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PRELIMINARY STUDY ON CARBON DIOXIDE GEOLOGICAL STORAGE IN DEPLETED OIL RESERVOIR IN FANG OIL FIELD, THAILAND

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ABSTRACT

Recently, climate change is the major global issue on environmental concern resulting from the emission of Carbon dioxide (CO_2) into atmosphere. The CO_2 sources mainly come from fossil-fired power generation and industrial sectors. The current technology used to mitigate and store CO_2 is carbon capture and storage (CCS) especially geological storage. In Thailand, CCS technology is still infant and less research has been studied. Therefore, this work is focused on the preliminary study on the CO_2 onshore geological storage in one formation of a depleted oilfield in Fang, the North of Thailand by using simulation. The model with local grid refinement demonstrates how CO_2 injected into depleted oilfield can be implemented with the flow rate from 1000-4000 tons/day based on the depth of this area around 2450-2550 meters. The pressure distribution and the movement of CO_2 have been studied and predicted within a period from 1-50 years for CO_2 monitoring. The results present that 16 Mt of CO_2 storage can be achieved. Furthermore, pressure distribution and CO_2 migration are presented without breaking the caprock formation for the period of 50 years. This study can be used as a basic model for CO_2 storage in an onshore area in Thailand.

Keywords: Carbon dioxide; Carbon capture and storage; Geological storage; Plume migration; Pressure distribution

INTRODUCTION

Currently, the problem of global warming and climate change are the major global issue on environmental concern occurring from the emission of Carbon dioxide (CO_2) into atmosphere. Mainly due to the human activities such as transportation, combustion of fossil fuels leading to an increase in the amount of emitted CO_2 [1]. The main CO2 sources come from fossil-fired power plants. In Thailand, Mae Moh power plant has used coal and emitted CO_2 for 13 million tons (Mt) into the atmosphere in 2013 [2]. Carbon capture and storage (CCS) is the technology that can be used to reduce CO2 emission and store it underground. CCS technology has 3 steps consisting of capture,

transportation and storage like geological storage which is the injection of CO_2 into geological formation. Now there are some successful ongoing projects for CO_2 injection into formation such as Sleiper project [3], Snohvit project in Norway [4], In Salah project in Algeria [5] and Wayburn project in Canada. However, in Thailand, CCS technology is still infant and less research has been studied and there are some possibility for CO_2 storage in certain area in Thailand. Therefore, the objective of this research is to provide preliminary study of geological storage in the depleted oil and gas reservoir by using simulation model to predict the CO_2 injection and pressure buildup as well as the movement of CO_2 in the formation for certain period of time. This study can be used as a fundamental model for CO_2 storage in an onshore area in Thailand.

EXPERIMENTAL

Simulation

Information of Fang oilfield is derived from Defense Energy Department (DED), Northern Petroleum Development Center. The detail of formation is shown in Table 1. CMG software from Computer Modeling Group Ltd. is used to create the simulation model. The 3D model is applied to predict the CO_2 injectivity in the geological formation and monitor CO_2 movement over the period of time for 50 years. Furthermore, the local grid refinement (LGR) is applied to obtain the results with more accuracy. Also, many assumptions have been made to simplify and modify the unavailable data of the reservoir such as storage capacity and types of formation [6]. In addition, the maximum pressure is used as criteria for the constraints of this simulation. The parameters for this study are CO2 injection rate at 1000, 2000 and 4000 tons/day and the simulation period ranging from 1 to 50 years. The amount of CO_2 capacity and pressure buildup as well as the CO_2 movement will be investigated from this study.

Maximum Pressure

The data from literature shows that formation temperature is 77°C [8], the bottom hole pressure is calculated from Eq. 1. The pressure gradient is 9.5233 kPa/m (0.421 psi/ft) from DED [7]. The maximum pressure assume at 90 % [9].

Table 1: The detail of formation data of Fang oilfield

Parameter/Layer	Bottom
Top depth [m]	2,450
Working pressure [MPa] (90% total maximum pressure)	32.29
Density of CO_2 [kg/m^3]	450
Reservoir Pressure [MPa]	2.76
Reservoir temperature [°C]	76.8
Porosity [%]	23.6
Permeability [md]	110-190
Thickness [m]	70
Type of rock	Sandstone
Injection pressure [tons/day]	1000-4000

RESULTS AND DISCUSSION

CO_2 emission from Mae Moh power plant will be used to calculate the injection rate and storage capacity. The CO_2 injection in a sand layer is assumed with constant rate over the whole injection period until the formation meets the criteria of storage capacity or maximum pressure to prevent the fracture of the caprock or CO_2 leakage to the surface. After the injection, the 3D model is simulated further to evaluate the pressure buildup and to monitor CO_2 movement for a period up to 50 years. For each period, amount of CO_2 stored, CO_2 movement as well as pressure buildup will be investigated as described below.

