CARBON DIOXIDE STORAGE SITE SELECTION AND ASSESSMENT IN THE OFFSHORE REGION OF MALAY BASIN

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ABSTRACT

For the past decades, the rise in concerns of carbon dioxide level in the atmosphere has escalated. Hence, it to actively think of alternative solutions on how to manage carbon dioxide that are often released from fuel consumption and petroleum production. One of the most discussed solutions is geological storage in depleted oil and gas reservoir. Hence, this study discusses the suitability of Malay Basin as a potential geological storage for carbon dioxide and storage capacity estimation by using Ogawa methods. The potential injection zone was identified and estimated Jerneh depleted gas field can store up to 150 MMton of carbon dioxidefor the sand Group D and E are main reservoirs (coastal plains) and shale in groups A and B are caprock (shallow marine deposits). Northern and Central Provinces of Malay Basin is found to be the most suitable subregion for carbon dioxide geological storage purpose due to abundant and enormous underdeveloped high contaminant field for injection of carbon dioxide rank down for priority. Site selection and characterization for CO2 storage in the offshore region of Malay Basin were carried out with reference to ISO 27914: 2017. Then Western Bujang and Jerneh gas field were selected for the potential CO2 storage sites because of high-ranking resulting from storage capacity and safety assessments. The study focused on characterization of geological complex of both sites to determine injection formations and, seal rocks and proceeded assessments of capacity and injectivity of the Bujang West saline aquifer.

ABSTRAK

Baru-baru ini terdapat peningkatan tahap karbon dioksida yang membimbangkan di atmosfera. Ini telah menggalakkan para penyelidik untuk secara aktif memikirkan penyelesaian alternatif tentang cara menguruskan karbon dioksida yang sering dibebaskan daripada penggunaan bahan api dan pengeluaran petroleum. Salah satu penyelesaian yang paling banyak dibincangkan ialah penyimpanan geologi dalam resebor minyak dan gas yang telah habis. Oleh itu, kajian ini membincangkan kesesuaian Lembangan Melayu Utara sebagai storan geologi yang berpotensi untuk carbon dioxide dan anggaran kapasiti penyimpanan dengan menggunakan kaedah Ogawa. Zon suntikan berpotensi kemudiannya dikenal pasti dan dianggarkan medan gas Jerneh yang habis boleh menyimpan sehingga 150 MMton carbon dioxide dengan takungan Kumpulan D dan E adalah takungan utama (dataran pantai) dan kumpulan A dan B adalah batu tangkup (mendapan laut cetek). Wilayah Utara dan Tengah Lembangan Melayu didapati sebagai subwilayah yang paling sesuai untuk tujuan penyimpanan geologi carbon dioxide kerana ia mempunyai medan gas tercemar yang banyak dan tidak dibangunkan untuk suntikan carbon dioxide untuk keutamaan. Pemilihan tapak dan pencirian untuk penyimpanan CO2 di kawasan luar pesisir Malay Basin telah dijalankan dengan merujuk kepada ISO 27914: 2017. Kemudian medan gas Bujang Barat dan Jerneh dipilih untuk tapak penyimpanan CO2 yang berpotensi kerana kedudukan tinggi hasil daripada kapasiti penyimpanan dan penilaian keselamatan. Kajian tertumpu kepada pencirian kompleks geologi kedua-dua tapak untuk menentukan pembentukan suntikan dan batuan pengedap dan kemudian meneruskan penilaian kapasiti dan penyuntikan akuifer masin Bujang Barat.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Problem Background

Malaysia is currently undergoing a rapid transformation and development in economy due to the urge of Industrialisation Revolution 4.0 worldwide which goal to be a developed and high.income country. As one of leading countries in technology and artificial intelligence in Southeast Asia region, Malaysia is projected to consume huge scale of fossil.fuel in near future. The robust development of mega projects in recent decades has shown fear in the remnant volume of carbon footprint released to our breathing air. In fact, as mentioned by BP (2017), the total of carbon dioxide gas released by industrialization in Malaysia itself has reached approximately 250 million tonnes in year 2016.

Malaysia's National Oil Company (NOC), PETRONAS has committed to grow the net zero carbon emission moving towards environmental.friendly green energy by 2050. As for now, Malaysia's gas reserves with high carbon dioxide contaminant have a total.up gas volume of approximately 13tcf and 27tcf for hydrocarbon gas and carbon dioxide volume respectively (Jalil et al., 2012). In November 2021, PETRONAS has joint.ventured with Exxon in moving Malaysia a step ahead in Carbon Capture and Storage solution hub in the region; to develop, test and pilot the Carbon Capture and Storage project latest by 2025 (PETRONAS, 2021). This initiative will also help continuous optimisation oil and gas field production to fund the billion.dollar Carbon Capture and Sequestration project.

