A Workflow to Determine CO_2 Storage Potential in Deep Saline Formations

Robert C.L. Klenner, Wesley D. Peck, Scott C. Ayash, Charles D. Gorecki, Jason R. Braunberger, Guoxiang Liu, and Neil W. Dotzenrod

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, North Dakota 58202-9018

Abstract

Carbon capture and storage (CCS) has gained interest over the past decade as a potential technology for mitigating anthropogenic carbon dioxide (CO_2) emissions to the atmosphere. In order to achieve significant reductions, billions of tonnes of CO_2 need to be stored each year, thus creating the need for vast storage capacity. Deep saline formations are expected to have the largest storage potential because of their size and geographic distributions. The United States and Canada alone have an estimated CO_2 storage resource potential for 2102 of 20,043 billion tonnes in deep saline formations (U.S. Department of Energy National Energy Technology Laboratory [DOE NETL] 2012). Because of the great need for CO_2 storage and the wide range of storage resource potential, it is important to accurately estimate the effective volumetric CO_2 storage resource potential of a target formation.

The effective CO_2 storage resource potential of a targeted saline formation is typically estimated using a volumetric equation where the pore volume of the target formation is multiplied by a storage efficiency term and the density of the CO_2 at reservoir conditions. The two most commonly used methodologies are those developed by DOE NETL (2010) and the Carbon Sequestration Leadership Forum (CSLF) (2005). These two methodologies have been compared and found to be equivalent provided the same assumptions are made and the efficiency terms properly applied (IEA Greenhouse Gas R&D Programme, 2009). Although volumetric methods are straightforward, misapplication of the equations and efficiency factors commonly occur and may ultimately lead to under- or overestimation of the effective storage resource potential of the formation under investigation. Errors typically occur through either miscalculation of the pore volume or using the incorrect storage efficiency term. To avoid these errors, this paper presents a workflow to properly assess the effective CO_2 storage resource potential of a deep saline formation under investigation (Figure 1). The purpose of the workflow is to limit confusion and guide the user in a step-by-step process to help accurately calculate the storage potential of the formation. For the purposes of this paper, the DOE NETL method was utilized (U.S. Department of Energy National Energy Technology Laboratory, 2010); however, a similar approach could be used for the CSLF and other volumetric approaches.

Each formation evaluation is unique. The lithology, depth, boundary conditions, and salinity can all have a large impact on a formation's suitability for CO_2 storage. Additionally, these parameters are important in determining the portion of the formation that is amenable to CO_2 injection and storage, (i.e., the net-to-gross formation pore volume or E_{Geol} [IEA Greenhouse Gas R&D Programme, 2009]) and choosing the appropriate storage efficiency term. The workflow presented in this paper is set up to guide the user, step by step, in properly assessing the saline formation based on these formation characteristics.

To help illustrate the workflow, the Minnelusa Formation of the Powder River Basin is used as an example of how an effective CO_2 storage resource estimate could be applied to a saline formation with different levels of information. Three scenarios were created: 1) a basic reservoir assessment with only average porosity, formation extent, and average thickness known; 2) a more thorough assessment with all net-to-gross terms known; and 3) a combination of Scenarios 1 and 2, with some of the net-to-gross properties known, but some information still lacking.

This workflow and example scenarios will help guide both the CCS expert and inexperienced researcher to more consistently determine the storage resource potential in a given deep saline formation using a volumetric methodology. The workflow, terms, and concepts presented in this paper will provide the user confidence in performing CO_2 storage resource assessments and help reduce under- or overestimation of the effective CO_2 storage resource potential of a given deep saline formation.

References

Carbon Sequestration Leadership Forum, 2005, A task force for review and development of standards with regards to storage capacity measurement—Phase I: CSLF-T-2005-9 15, 8 August 2005, 16 p., www.cslforum.org/publications/documents/PhaseIReportStorageCapacity MeasurementTaskForce.pdf (accessed February 2013).

IEA Greenhouse Gas R&D Programme, 2009, Development of storage coefficients for CO_2 storage in deep saline formations: 2009/12, October 2009.

U.S. Department of Energy National Energy Technology Laboratory, 2010, Carbon sequestration atlas of the United States and Canada (3rd ed.).

U.S. Department of Energy National Energy Technology Laboratory, 2012, Carbon sequestration atlas of the United States and Canada (4th ed.).

