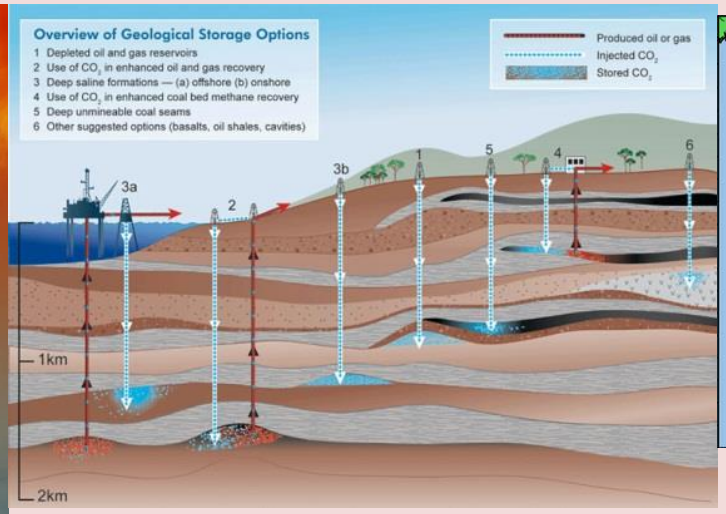

MALAYSIA'S EXPERIENCE IN CULTIVATING THE OPPORTUNITY OF CARBON CAPTURE AND STORAGE

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Outlines of Talk

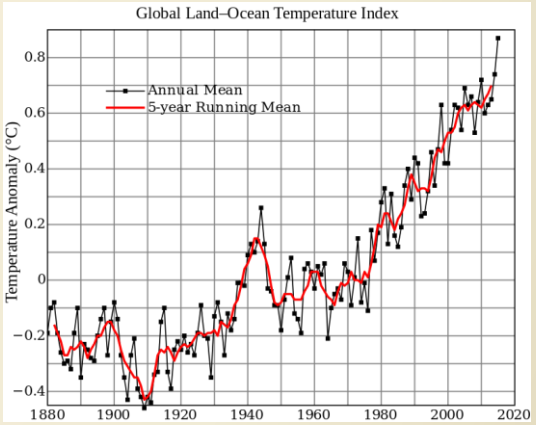
1. **Introduction**
   - Malaysia CO_2 Emissions
2. **CCS Activities in Malaysia**
   - CO_2 Emissions Reduction & CCS Activities
3. **CO_2 Storage Assessment in Malaysian Basins**
   - Problem Statement & Objective
   - Methodology
   - Basins Ranking & CO_2 Storage Capacity
   - Mineral Carbonation
4. **Summary**

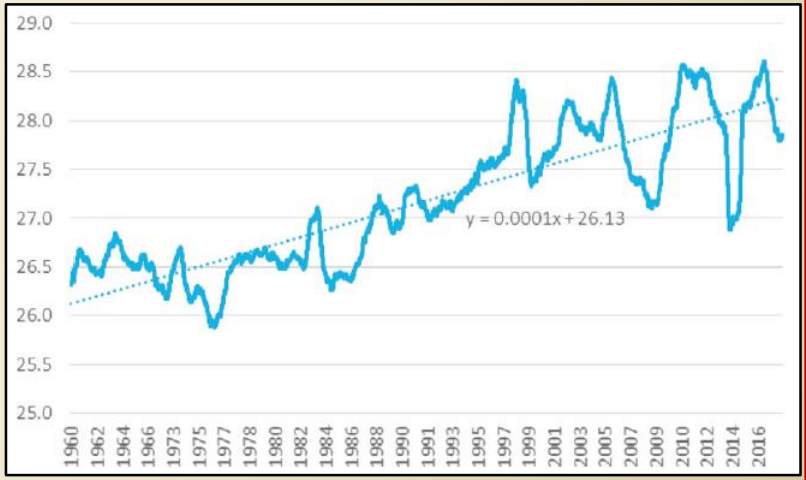
1. Introduction

- Malaysia CO_2 Emissions

- Malaysia CO_2 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 CO_2 Emissions

- Data from IEA (2019) shows CO_2 emissions in 2018 for Malaysia was 257.8 million tonnes, or 8.05 metric tonnes CO_2 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 CO_2 emissions per unit of GDP by 45% from the level in 2005 (Paris Climate Conf., 2015).

2. CCS Activities in Malaysia

- CO_2 Emissions Reduction & CCS Activities

- CO_2 Emissions Reduction & CCS Activities

- 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.