As for now, limited access to data and technology to study on how to manage the carbon dioxide footprint problem. Some researchers (Amran, Zainuddin, & Zailani, 2013) suggested that Malaysia should regulate a law on trading carbon dioxide and some (Madon, et al., 2006) suggested to inject the carbon dioxide into a proven sealing

capability of geological carbon.storage reservoir. A geological carbon.storage is a proven concept on how carbon dioxide contaminant is injected into a geological reservoir sequestrated permanently or limited into a certain window of time. Few of the proven examples of successful Carbon Capture and Storage project by United Arab Emirates's Abu Dhabi National Oil Company in Rumathai and Bab Field currently implementing carbon dioxide gas sequestration inside of geological oil.depleted reservoir (Ustadi, Mezher, R.M, & Zahra, 2017).

Carbon dioxide geo.sequestration is very important in oil and gas industry in Malaysia due to abundant of underdeveloped high carbon dioxide gas field. Much research had been done showing a significant role in carbon dioxide technology and expected the depleted gas.reservoir geological storage and saline aquifer reservoirs will be demanded by the oil and gas companies to further mature the undeveloped high carbon dioxide fields in offshore Peninsula Malaysia.

The Malay Basin is entirely offshore and is in north of the Malaysian Peninsula. The Malay Basin is approximately 83,000 km2. The basin is approximately 500 km long and 200 km wide. Water depth is less than 200 m. It is well known there are some carbon dioxide.rich gas fields mainly in the northern region of the basin (Figure **1.1**) and the carbon dioxide content reaches 70% in the Dulang Field (Madon, et al., 2006). Up until now, the large amounts of carbon dioxide associated with the natural gas production in Malay Basin have simply been emitted into the atmosphere through flaring. Most of the carbon emission reduction pledges for 2030 that 184 countries made under the Paris Agreement (Sharma, 2020). Countries are required to make great efforts on emission reduction to achieve their Paris Agreement reduction commitments.

Offshore carbon storage has been successfully implemented at Norway's Sleipner storage site in the North Sea since 1996, and a second offshore storage site, Snøhvit, has been in operation since 2008. As indicated by Sleipner and Snøhvit offshore storage can be implemented close to large carbon dioxide emission point sources, helping to avoid logistical difficulties, ground water protection regulation, and local public opposition resulting from uncertainty and unfamiliarity with subsurface development for geological storage.

Implementation of Carbon Capture and Storage (CCGS, 2017) technology at the regional scale needed to achieve a significant and meaningful reduction in carbon dioxide emissions requires knowledge of the available carbon dioxide storage capacity. Carbon dioxide storage capacity assessments may be conducted at various scales—in decreasing order of size and increasing order of resolution: country, basin, regional, local, and site.specific. Estimation of the carbon dioxide storage capacity in depleted oil and gas reservoirs is straightforward and is based on recoverable reserves, reservoir properties and in situ carbon dioxide characteristics (Bachu, 2003).

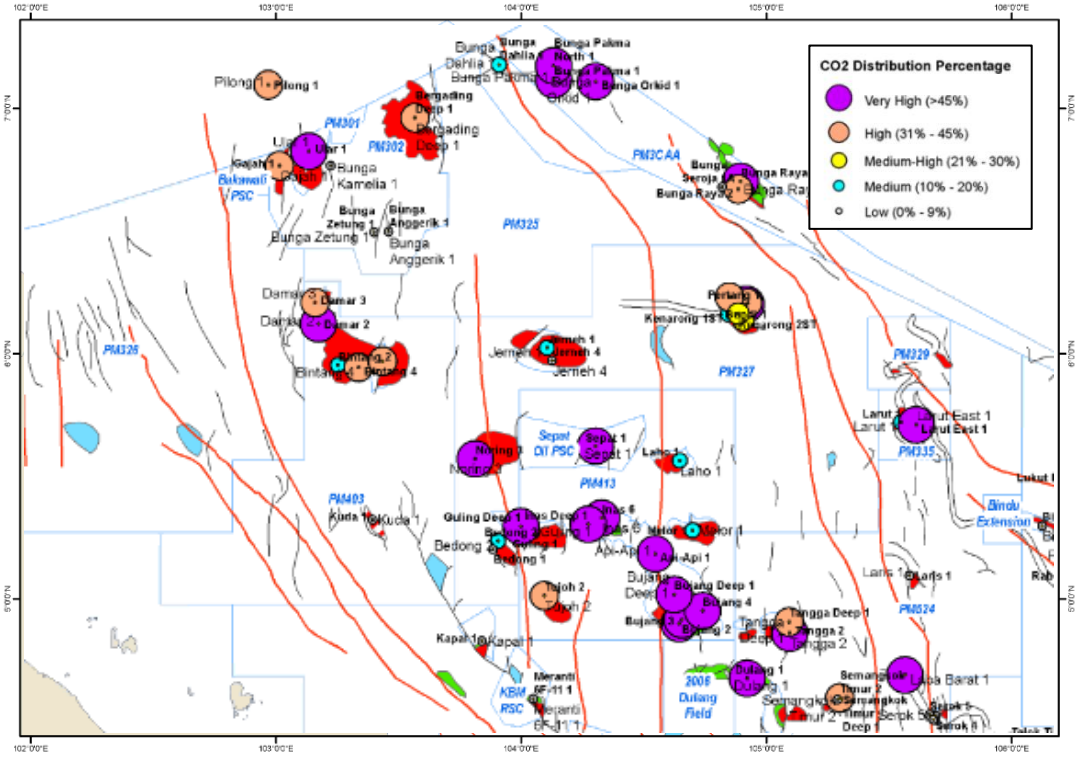

Figure 1.1 shows the location of high carbon dioxide fields recorded with the highest value of carbon dioxide in Northern Malay Basin. (Modified after Madon, et al., 2004).

