EMERGING INDUSTRY CHALLENGE

CCS and CCUS in Energy Transition for Indonesia Reaching Net Zero Emissions

Indonesia CCS Center (ICCSC)

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ICCSC
INDONESIA CARBON CAPTURE AND STORAGE CENTER

Dr. Ir. Belladonna Maulianda, PEng

- Executive Director Indonesia CCS Center
- Special Advisor in Energy for Coordinating Minister of Maritime & Investment

Experience

Deloitte.
PERTAMINA
UTP
UNIVERSITI TEKNOLOGI PETRONAS
Weatherford
BitCan
Geosciences & Engineering Inc.
TOTAL
TOTAL E&P INDONESIE
Schlumberger
UNIVERSITY OF CALGARY

Profile Summary

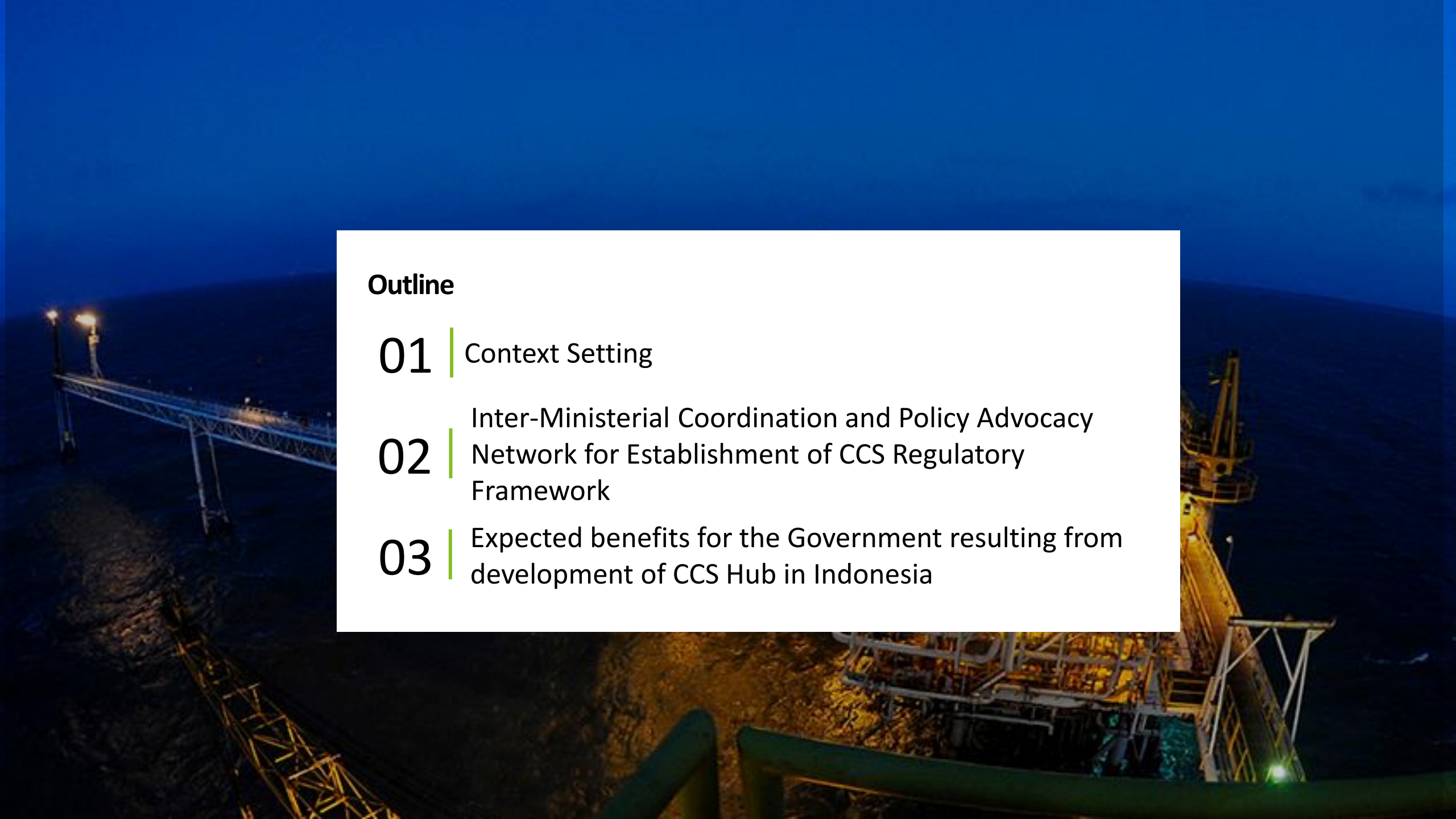
Energy Transition Leader

Relevant Experience

- 20 years experience in North America & SEA
- Leader of CCS Government Regulation Draft Development
- G20 Speaker in CCS/CCUS
- Task Force Team Energy B20;
- MEMR CCUS Regulation
- SOE Ministry Net Zero Emission Roadmap
- Leader of Pertamina's CCS/Projects

Education

- BSc in Gas & Petrochemical Engineering - University of Indonesia.
- PhD in Petroleum Engineering - University of Calgary.
- Professional Engineer - Canada