Pressure buildup

Figure 1 and Table 2 present the changes in the pressure buildup with time from different injection rates. The results show that all injection rates provide pressure below the maximum pressure for the whole period from 1-50 years. At 1000 tons/day, pressure increases until the shutin period after 35 years and slightly decreases. Also, for other injection rates, pressures build up and slightly decrease at later period. Moreover, with 4000 tons/day injection rate, the pressure increases until the shutin time accounting for 9 years of injection and decreased because of the plume migration.

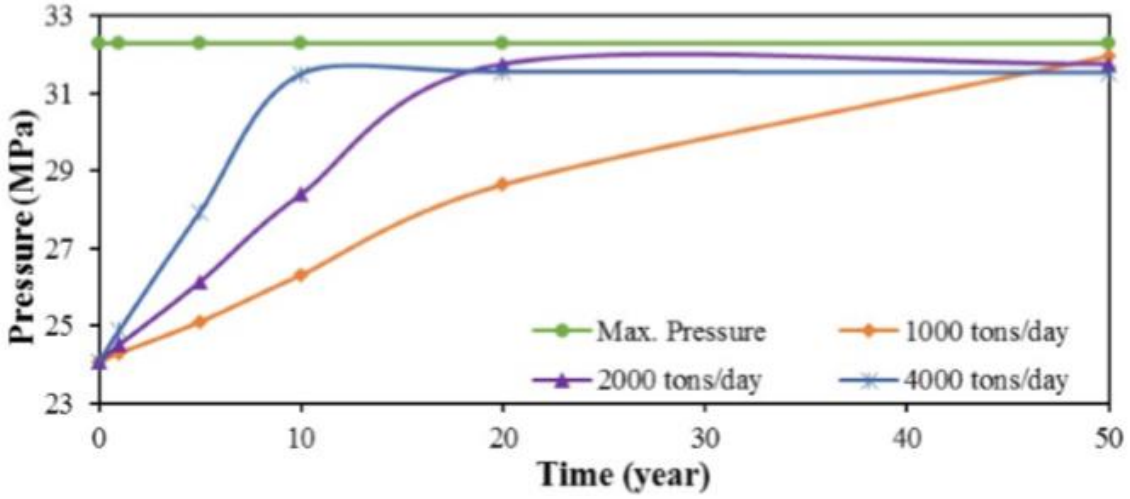


Figure 1: Pressure buildup from CO_2 injection in sandstone formation

Table 2: Pressure buildup at different injection rate

Depth (m)	Initial Pressure (MPa)	Maximum Pressure (MPa)	Injection Time/Pressure buildup		
			1000 tons/day	2000 tons/day	4000 tons/day
2,450	24.07	32.29	35 years 31.94 MPa 50 years 31.97 MPa	17 years 31.66 MPa 50 years 31.76 MPa	9 years 31.19 MPa 50 years 31.54 MPa

CO_2 Movement. This formation is assumed to be open-system formation [6]. It means that CO_2 can migrate horizontally along the sand layer after stop injecting. Figure 2 presents the area of plume migration with 1000, 200 and 4000 tons/day injection rate for 50 year period. Figure 3 presents in both side view and top view of the CO_2 movement with time for injection rate at 1000 tons/day. From the results, it is clear that CO_2 movement develops from the bottom and moves from the bottom to the top of the layer because of the lower density and it expands horizontally. For this case, there is no CO_2 leakage from this formation because the pressure is lower than the maximum pressure and the formation is strong and thick enough.

