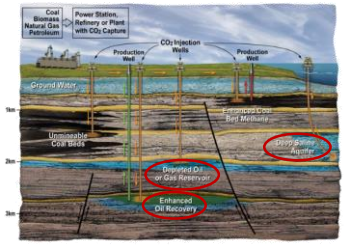
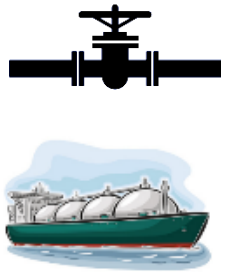
Regional CCS Study to Develop a Quantitative Understanding of Geologic CO_2 Sequestration Options for ASEAN



Geo-sequestration storage

- Identify and quantitatively evaluate subsurface CO_2 storage capacity
- Estimate costs of CO_2 storage



Transportation options, costs

- Transport via pipeline or ship
- Estimate costs of transportation using existing and new infrastructure

Policy, Regulation, and Incentives

- Understand current ASEAN policies that may enable significant CO_2 sequestration capacity
- Identify how ASEAN countries could establish policies and regulatory framework to allow CO_2 to be sequestered in an economical manner

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Regional CO_2 Storage Capacity: Workflow

Data
Reservoir reports
Production volumes
Published literature

All produced/producing fields

Selection Process

Selection Criteria
1) Water Depth < 100 m
2) Onstream or ceased production fields
3) Subsurface pressure and temperature above CO_2 supercritical point
4) Thickness * permeability > 1,000 mD·m
5) etc.

EOR Criteria

API°	Depth (ft)
>40	>2500
32~39.9	>2800
28~31.9	>3300
22~27.9	>4000
<22	unsuitable

~150 selected fields

Deduced Information
1) Geothermal gradients
2) Pressure gradients

USGS Storage methodology
IEA EOR methodology

CO_2 storage capacity estimate in O&G fields
EOR potential

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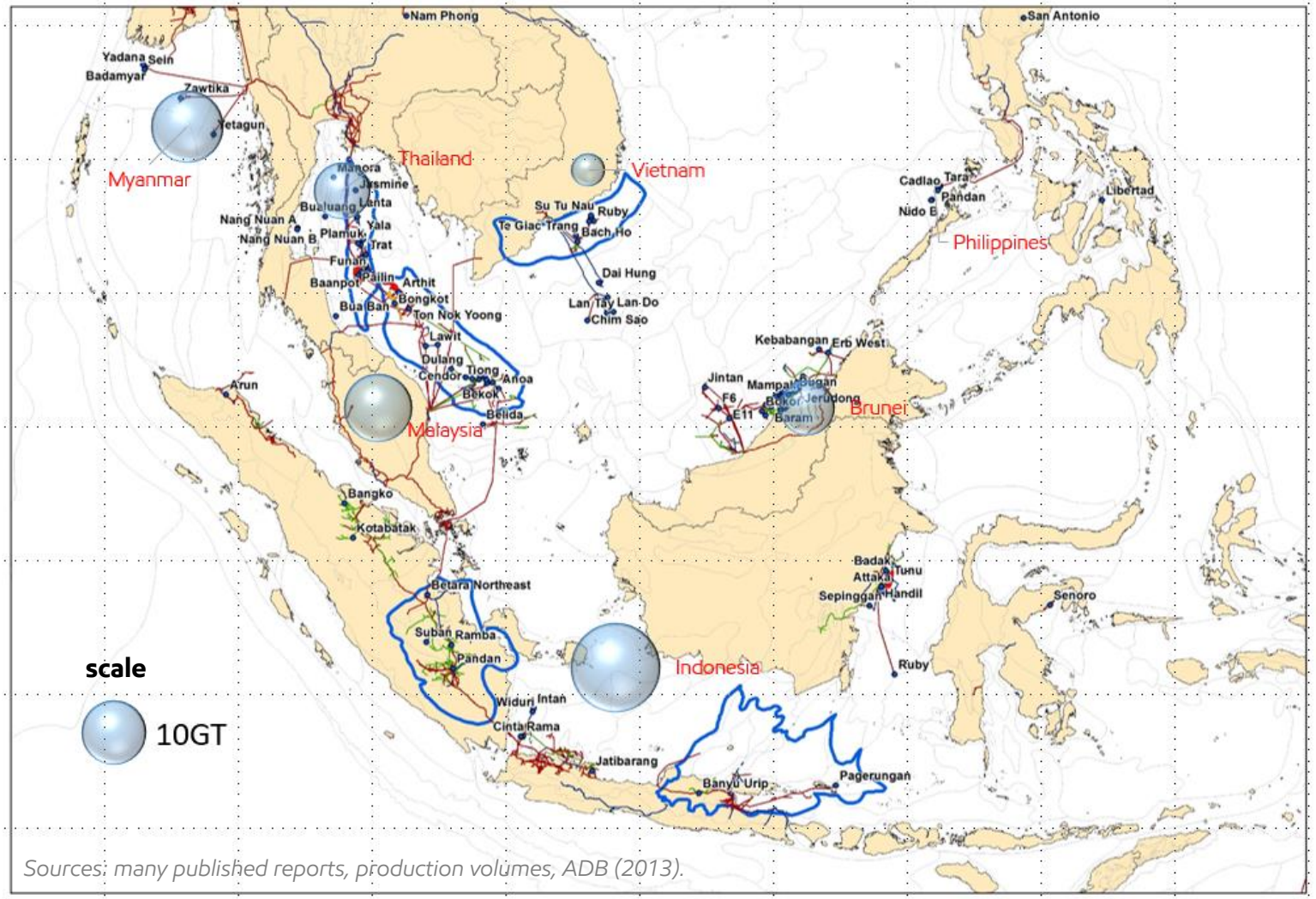
Regional CO_2 Initial Storage Capacity Estimates in O&G Fields



