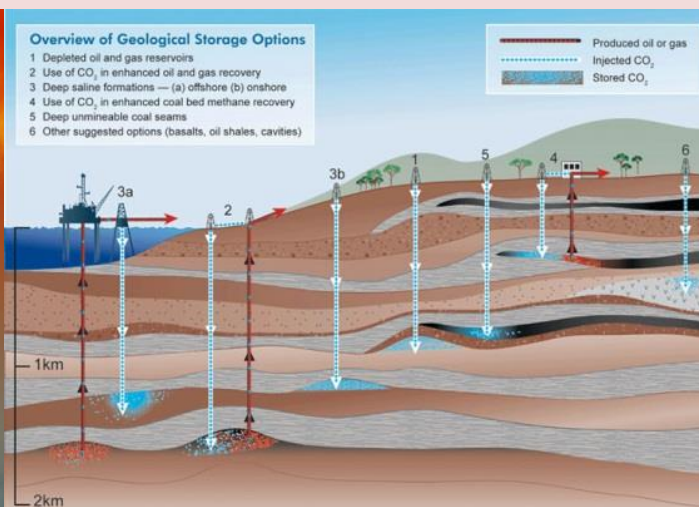




MALAYSIA'S EXPERIENCE IN CULTIVATING THE OPPORTUNITY OF CARBON CAPTURE AND STORAGE

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Outlines of Talk

1. Introduction

- Malaysia CO₂ Emissions

2. CCS Activities in Malaysia

- CO₂ Emissions Reduction & CCS Activities

3. CO₂ Storage Assessment in Malaysian Basins

- Problem Statement & Objective
- Methodology
- Basins Ranking & CO₂ Storage Capacity
- Mineral Carbonation

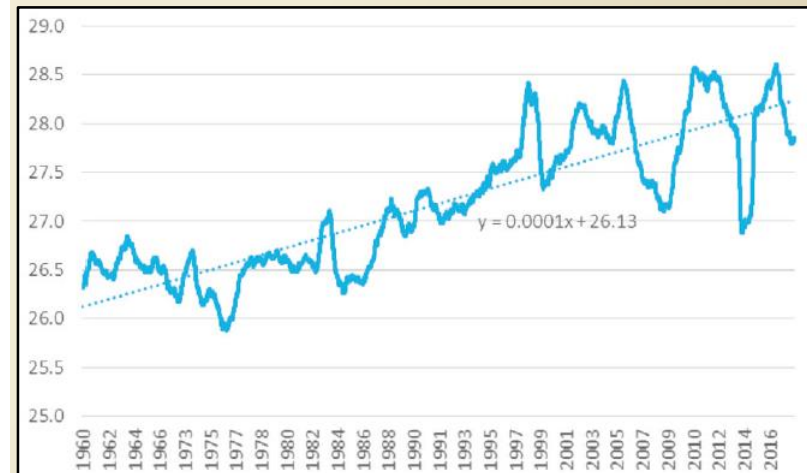
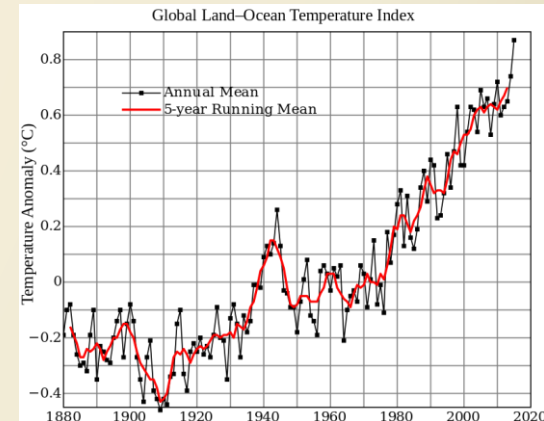
4. Summary

1. Introduction

- Malaysia CO₂ Emissions

- Malaysia CO₂ Emissions

- Global warming is a global phenomenon, **unusually rapid increase** in Earth's **mean surface temperature**.
- Malaysia is also experiencing a **warming trend** with an increase of mean surface temperature in KL from **26.2 °C** (1961) to **28.2 °C** (2018) (Tang, 2019).



