Data-Driven Reservoir Screening and Ranking for CCUS in the Gulf of Mexico Depleted Fields

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Summary

The geological storage of carbon dioxide (CO2) and its benefits in abating unfavourable climate change have existed for decades. Even though the development of technical solutions has been slow, there has been some progress in key areas including several storage projects around the world, nations setting mandates with the hope of reaching net-zero in specific timelines, and establishment of policies and regulations to support the drive.

The capture and subsequent storage of CO2 from emitters such as power stations and industrial processes, among others, play a major role in curtailing this threat to the ecosystem. A recent study indicates that the utilisation of Carbon Capture and Storage (CCS) technology could reduce CO2 emissions by 20% by 2050 (Aminu, 2017; Tomić et al., 2018).

The aim of this study is to determine the order of suitability of potential CO2 storage formations in the Gulf of Mexico Outer Continental Shelf (OCS), including both shallow and deep waters. The objectives of the study include screening of the formations with respect to geological suitability and ranking of the screened formations based on technical and techno-commercial considerations.

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Introduction

The geological storage of carbon dioxide (CO_2) and its benefits in abating unfavourable climate change have existed for decades. Even though the development of technical solutions has been slow, there has been some progress in key areas including several storage projects around the world, nations setting mandates with the hope of reaching net-zero in specific timelines, and establishment of policies and regulations to support the drive.

The plan to constrain global temperature increase to 1.5^0C is laid out in the 2015 Paris Agreement (IPCC, 2018; Alcalde et al., 2021). The United States announced plans to halve US greenhouse-gas (GHG) emissions by 2030 and reach net-zero emissions by 2050, while the UK also has a similar target of net-zero by 2050. These plans and strategies have been validated in recent years by reports of firestorms, floods, and rainstorms inundating several locations around the world. Similarly, the IPCC report demonstrates the urgent need to curtail global temperature to 1.5°C above the pre-industrial levels, or else we risk losing control of the climate and disastrous incidents are likely to occur more frequently and with greater intensity, affecting crops or causing sea levels to rise, leading to displacement of at-risk populations (IPCC, 2018). The capture and subsequent storage of CO_2 from emitters such as power stations and industrial processes, among others, play a major role in curtailing this threat to the ecosystem. A recent study indicates that the utilisation of Carbon Capture and Storage (CCS) technology could reduce CO_2 emissions by 20% by 2050 (Aminu, 2017; Tomić et al., 2018).

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Method and/or Theory

The workflow starts with the preliminary screening of the 13,394 oil and gas sands present in the Gulf of Mexico OCS (BOEM, 2019). This section of the workflow, as shown in *Figure 1*, is necessary to streamline the number of sands to be considered, thus filtering out reservoirs with less desirable geological attributes and ensuring that the considered sands or reservoirs are of good quality, i.e., allowing for sufficient storage, good injectivity, and ensuring that CO_2 remains in the supercritical phase.

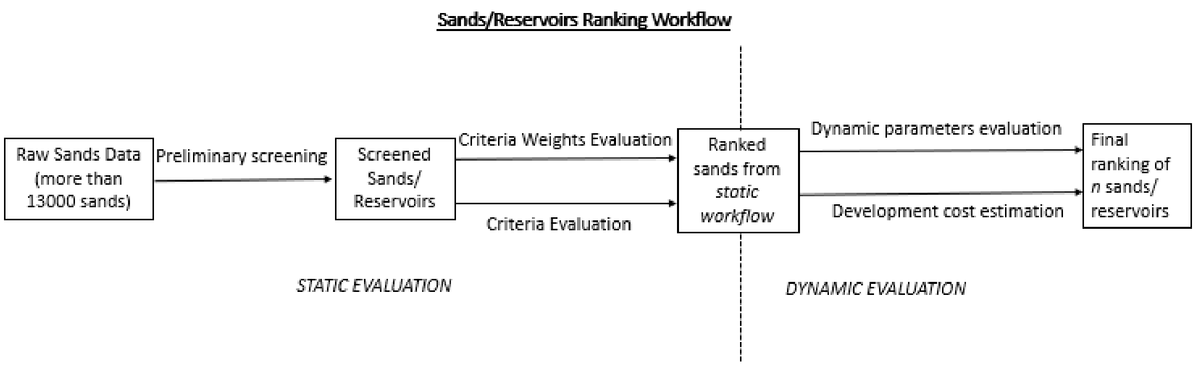

Figure 1 *Schematic of the workflow utilized for the data-driven reservoirs screening and ranking for* CO_2 *storage.*

In the static evaluation section of the workflow (*Figure 1*), multiple criteria were considered, which are: storage capacity and proxies for reservoir injectivity, gravity-to-viscous ratio (number), well risk and geologic risk. While the CO_2 storage capacity evaluation is based on the Department of Energy (DOE) and The Carbon Sequestration Leadership Forum (CSLF) estimation methods, the reservoir injectivity proxy is evaluated based on the permeability, net thickness, and the obtainable CO_2 viscosity at the formation depth. The gravity-to-viscous ratio proxy describes the buoyancy effect of CO_2. The evaluation of the proxies for well risk and geologic risk reflects the potential for CO_2 leakage from abandoned wells and existing or potentially induced fractures or faults.