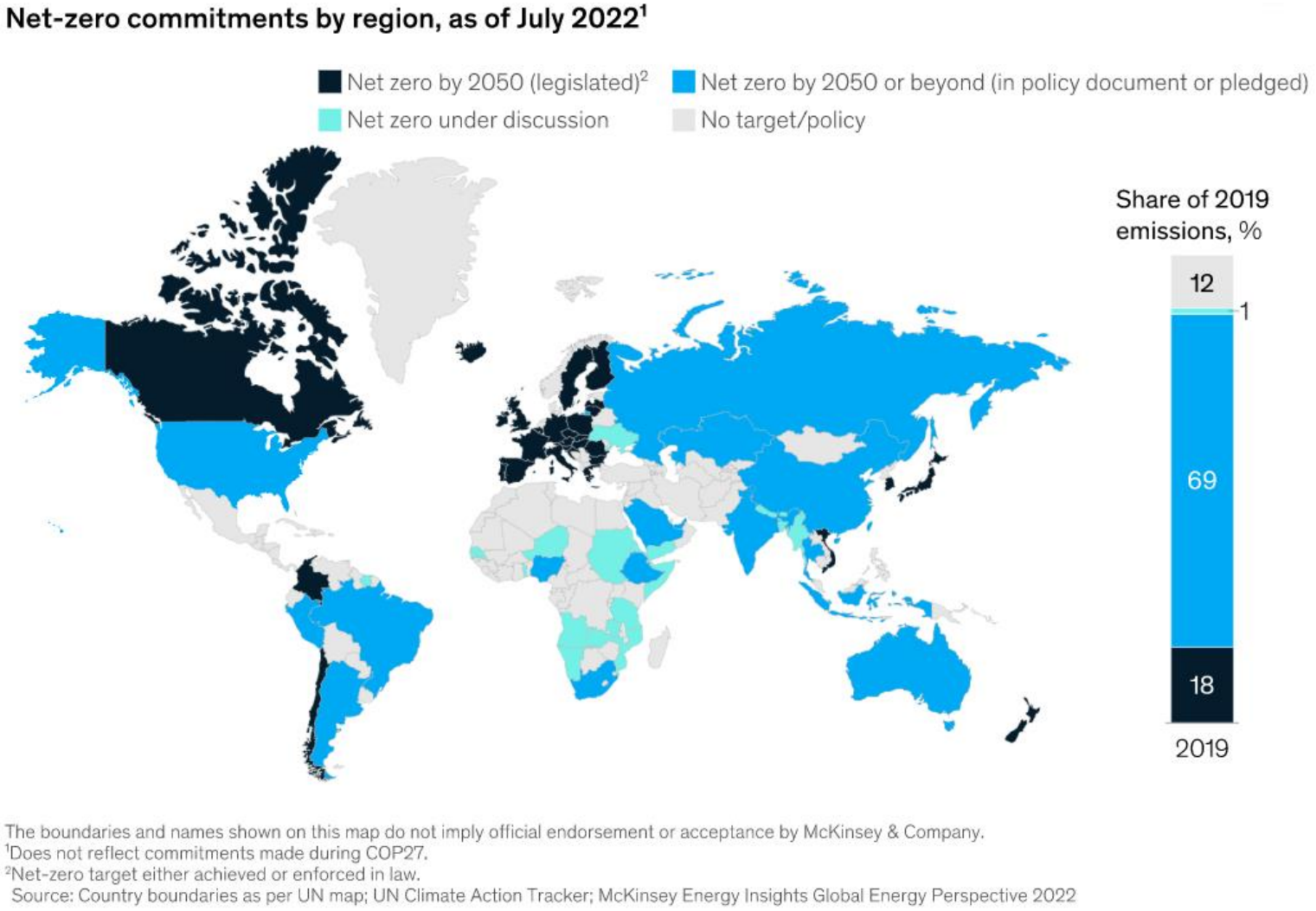
Outline

01 Context Setting

02 Inter-Ministerial Coordination and Policy Advocacy Network for Establishment of CCS Regulatory Framework

03 Expected benefits for the Government resulting from development of CCS Hub in Indonesia

Global commitments on climate change actions with a total of 68 Countries (covering 88% of global emissions) have made net-zero announcements. These commitments would be delivered by implementing different solutions' framework



Source: McKinsey & Company (2023))

A nine step problem solving framework can help structure the solutions

Physical Building Blocks

- Technological innovation.
- Capabilities to create at-scale supply chains and support infrastructure.
- Supply of necessary natural resources.

Commitments and enabling mechanisms

- Governing standards, tracking and pricing mechanisms, and effective institutions.
- Conviction, collaboration, and concerted action by public and private sector leaders globally.
- Support from citizens and consumers.

Economic and social adjustments

- Mechanisms to address socioeconomic impacts.
- Management of demand shifts and near-term unit cost increases.
- Effective capital allocation and financing structures.

Inter-Ministerial Coordination and Policy Advocacy Network for Establishing CCS Regulatory Framework. How can we effectively develop a domestic CCS/CCUS system to address the energy trilemma? Developed and Emerging Countries Journey