Trends of daily mean temperature of Kuala Lumpur

- Malaysia CO₂ Emissions

5

- Data from IEA (2019) shows CO₂ emissions in 2018 for Malaysia was 257.8 million tonnes, or 8.05 metric tonnes CO₂ emission rates based on per capita.
- The main sources of the emissions were energy (76%), mobility, and waste.
- Malaysia made a commitment to reduce by 2030 its CO₂ emissions per unit of GDP by 45% from the level in 2005 (Paris Climate Conf., 2015).



2. CCS Activities in Malaysia

- CO₂ Emissions Reduction & CCS Activities

- CO₂ Emissions Reduction & CCS Activities

7

- Since 2011, Malaysia has established the **Low Carbon Cities Framework (LCCF)**.
- LCCF is a national framework assessment system to guide and assess the development of cities into **low carbon cities** and to promote green technology, in line with the **Green Technology Master Plan 2017-2030**.
- One of five key elements in the framework is to **increase carbon sequestration** from protecting and adding green spaces.

- CO₂ Emissions Reduction & CCS Activities

8

- In 2010, the **Malaysian CCS Scoping Study** was carried out by Global CCS Institute and KeTTHA.
- The scoping studies identified some **main potential 'source-sink' clusters** include:
 - Cluster of point sources in **eastern Peninsular Malaysia** which can assess potential storage areas in the **offshore Malay and Penyu Basins**, and
 - Cluster of point sources in **Sarawak** which can assess potential storage areas in the **offshore Greater Sarawak**.
- They also explored the **legal and regulatory** aspects of implementing CCS in Malaysia.

- CO₂ Emissions Reduction & CCS Activities

9

- Malaysia's commitment of **using low emission coal technology in coal-fired plant** in Malaysia for carbon capture, use and storage (CCUS).
- [TNB Manjung 4](#) is Southeast Asia's first **ultra-supercritical** coal-fired power plant, began its commercial operation in April, 2015.
- Using high efficiency low emission (HELE) technologies can **reduce CO₂ emissions by as much as 35%** compared to older less efficient technology.