Acknowledgments

This material is based on work supported by the DOE NETL under Award Nos. DE-FC26-05NT42592, DE-FE0009114, and Cooperative Agreement No. DE-FC26-08NT43291. This work was also prepared with the support of the IEA Greenhouse Gas R&D Programme under reference IEA/CON/13/208.

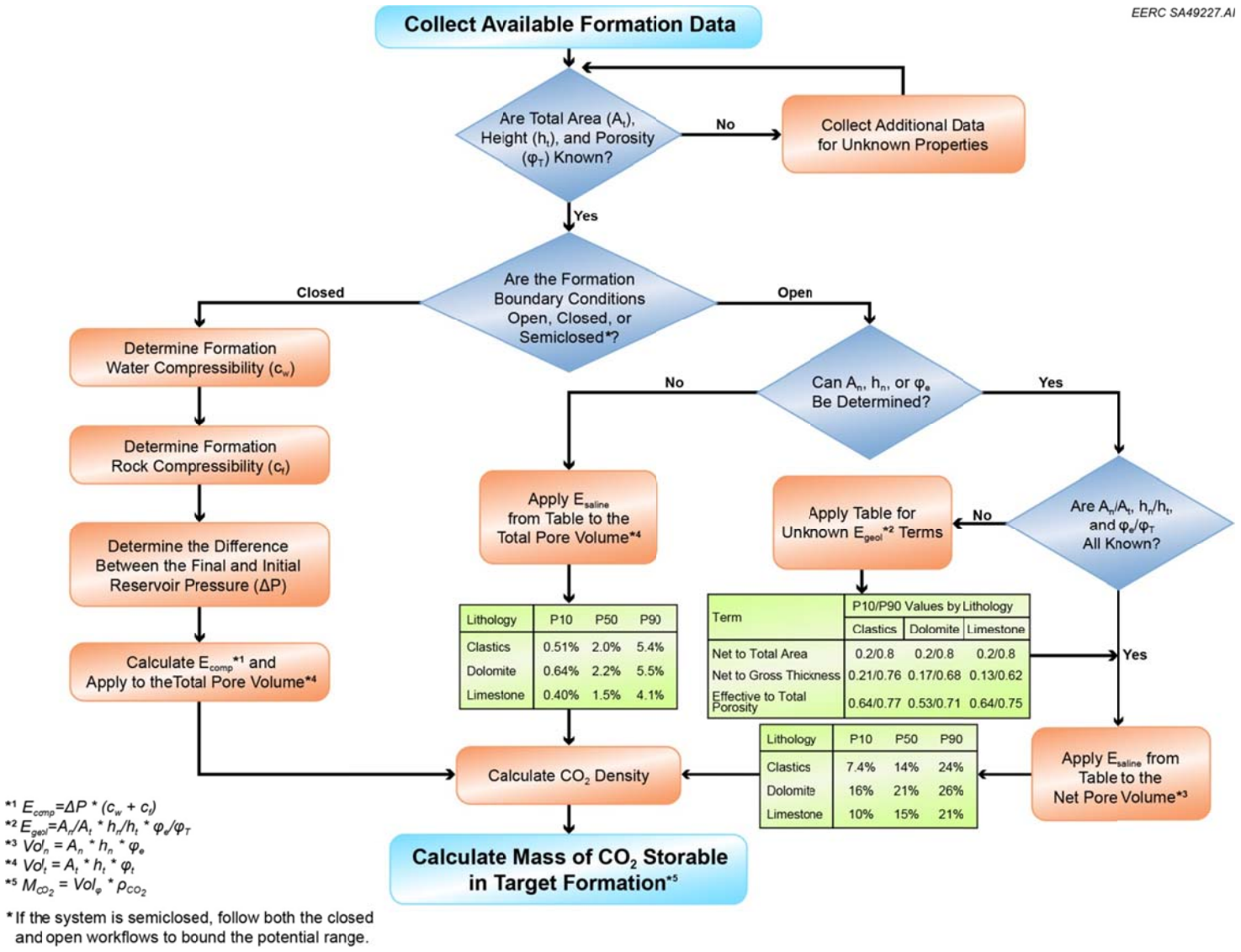

Figure 1. A step-by-step workflow to estimate CO_2 storage resource in deep saline formations.