- CO_2 Emissions Reduction & CCS Activities

- 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.

- CO_2 Emissions Reduction & CCS Activities

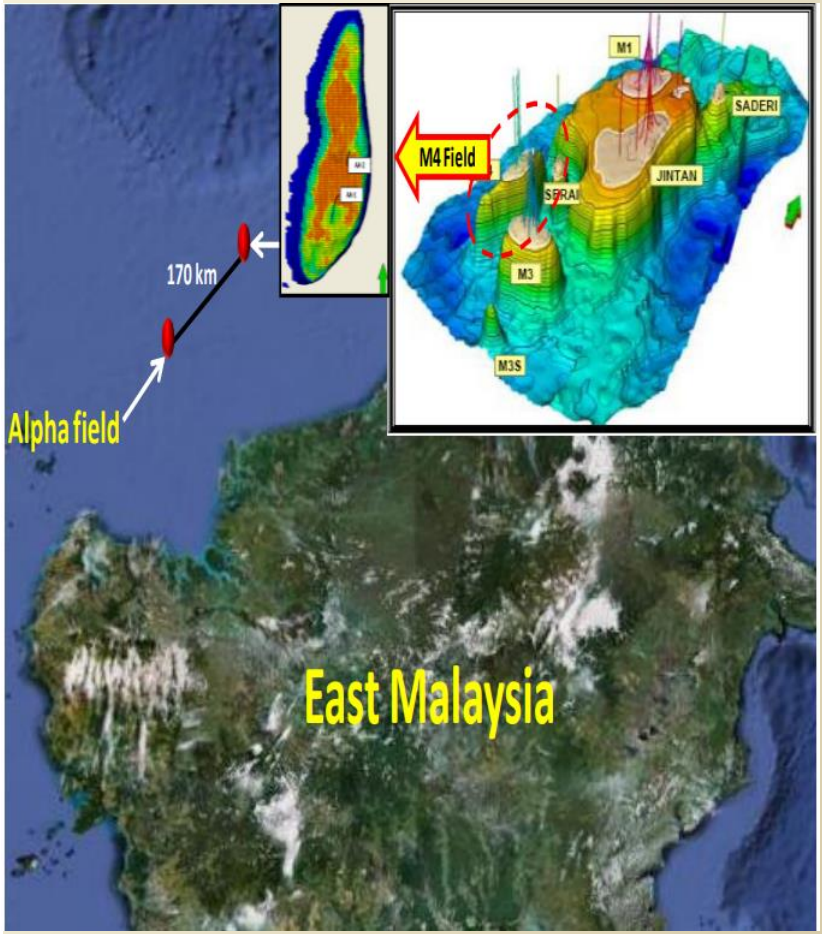
- Malaysia's commitment of using low emission coal technology in coal-fired plant in Malaysia for carbon capture, use and storage (CCUS).
- TNB Manjung 4 is Southeast Asia's first ultra-supercritical coal-fired power plant, began its commercial operation in April, 2015.
- Using high efficiency low emission (HELE) technologies can reduce CO_2 emissions by as much as 35% compared to older less efficient technology.

- CO_2 Emissions Reduction & CCS Activities

- To maintain Malaysia as a natural gas producer and net exporter, PETRONAS has identified 15 offshore gas fields to have a high content of CO_2, 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 CO_2 gas fields, utilizing CCS technology.
- In the study, CO_2 produced from the fields is to be separated, captured and injected into suitable storage reservoirs such as mature and depleted gas reservoirs.

- CO_2 Emissions Reduction & CCS Activities

- In conjunction with a high CO_2 field development, a depleted gas field, located offshore Sarawak has been identified as potential candidate for CO_2 sequestration site.
- A detail 3D simulation analysis was conducted by PETRONAS to identify effective storage capacity in the candidate field.