1.2 Problem Statement

The main question asked for carbon dioxide sequestration and injection, both processes require high.technology carbon dioxide.friendly surface facilities and downhole infrastructure. Thus, this urges the needs to understand the long.term effect of carbon dioxide in a reservoir and its reaction with caprock. In terms of the CO_2 storage, not much of CCS study has been done in the Malay Basin and most of the

well drilled in the region had not tested the caprock but focusing more on the hydrocarbon bearing sand. Site selection shall not include area that prone to seal leakage within the caprock layers and anticipation of potential injection zone.

Implementation of carbon dioxide capture and geological sequestration (CCS) technology at the scale is needed to achieve a significant and meaningful reduction in carbon dioxide emissions requires knowledge of the availability of carbon dioxide storage capacity. There are a lot of assessments based on different scale in terms of calculating the storage capacity (Bachu, 2003). The multi.levels of assessment with extensive datasets for data integration required to give a good result – country, regional, local and site scale of assessment (Bachu, 2007). Given the significant variability that exists in many estimates and in their underlying criteria, it is necessary to document the limitations of many of the assumptions used, and to make suggestions and give examples of how better and more reliable estimates can be determined. At the same time, a series of definitions need to be established to provide consistency between capacity estimates and comparing various capacity calculations.

1.3 Objective

The objectives of this research are lined up as below:

1. To determine geologically suitable carbon dioxide storage site candidates to accommodate carbon dioxide from the north Malay Basin fields.

2. To assess the potential injection zone and estimate storage capacity of carbon dioxide in a geologic complex.

3. To evaluate the assessments of capacity and injectivity of the Bujang West saline aquifer.

1.4 Scope of Research

The scopes of this research are as below:

1. This research concentrated on the assessment of sedimentary gas.depleted reservoir Northern Malay basins which only includes 3 sites selection, namely, Jerneh, Lawit, and Bintang.

2. This research concentrated on the assessment of sedimentary saline aquifer reservoir which only includes 8 sites selection, namely, outher Duri/Aring are, in between Lawit.Jerneh, Northern Jerneh, Southern Jerneh, in between Sepat.Inas, in between Laho.Melor, Western Bujang and Eastern Bujang.

3. The location of storage site must have accessible reservoir and containment. Storage capacity must have enough volume to hold all the planned carbon dioxide in subsurface for the saline aquifer reservoir selection.

4. Use of International Standard for carbon dioxide Storage (ISO 27914) guidelines we carried out the site selection and assessment for geological storage of carbon dioxide

5. Data collection, interpretation, and assessment to be done based to its geological characteristics and available data. The data available for each reservoir were highly variable in coverage, type, quality, and source. Some good maps have been identified for geological study. (Mapping tool ArcGIS 10.6)

6. Detailed basin assessment for the most potential basins to be conducted to locate potential injection zone (D or E Group) and caprock (A or B Group).

7. The screening process in this study aimed to grasp geological characteristics / trend and then eliminate unsuitable subregion(s). In this study, only technical criteria were applied for the screening process, but no legal and regulatory

criteria were taken into consideration. The screening process was proceeded based mainly on published documents.

8. However, this research was not including and discussing carbon dioxide trapping mechanism in sedimentary basin, the oil management (carbon dioxide transportation), and the flow formation of carbon dioxide in the reservoir.

1.5 Significant of Research

The main contribution of this research is to evaluate the potential sites for long.term carbon dioxide containment in Malay Basin as an initiative to develop the high carbon dioxide fields in Northern Malay Basin and to the best of our knowledge, there have been no comprehensive studies of the carbon dioxide geologic storage in the region.

The methodology used in this research is by screening and ranking to locate potential selection of site storage and injection zone and to evaluated detailed assessment for storage capacity estimation which was used in several study such as Dayang (2017). The findings of this research are valuable for oil and gas industries as it suggests an alternative to carbon dioxide management. Potential storage sites for carbon dioxide storage in Malaysia mapped by using ArcGIS is very useful to locate the site storage and injection zone.

The study outcome will be useful as a foundation for future researchers to study on carbon dioxide geological storage in Malay Basin. In addition, this study supports primary perceptions into site suitability evaluation and screening for early deployment of geological carbon storage technology in the region. This research is done to reflect carbon dioxide geological storage as an option to reduce carbon dioxide emission by making use of the depleted.gas reservoir as storage.

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