Sources: many published reports, production volumes, ADB (2013).

Country	2018 Emissions (2018 Million Metric Tonnes*)
Brunei	7
Myanmar	33
Indonesia	469
Malaysia	211
Philippines	126
Singapore	47
Thailand	244
Viet Nam	191
Total	1328

* Source: www.iea.org

- Total storage capacity in O&G fields alone is 60 GT (CO_2 storage capacity in saline formations is not included)
- Capacity estimates based on the available data

- Storage capacity is sufficient for all

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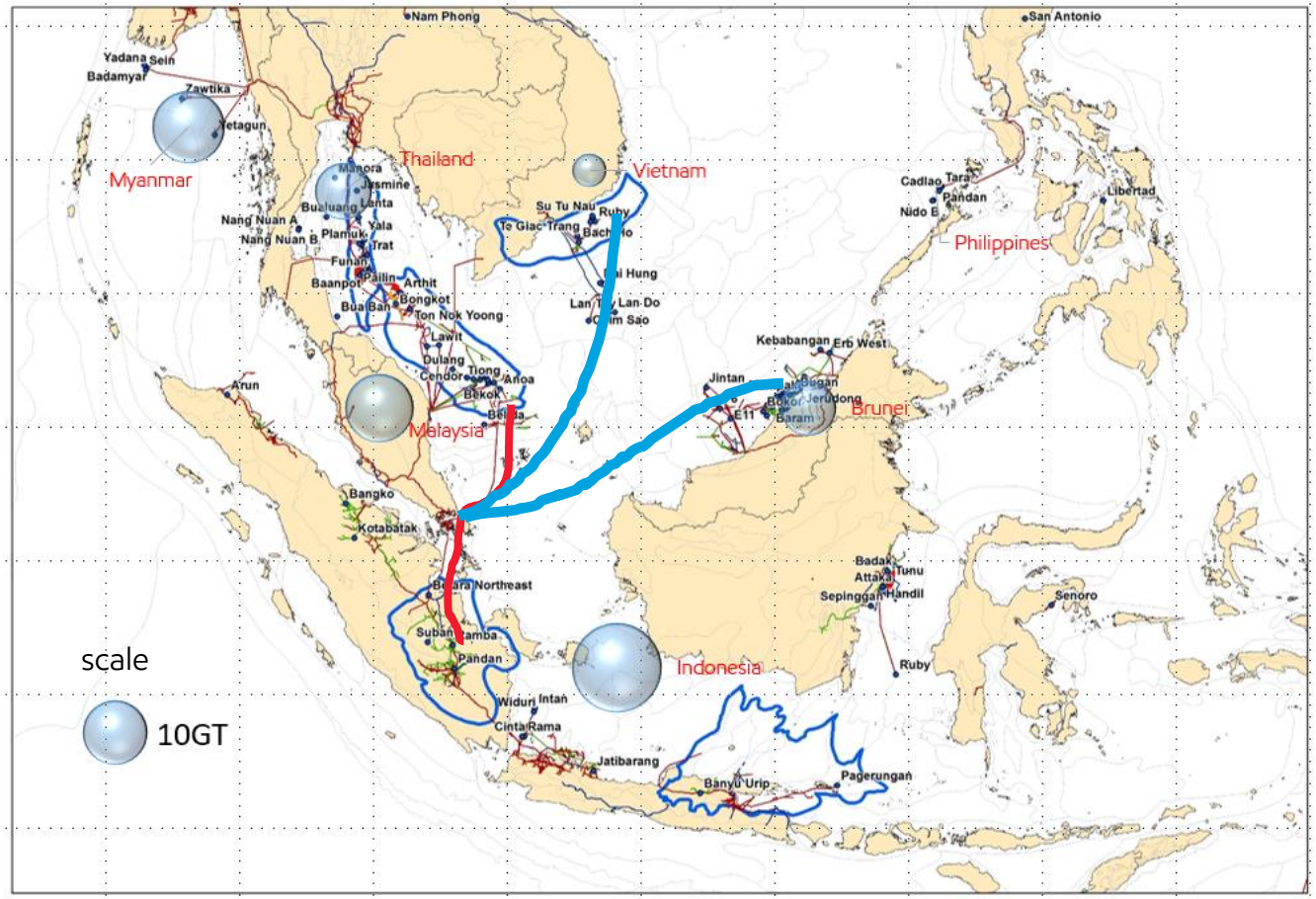
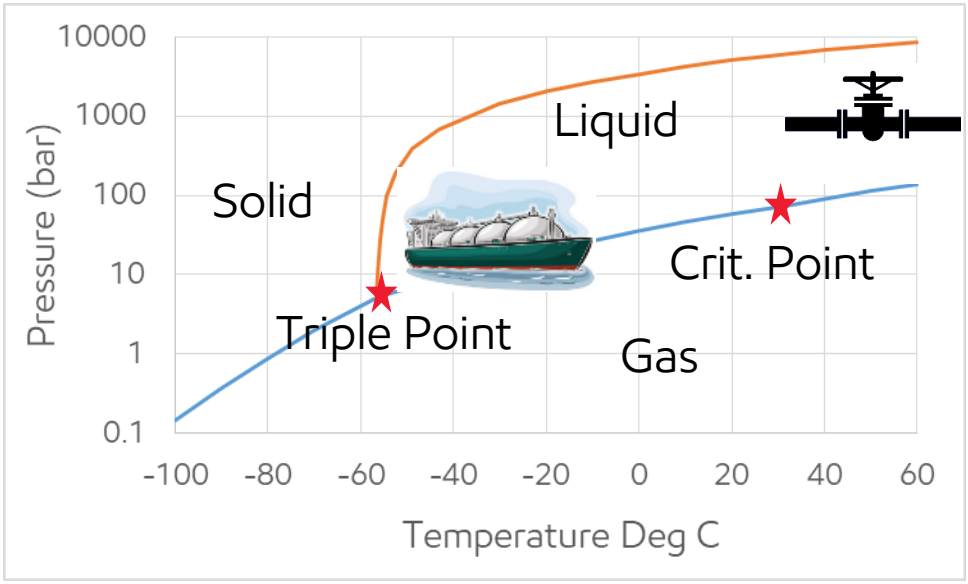
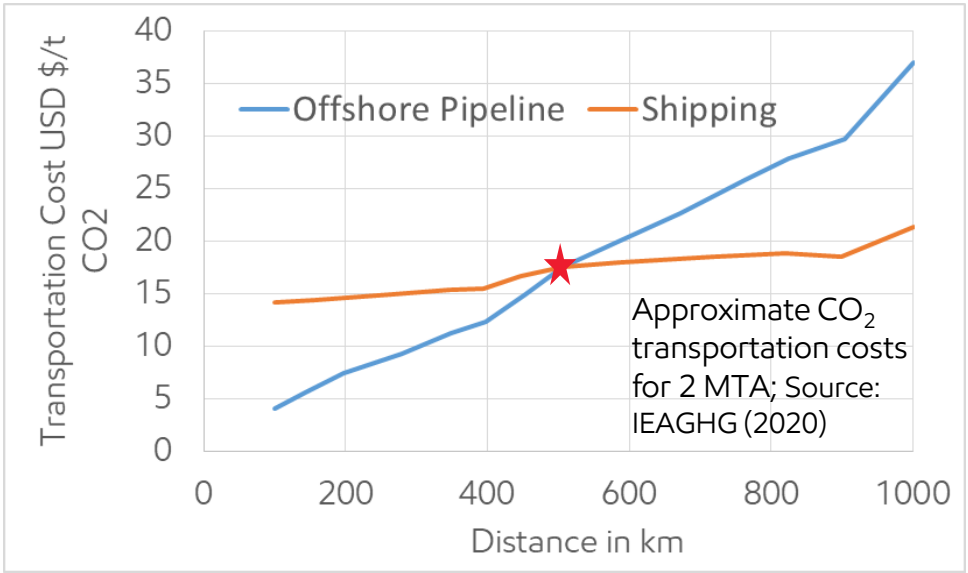
ASEAN Regional CO_2 Transportation



Typical CO_2 Transportation Routes (Pipelines and Ships)





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Summary

- Carbon Capture and Sequestration (CCS) will play a significant role in mitigation of greenhouse gases worldwide as well as in ASEAN region
- ASEAN region has sufficient subsurface storage capacity to safely sequester its CO_2 emissions
- Pipelines and shipping technologies are available or will be available soon to facilitate individual CCS projects or regional hubs
- Singapore could play an active role to kick start CCS activity for whole ASEAN region

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