3. CO_2 Storage Assessment in Malaysian Basins

- Problem Statement and Objective
- Methodology
- Basins Ranking & CO_2 Storage Capacity
- Mineral Carbonation

Problem Statement & Objective

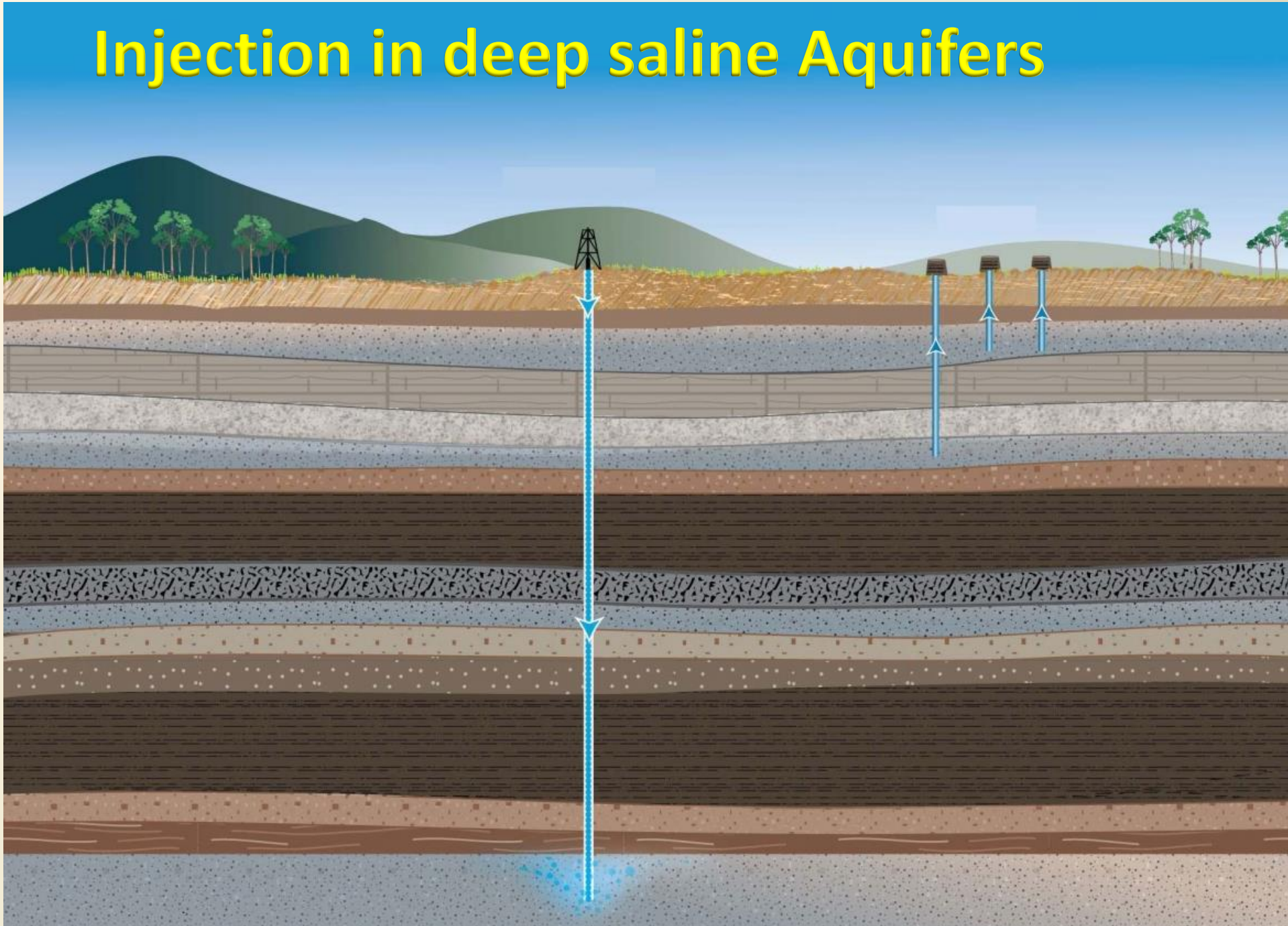
The suitability of the Malaysian Basins to be storage site for CO_2 in Malaysia

Basin-scale evaluation

Objective:

- **The main aim of this study was to evaluate site suitability of potential geological storage of CO_2 in Malaysian sedimentary basins and to estimate CO_2 storage capacity within the deep saline aquifer.**

Injection in deep saline Aquifers



Screening Criteria

Table 1: Evaluation criteria for preliminary evaluation of CO_2 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.)

(cont) Table 1: Evaluation criteria for preliminary evaluation of CO_2 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)

$$G_{CO2} = A_t \times h_g \times \Phi_{tot} \times \rho \times E_{saline}$$

Where :

G_{CO2} = Geologic storage of CO2 in saline aquifer, Gt

- A_t = total geographical area of the basin being assessed for CO_2 storage, m^2
- h_g = gross thickness of the saline formation for which CO_2 storage is assessed within the basin, m
- Φ_{tot} = total porosity in volume defined by the net thickness,
- ρ = density of CO_2 within the reservoir and assumed to be 620 kg/m^3 across the basin (Koukouzas et al., 2009).
- E_{saline} = CO_2 storage efficiency.