- CO₂ Emissions Reduction & CCS Activities

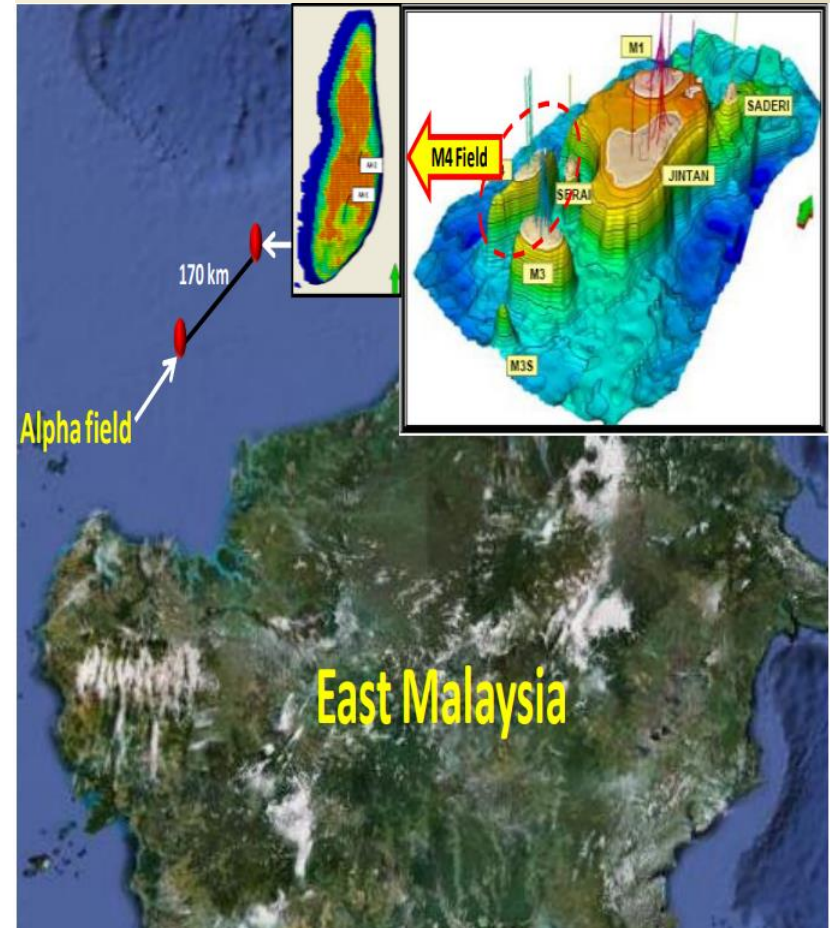
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- To maintain Malaysia as a natural gas producer and net exporter, PETRONAS has identified **15 offshore gas fields** to have a **high content of CO₂**, have to be developed timely.
- PETRONAS has signed an agreement with Japan Oil, Gas and Metals National Corporation (JOGMEC) to study the **development of high CO₂ gas fields, utilizing CCS technology**.
- In the study, CO₂ produced from the fields is to be **separated, captured and injected** into suitable storage reservoirs such as mature and depleted gas reservoirs.

- CO₂ Emissions Reduction & CCS Activities

11

- In conjunction with a **high CO₂ field development**, a depleted gas field, located offshore Sarawak has been identified as **potential candidate for CO₂ sequestration** site.
- A detail 3D simulation analysis was conducted by PETRONAS to identify effective **storage capacity** in the candidate field.



3. CO₂ Storage Assessment in Malaysian Basins

- Problem Statement and Objective
 - Methodology
- Basins Ranking & CO₂ Storage Capacity
 - Mineral Carbonation