It is worth noting that this is a multi-criteria problem where the considered criteria are of varying importance, e.g., well risk can be considered more critical than gravity-to-viscous ratio due to the potential risk of CO_2 leakage associated with abandoned wells. Therefore, it is important to assign priority weighting to the different criteria considered in the study. The decision-making tool utilised for this purpose is the Analytical Hierarchy Process (AHP) method, developed by Saaty (2008). This method evaluates the criteria weighting factors through the assignment of ratings to the relative importance of one criterion with respect to another. *Figure 2* shows the result of the criteria weighting, which involved contribution from academics and industry subject-matter experts.

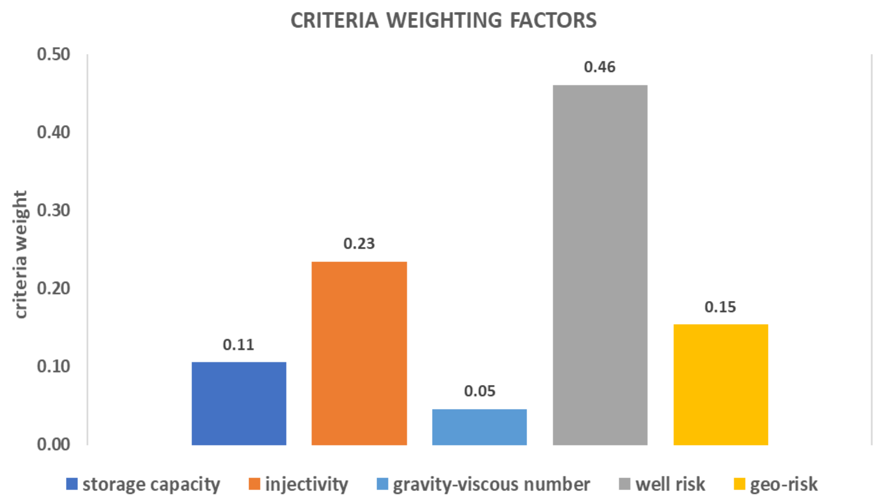

Figure 2 *Evaluated weighting factors for the considered ranking criteria, as obtained using the AHP (Analytical Hierarchy Process) method.*

The static evaluation section of the workflow (*Figure 1*) involves the determination of performance scores and therefore, ranking of the depleted hydrocarbon sands in the study. This multi-criteria analysis employs the "Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS)" method, which is utilised in this study for its good computational efficiency. Additionally, it accounts for both the best and worst alternatives in the evaluation of the relative performance of each considered depleted hydrocarbon sand (Hung and Chen, 2009).

The dynamic evaluation section of the workflow (*Figure 1*) includes the estimation of maximum injection rate, dynamic storage capacity, formation pressure build-up, and predicted number of injection wells. The prediction of the pressure build-up in the formations is based on an approach proposed by De Simone and Krevor (2021), which takes into account the non-linear relationship between pressure build-up and injection rate in multi-phase flow.

Results

Figure 3 shows an illustration of the map of depleted hydrocarbon sands in the Gulf that passed the preliminary screening stage. The size of the points represents the evaluated performance score (obtained using the *TOPSIS* method) from the static evaluation section of the workflow.