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
CLIMATE ACTION
Directorate C – Innovation for a Low Carbon, Resilient Economy
CLIMA.C.2 – Low Carbon Solutions (II): Research & Low Carbon Technology Deployment

- February 2022, European Commission "Enabling cross-border CCS“
- New relevant provisions for CCS projects
- **Participants:** Member States, Innovation Fund and PCI projects, Commission services, EFTA secretariat, IMO secretariat

Policy paper
The Carbon Capture and Storage Infrastructure Fund: an update on its design (May 2021) (accessible webpage)
Updated 16 December 2022

- 2020, UK Gov published Ten Point Plan for a Green Industrial Revolution
- **Without government** (Ministers, regulators, & administrations) intervention, it is unlikely, private firms would coordinate FID
- O&G invest £3B in T&S infrastructure by 2030

- Inflation Reduction Act, August 2022, boosts federal tax incentives CCS.
- **Five US Gov Agencies account for 96% of IRA Funding**
- increases credit for CCS from $50/ton to $85/ton ($180/ton for CO2 captured using direct air capture technology)

OFFICIAL PORTAL OF MINISTRY OF FINANCE

- Malaysia 2023 tax incentives CCS
- Eligible for investment tax allowance of 100% for 10 years, full import duty, sales tax exemption on equipment until 2027, tax deduction for 5 years
- **MoF supports Ministry of Energy & Natural Resources**

