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Geological storage of CO_2 in saline aquifers—A review of the experience from existing storage operations

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ABSTRACT

The experience from CO_2 injection at pilot projects (Frio, Ketzin, Nagaoka, US Regional Partnerships) and existing commercial operations (Sleipner, Snøhvit, In Salah, acid-gas injection) demonstrates that CO_2 geological storage in saline aquifers is technologically feasible. Monitoring and verification technologies have been tested and demonstrated to detect and track the CO_2 plume in different subsurface geological environments. By the end of 2008, approximately 20 Mt of CO_2 had been successfully injected into saline aquifers by existing operations. Currently, the highest injection rate and total storage volume for a single storage operation are approximately 1 Mt CO_2/year and 25 Mt, respectively. If carbon capture and storage (CCS) is to be an effective option for decreasing greenhouse gas emissions, commercial-scale storage operations will require orders of magnitude larger storage capacity than accessed by the existing sites. As a result, new demonstration projects will need to develop and test injection strategies that consider multiple injection wells and the optimisation of the usage of storage space. To accelerate large-scale CCS deployment, demonstration projects should be selected that can be readily employed for commercial use; i.e. projects that fully integrate the capture, transport and storage processes at an industrial emissions source.

1. Introduction

Injecting carbon dioxide (CO_2) into deep saline aquifers is one of three main options for the geological storage of CO_2 in order to decrease anthropogenic greenhouse gas emissions into the atmosphere. Previous studies have shown that compared to the other two major options (storage in depleted hydrocarbon reservoirs and in deep, un-mineable coal seams), deep saline aquifers have the highest potential capacity globally for CO_2 storage (i.e., Bachu, 2003; IPCC, 2005; USDOE, 2007a; Bradshaw et al., 2007). The Special Report on CO_2 Capture and Storage by the IPCC (2005) identified various knowledge gaps related to aquifer storage of CO_2, many of which needed addressing before the widespread commercial implementation of carbon capture and storage (CCS) technology is possible. More than 10 saline aquifer injection operations have been conducted over the past 10 years by governments and industries specifically to reduce knowledge gaps and many more projects are in development stages (Fig. 1). A variety of factors have limited the number of projects that have been conducted so far, including availability and cost of CO_2, especially anthropogenic CO_2, difficulties gaining site access, poor injectivity, and cost of monitoring. Consequently, the IEA Greenhouse Gas R&D Programme instigated a study to review the recent advancements in the science related to aquifer storage of CO_2, to compile the knowledge gained from existing CO_2 injection operations and to address the need for future research. The scientific advancements related to CO_2 storage in saline aquifers, including aspects of geochemistry, numerical modelling and storage capacity estimation, are summarised in Michael et al. (2009). This paper critically reviews the experience gained from pilot and commercial projects, including:

1. A detailed examination of data from existing saline aquifer storage sites and pilot projects; provision of a database of available reservoir properties (e.g., lithology, porosity,

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