Problem Statement & Objective

13



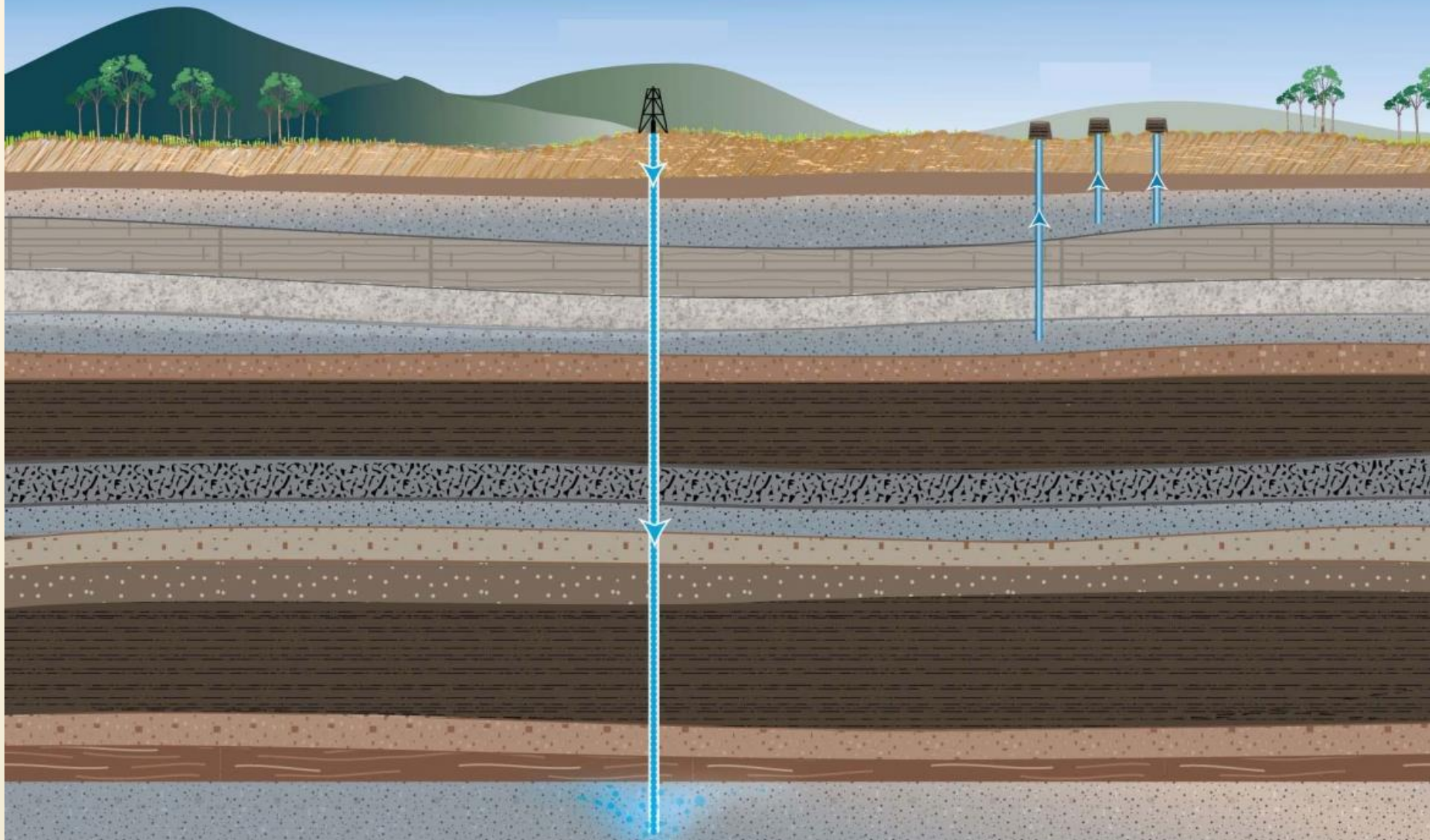
The suitability of the Malaysian Basins to be storage site for CO₂ in Malaysia

Basin-scale evaluation

Objective:

- The main aim of this study was to evaluate **site suitability of potential geological storage of CO₂ in Malaysian sedimentary basins and to estimate CO₂ storage capacity within the deep saline aquifer.**

Injection in deep saline Aquifers



Screening Criteria

Table 1: Evaluation criteria for preliminary evaluation of CO₂ geological storage in Malaysia (modified from Bachu, 2003)

	Criterion, i	Classes, j						
		1	Score	2	Score	3	Score	W
1	Tectonic setting	For arc	1	Back arc	3	Platform	7	0.09
2	Faulting intensity	Extensive	1			Moderate	5	0.1
3	Reservoir seal pair	Poor	1			Medium	3	0.1
4	Depth	Very shallow (<300m)	1	Shallow (300-800m)	3			0.08
5	Size	Very small (<1000km ²)	1	Small (1000-5000km ²)	3	Medium (5000-25000km ²)	5	0.06
6	Geothermal	Warm basin (>40° C/km)	1			Moderate (30-40° C/km)	3	0.09
7	Hydrogeology	Shallow, short flow systems	1			Intermediate flow system	3	0.08
8	Maturity	Unexplored	1	Exploration	2	Developing	4	0.08
9	Hydrocarbon potential	None	1	Small	3	Medium	7	0.06
10	Onshore/Offshore	Deep offshore	1			Shallow offshore	4	0.1
11	Accessibility	Inaccessible	1	Difficult	3			0.03
12	Infrastructure	None	1	Minor	3			0.05
13	Climate	Arctic	1	Sub-arctic	2	Desert	4	0.08

Screening Criteria (cont.)