KEMENTERIAN KOORDINATOR
BIDANG KEMARITIMAN DAN INVESTASI
REPUBLIK INDONESIA

- MEMR Regulation 3/2023 for CCS/CCUS in O&G Working Area
- **Early 2023 onwards on CCS Cross-Border Multi-Ministries Regulation**
- CCS discussion by different stakeholders facilitated by ICCSC

METI
Ministry of Economy, Trade and Industry

- 2021, Cabinet Decision on the Sixth Strategic Energy Plan
- METI has drafted CCS roadmap, aiming to store 120–240 Mt CO2 offshore from Japan by 2050.
- **METI supports Gov of Japan’s Cabinet Strategic Energy plan**

Source: The Global CCS Institute. (2023), UK Gov (2023), Jonesday (2022), McKinsey & Co (2023), MoF Gov Malaysia (2023), METI (2021)

Expected benefits for the Government resulting from development of CCS Hub in Indonesia. Unlocking Government Benefits: How Will the Development of a CCS Hub in Indonesia Contribute?

Indonesia as CCS Hub

Storage at Scale

- Large CO2 storage resource for domestic and also for the region especially for hard to abate industries
- The storage has potential in storing emission from Oil and Gas and other sectors with up to 400 Gt capacity

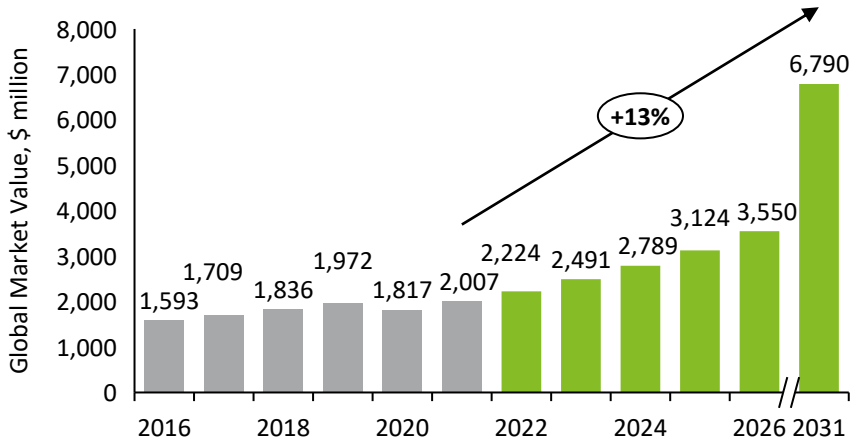
Regional demand and market will bring foreign investment

- Regional demand for CO2 storage that is shown with willingness to pay with global market size $7B, CAGR 13%
- The region/neighboring high carbon tax that creates opportunities for CO2 storing in Indonesia

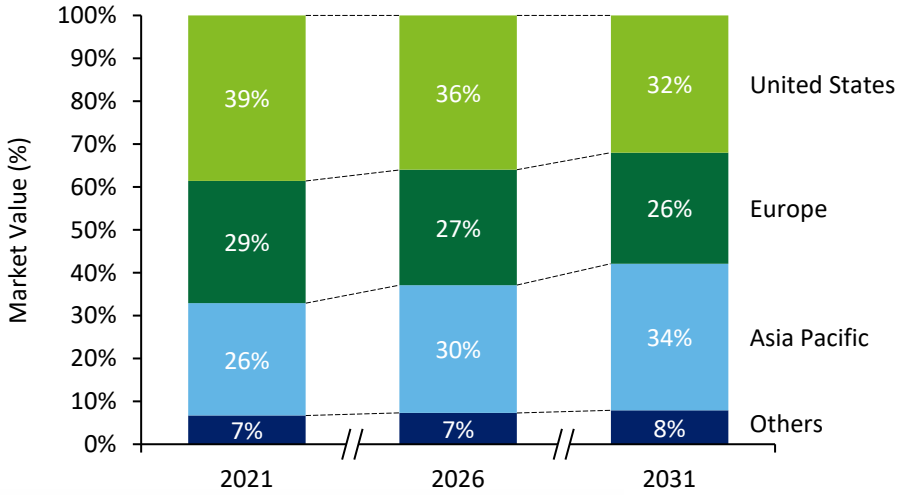
Long term investments and business

- CCS Hub and Infrastructure will serve as starting point for the future investment and business
- The future investment and business such as hydrogen, green and blue ammonia, green and blue methanol