(Assume: E_{saline} to be 2.0% for clastic and 1.5% for limestone formations based on 50^{th} percentiles).

Results:

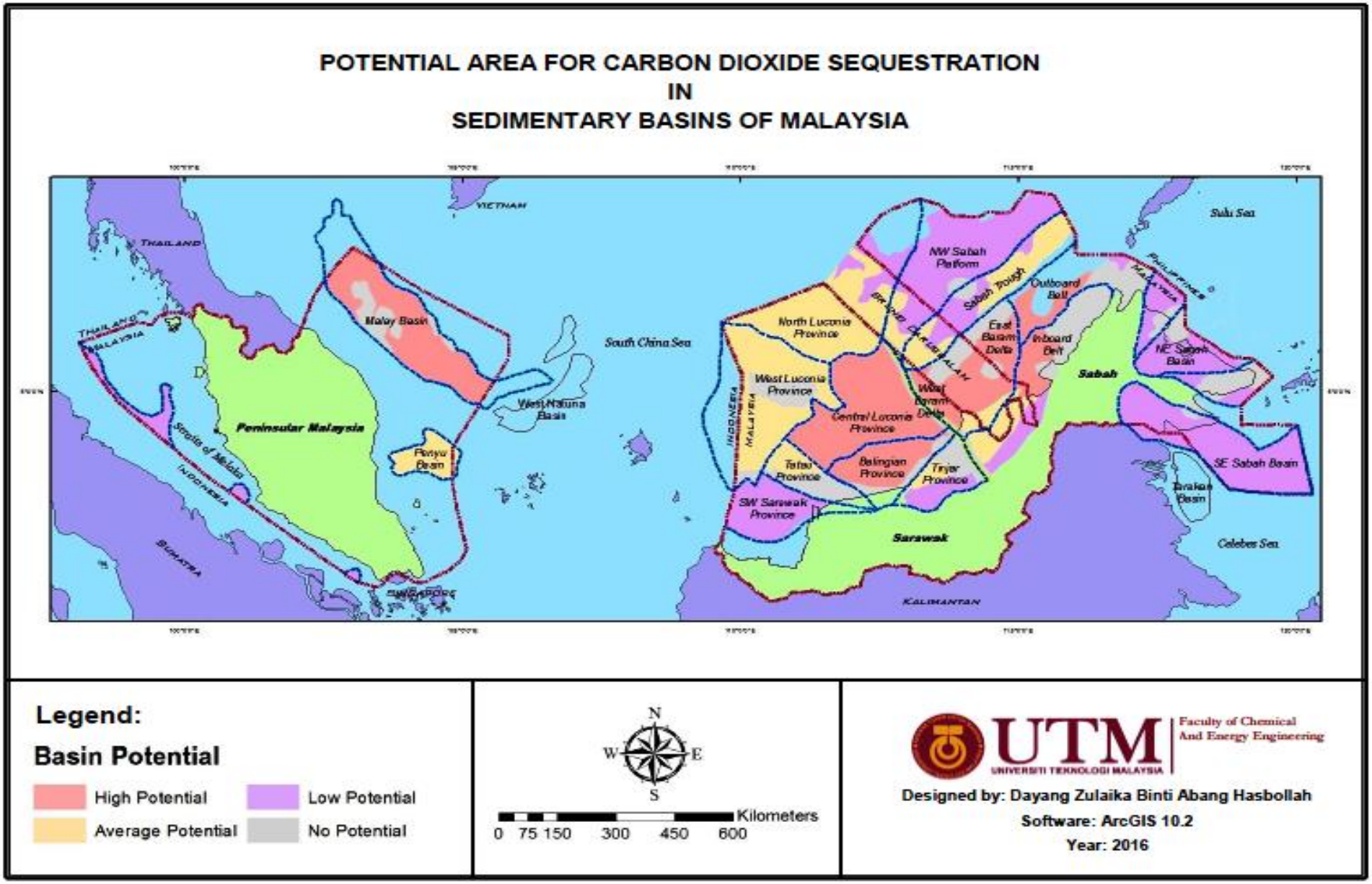
Ranking for Sedimentary Basins in Malaysia