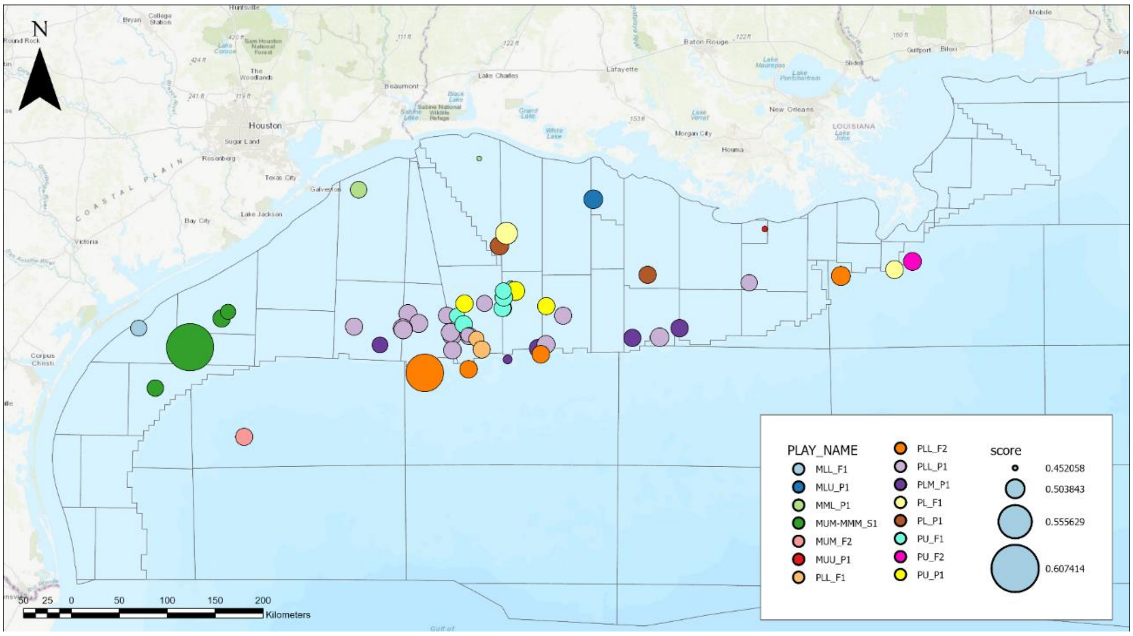

Figure 3 *Map showing the screened sands distribution and the associated performance score.*

Figure 4 represents an illustration of the pressure response and dynamic storage capacity for a reference injection rate for different scenarios of number of injection wells. Except in a few notable cases, the optimum number of injection wells required for a potential CO_2 storage formation is the minimum number of wells for which the dynamic storage capacity is maximized. This information further proves valuable in the techno-commercial consideration, which, in this study, entails the costs associated with the transport and storage of CO_2, and represents the other critical factor considered in the final ranking at the end of the workflow.

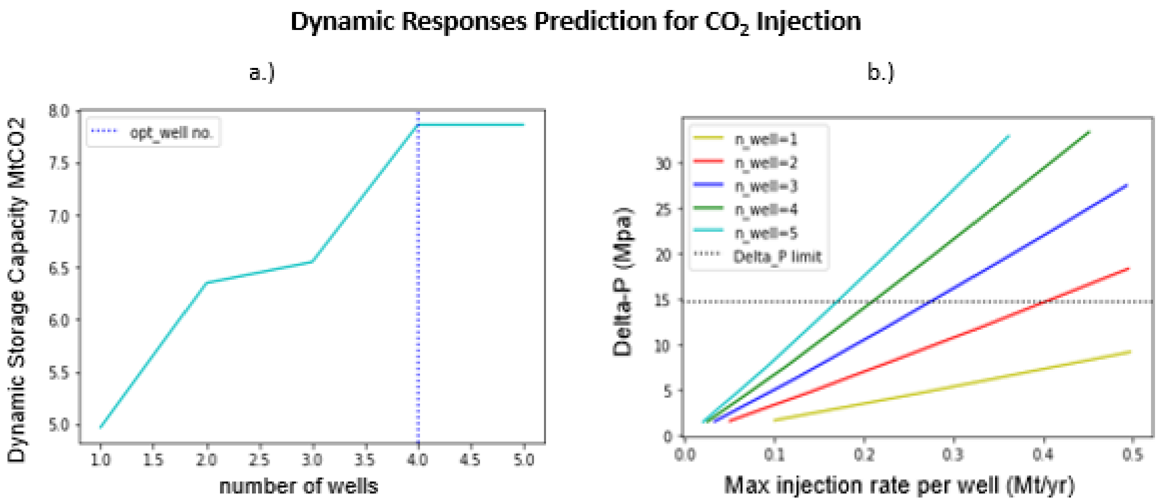

Figure 4 *Plots of a.) predicted response of dynamic storage capacity with respect to number of injection wells; b.) predicted pressure build-up with respect to injection rate for different scenarios of well numbers.*

Conclusions

The screening criteria employed in this study are based on recommendations and guidelines for best practices for CO_2 storage, as drawn from experiences from different CO_2 storage projects around the world. This implies that the predicted results can be further improved by applying recommendations from related operations in the Gulf of Mexico.

It is important to note that an element of economic consideration is involved in the selection of the optimum number of injection wells, especially considering that pressure build-up abates with an increase in the number of injection wells, thus suggesting a potential for improved dynamic storage capacity.

In conclusion, this workflow provides a very effective tool for quick decision making to determine the order of suitability of numerous potential CO_2 storage sites in the Gulf of Mexico, while also providing the possibility of applying a similar methodology to other basins for the selection of potential geological storage sites.

Acknowledgements

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