16

(cont) Table 1: Evaluation criteria for preliminary evaluation of CO₂ geological storage in Malaysia
(modified from Bachu, 2003)

	Criterion, i	Classes, j				
		4	Score	5	Score	W
1	Tectonic setting	Deltaic	15	Rift valley	15	0.09
2	Faulting intensity			Limited	9	0.1
3	Reservoir seal pair			Excellent	7	0.1
4	Depth	Deep (>3500m)	5	Intermediate (800-3500m)	15	0.08
5	Size	Large (25000-50000km ²)	9	Very large (>50000km ²)	15	0.06
6	Geothermal			Cold basin (30° C/km)	7	0.09
7	Hydrogeology			Long range flow system	7	0.08
8	Maturity	Mature	8	Super-mature	10	0.08
9	Hydrocarbon potential	Large	13	Giant	21	0.06
10	Onshore/Offshore			Onshore	10	0.1
11	Accessibility	Acceptable	6	Easy	10	0.03
12	Infrastructure	Moderate	7	Extensive	10	0.05
13	Climate	Tropical	7	Temperate	11	0.08

Storage Capacity Assessment

US-DOE Method (2012)

17

$$G_{CO_2} = A_t \times h_g \times \Phi_{tot} \times \rho \times E_{saline}$$



Where :

- G_{CO_2} = Geologic storage of CO₂ in saline aquifer, Gt
- A_t = total geographical area of the basin being assessed for CO₂ storage, m²
- h_g = gross thickness of the saline formation for which CO₂ storage is assessed within the basin, m
- Φ_{tot} = total porosity in volume defined by the net thickness,
- ρ = density of CO₂ within the reservoir and assumed to be 620 kg/m³ across the basin (Koukouzas et al., 2009).
- E_{saline} = CO₂ storage efficiency.
(Assume: E_{saline} to be 2.0% for clastic and 1.5% for limestone formations based on 50th percentiles).

Results:

Ranking for Sedimentary Basins in Malaysia



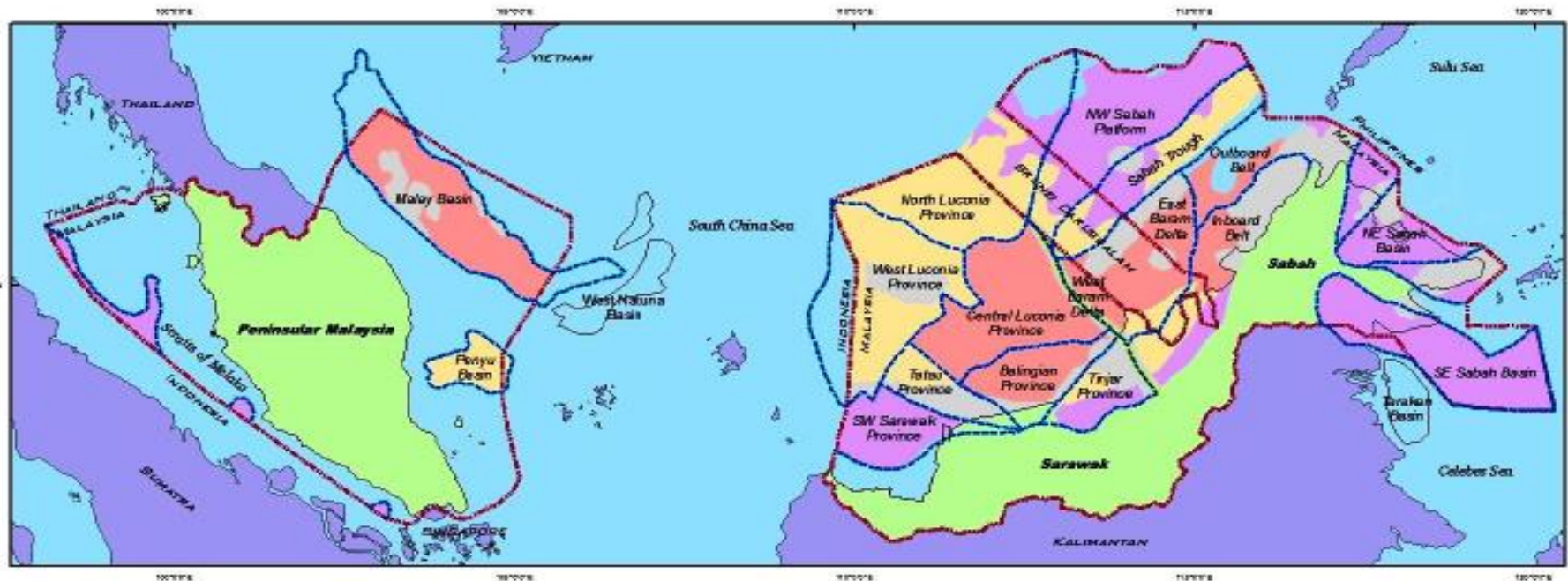
Rank, R	Basin, k	Score
1	Malay Basin	0.8113
2	Central Luconia Province	0.7356
3	West Baram Delta	0.7041
4	Balingian Province	0.6938
5	Sabah Basin	0.6864
6	East Baram Delta	0.6260
7	Straits of Melaka	0.6200