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

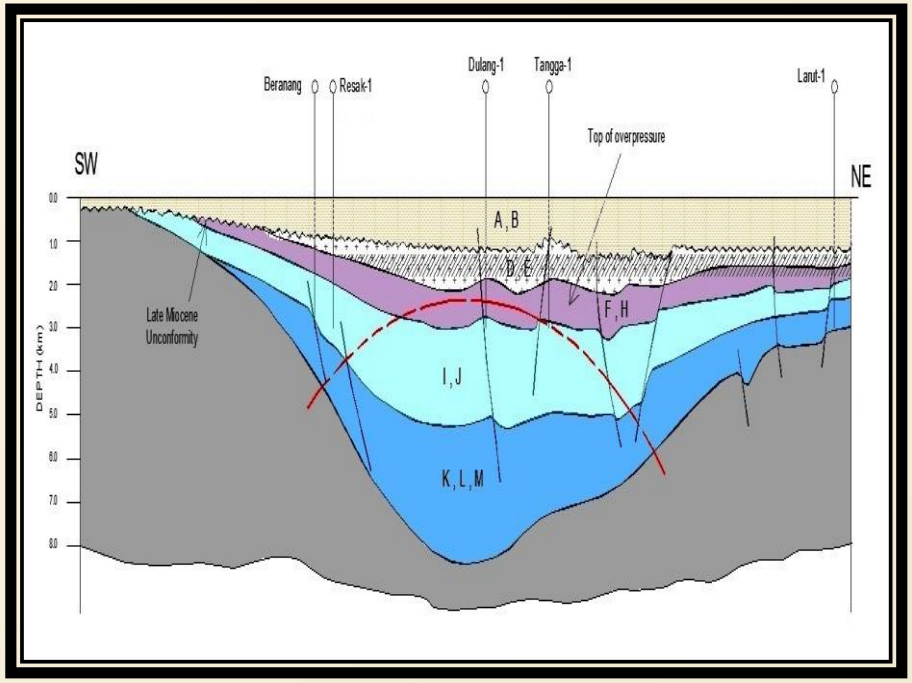
Potential Area for CO2 Storage



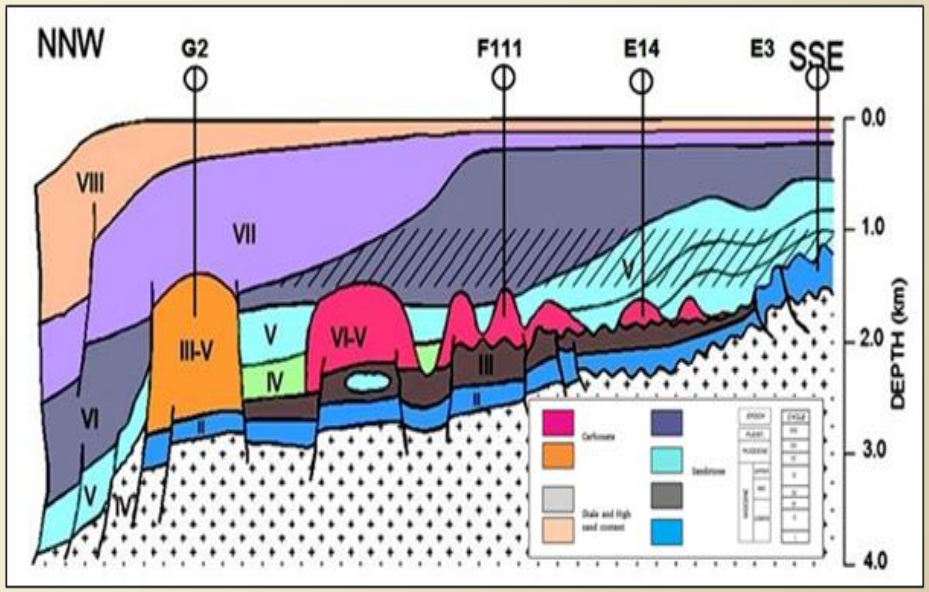
Potential Injection Sites

Potential injection site in:

Malay Basin



Central Luconia Province



CO_2 Storage Capacity

CO_2 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 CO_2 Storage in Deep Saline Aquifers

1.2 Mineral Carbonation/Sequestration


Waste Red Gypsum


Autoclave mini reactor


Carbonate product

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

- In 2018, Malaysia emitted 257.8 million tonnes of CO_2. The energy sector is the biggest emitter.
- With current CCS technology, Malaysia will be able to develop offshore fields with high CO_2 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 CO_2, respectively.


Thank You
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