Global Carbon Capture, and storage market, USD$ Millions



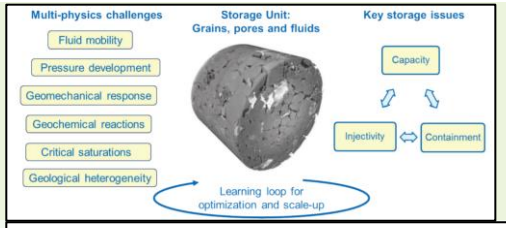
Global Carbon Capture, and storage market, by region, %



Source: Lemigas (2009, 2015 & 2016); ExxonMobil Low Carbon Solutions (CCS Study Approach and Timelines, Aug 2022); Rystad Energy (CCUS in SEA landscape with deep dive into Indonesian market, 2022)

Subsurface storage currently represents the only viable approach to isolate large volumes of CO2 from atmosphere, currently there are risks & challenges faced.
Collaboration & innovation provide solutions

1 **Injectivity & capacity challenges in CO2 storage (CCS)**



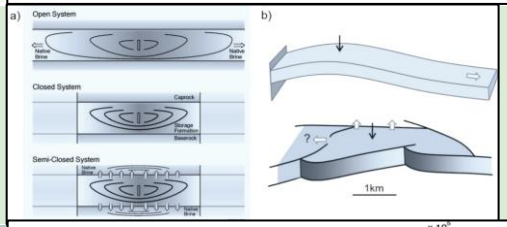
- CO2 migration & trapping processes
- Physics & chemistry- understanding CO2 flow at all scales in reservoir & storage complex

2 **Dynamic storage capacity challenges in CCS**

$$E = (c_p + c_w)\Delta P_{\max} + \frac{1}{2}(c_p + c_w)\frac{V_{sp}}{V_{fp}}\Delta P_{\max} + \frac{2Ak_s}{\mu_w H_s V_{fp}}\int_0^{t_{\max}} \Delta P(t)dt,$$

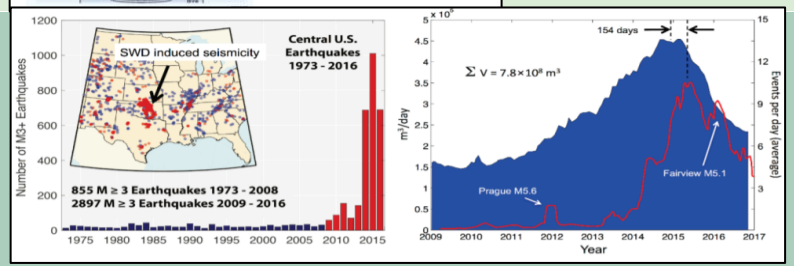
- Derivation of permeability & porosity as a function of pressure to be incorporated to determine CO2 Storage capacity dynamically

3 **Dynamic pressure limits**



- Improve understanding of detailed nature geomechanic limits control maximum allowable injection pressure

4 **CCS monitoring induced seismicity to avoid geohazards.**



- Geomechanical modeling studies for simulating fault reactivation & other geomechanical processes during CO2 injection

Source: US DOE: Accelerating Breakthrough Innovation in Carbon Capture, Utilization & Storage (2017), Maulianda: PhD Thesis, University of Calgary (2016), US DOE: Accelerating Breakthrough Innovation in Carbon Capture, Utilization & Storage (2017)

Thank You

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