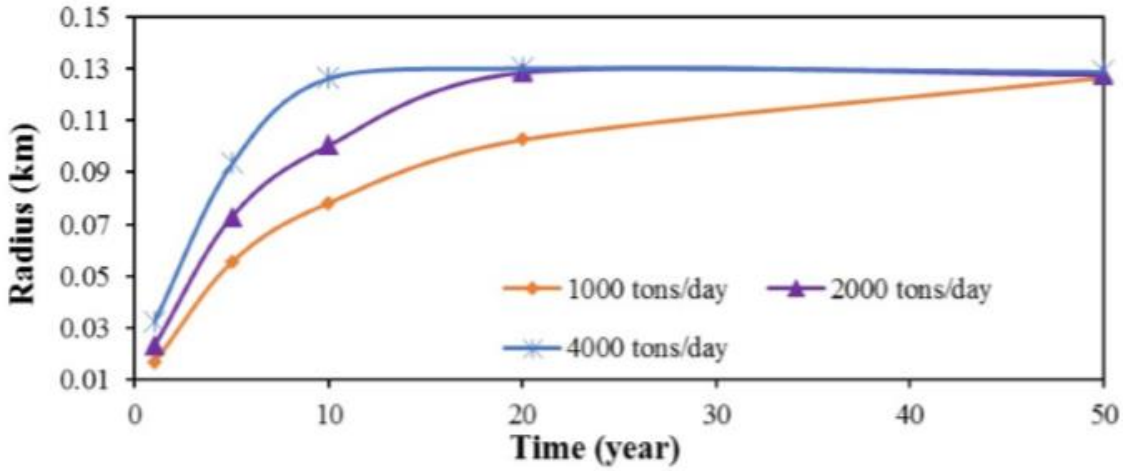
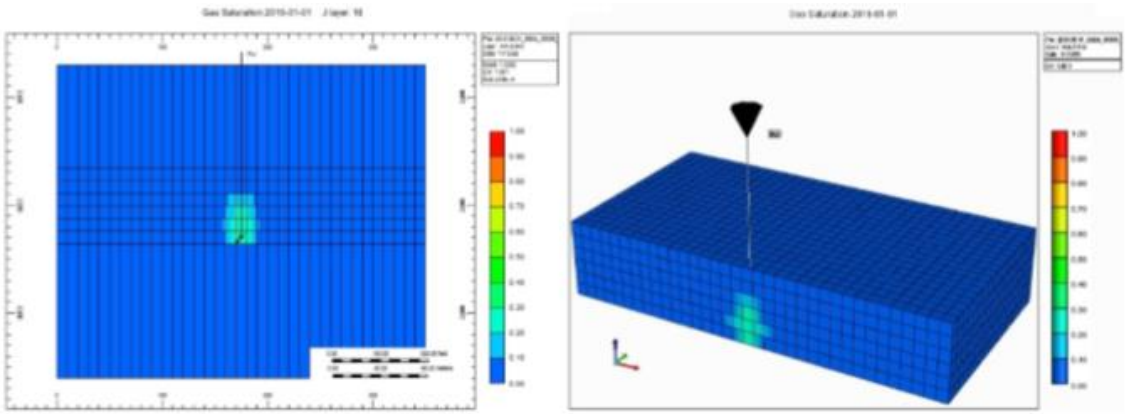
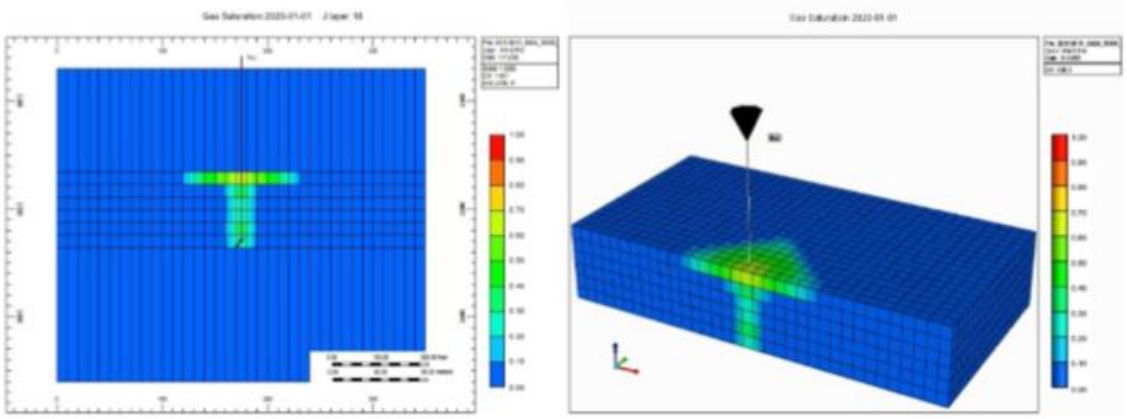