Rank, R	Basin, k	Score
8	Penyu Basin	0.5554
9	Tatau Province	0.4938
10	West Luconia Province	0.4553
11	Tinjar Province	0.4200
12	Northeast Sabah Basin	0.3543
13	Southeast Sabah Basin	0.3370
14	North Luconia Province	0.2659

Table 2: List of Ranking for Sedimentary Basins in Malaysia

Potential Area for CO₂ Storage

POTENTIAL AREA FOR CARBON DIOXIDE SEQUESTRATION IN SEDIMENTARY BASINS OF MALAYSIA



Legend:

Basin Potential

High Potential	Low Potential
Average Potential	No Potential



0 75 150 300 450 600 Kilometers



UTM
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Faculty of Chemical
And Energy Engineering

Designed by: Dayang Zulaika Binti Abang Hasbollah

Software: ArcGIS 10.2

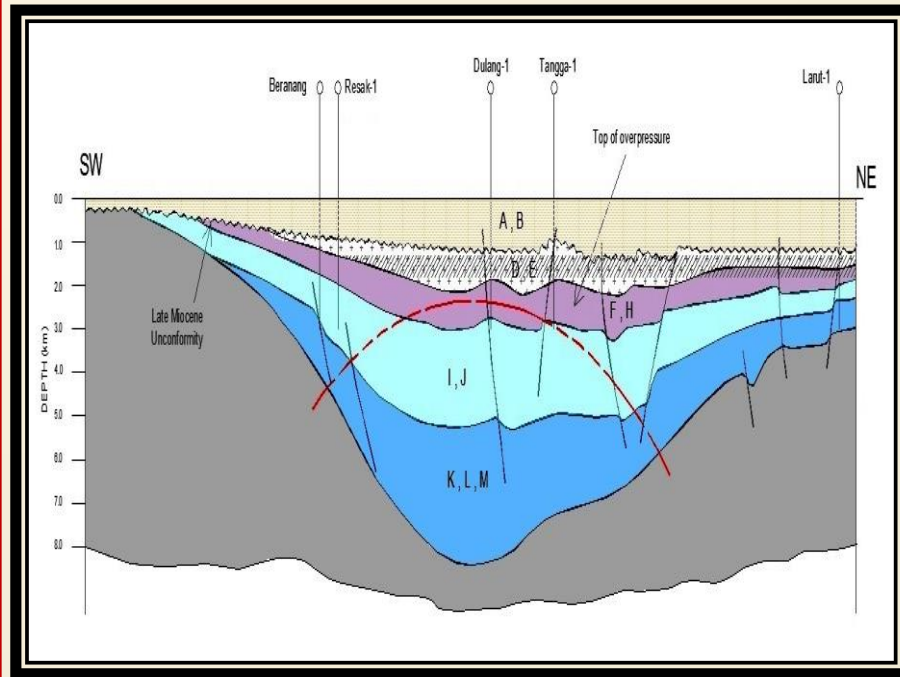
Year: 2016

Potential Injection Sites

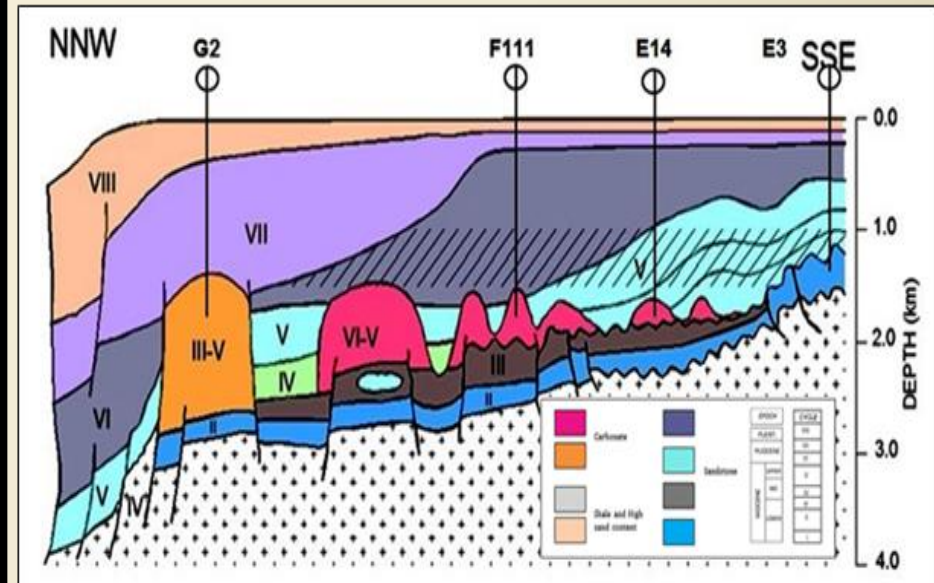
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Potential injection site in:

Malay Basin



Central Luconia Province



CO₂ Storage Capacity

21

CO₂ storage capacity estimation based on 50th percentile (US-DOE, 2012).

Basin	CO ₂ Storage Capacity (Gt)
Malay Basin	21
Central Luconia Province	14



Mineral Carbonation/Sequestration

1.1 CO₂ Storage in Deep Saline Aquifers

1.2 Mineral Carbonation/Sequestration



Research Output	Achievement
Articles (Index Journal)	8 (CIF=28.692)
Articles (Non-Index Journal)	2
Intellectual Property Right	1
Other Publication	5
Book/Standard	
Human Capital Development	Archievement
PhD Student	2
MSc Student	2
Undergraduate	4
Research Officer (RO)	
Research Assistant (RA)	1

4. Summary

Summary

24

- In 2018, Malaysia emitted **257.8 million tonnes** of CO₂. The energy sector is the biggest emitter.
- With current **CCS technology**, Malaysia will be able to develop offshore fields with **high CO₂ content gas fields**. It is likely that **suitable storage** would be available, particularly offshore depleted gas fields.
- **Malay basin & Central Luconia** are respectively ranked as the **top two in the ranking** system. The estimated results suggest that the Malay Basin and Central Luconia Province can store about **21 Gt and 14 Gt** of CO₂, respectively.

A nighttime photograph of a serene lake scene. In the background, a mosque with a prominent blue dome and minarets is illuminated against a dark blue sky with scattered clouds. The lights from the mosque and surrounding trees are reflected in the calm water. A wooden gazebo with a brown roof is situated on the right side of the lake. A wooden railing is visible in the bottom right corner. A palm frond hangs from the top left corner.

Thank You

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