Figure 2: Raduis of CO_2 movement for 50 years at different injection rate



a. Side view, 1 year injection

b. 3D view, 1 year injection



c. Side view, 5 year injection

d. 3D view, 5 year injection

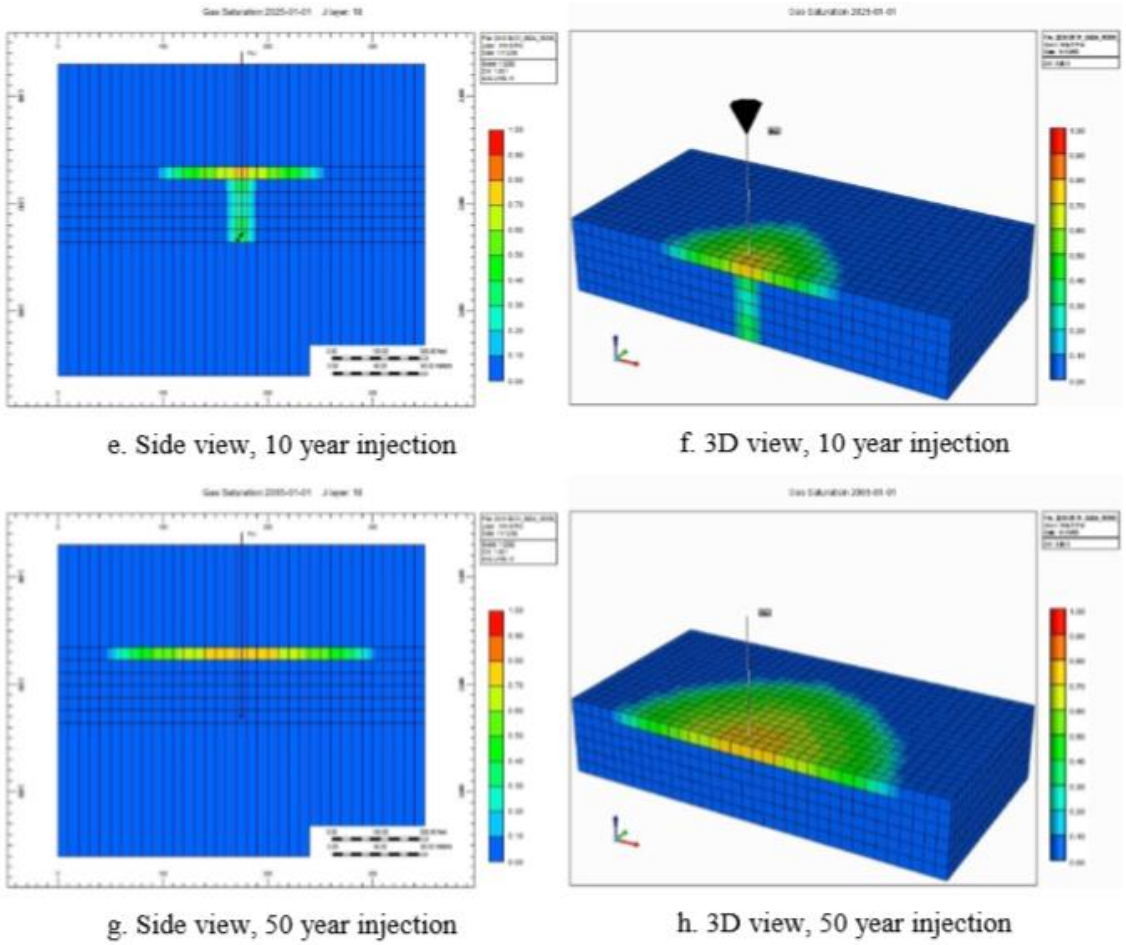


Figure 3: (a)-(h) CO_2 movement with time at 1000 ton/day injection rate

CONCLUSION

Mae Moh power plant has about 13 million tons of CO_2 emission per year. Some of this CO_2 can be injected into depleted oil field with injection rate from 1000-4000 tons/day. Storage capacity and maximum pressure are calculated and used as criteria for simulation. Pressure buildup and plume migration are investigated and the results show that pressure increases when CO_2 starts injection until shutin and slightly decreases. CO_2 moves up to the upper layer and the size of plume of CO_2 will be extending horizontally. Mostly, the trend of pressure buildup is going in the same direction during the first injection for 2000 and 4000 tons/day injection rate. The pressure buildup increases until it is near the maximum pressure and then shutin. However, for 1000 tons/day injection rate, pressure buildup will increase until 50 years of simulation. The change of radius of migration is same as the pressure buildup. However, the volume in the each layer depends on the injection rate and pressure buildup of each layers. In term of CO_2 capacity and pressure buildup, the suitable inject rate is 1000 tons/day.

However, in term of number of working days, 4000 tons/day injection rate is much better because it takes time less to finish the operation.

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