Risk Assessment for Future Geologic Sequestration Projects Based on Analysis of Information from the CO2-Enhanced Oil Recovery

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Climate change concerns are driving attempts to lower the carbon intensity of global energy production. Risk and the perception of risk are fundamental impediments to establishing a viable carbon capture and storage industry. The object of CCS is to put CO2 into long term storage in deep-brine reservoirs, oil reservoirs, and/or depleted gas fields. Risks for CCS, in the absence of actual historical data, must be inferred from analogues. CO2 based enhanced oil recovery (CO2-EOR) provides the only close analogue. This paper concerns itself with the risks associated operational phase of geologic CO2 sequestration projects by examining the risk elements associated with the analogous CO2 based enhanced oil recovery industry (CO2-EOR). The CO2-EOR industry has more than 38 years of experience in successfully transporting and injecting CO2. In the US alone the industry operates over 3,500 miles of high pressure CO2 pipelines that have transported some 600 million tons of CO2 (as well as operating over 13,000 CO2 EOR wells), has injected over 1,200 million tons of CO2 (22 trillion standard cubic feet) and produces about 245,000 barrels of oil a day from CO2 EOR projects. Over the past decade researchers in the field of brine sequestration have asserted that risks related to the transport and injection of CO2 are “reasonably well” understood and have been “successfully managed” for decades by the CO2 EOR industry in the USA. If the operational liability for CO2 sequestration in brine reservoirs is indeed similar to that already borne by the oil industry then this would CCS. Although these assertions may well be correct there are few if any published studies to support them. In fact some risk experts have suggested that there is relatively little basis for predicting the risks associated with a future brine CO_2 sequestration industry.

This paper is concerned with identification of the risks associated with transporting CO2 by pipeline for geological sequestration. The technology and practices used by the CO2-EOR industry in handling CO2 is a valuable resource for future CO2 sequestration projects. The nature of incidents associated with CO2 transmission and distribution pipelines in the US will be presented, including new unpublished data. This study also makes some significant corrections to previously published pipeline accident data. The lack of significant accident events in the data set suggest that transmission of over 600 million tons of CO2 over 38 years is too small a sample to make a robust estimate of risk for pipeline transportation of CO2 for a future large scale CCS industry. The risks resulting from events that have significant consequences but small probabilities of occurrence are difficult to estimate in the absence of large datasets.

The risks of CO2 storage in a geological reservoir should be seen in the context of an engineered reservoir. The subsurface engineering technology that will form the basis of a new sequestration industry is in large based on equipment and approaches developed over the last 37 years for CO2-EOR. Apart from possible ruptures of CO2 pipelines the next most plausible risk to public safety comes from the “blow out” or loss of control of a CO_2 injection well. Blowouts do occur rarely in association with CO_2-EOR injection activity and understanding the nature and consequences of these events can help us predict the risk of such events occurring in association with future CO_2 sequestration. There are currently 4,700 injector wells operating in the Permian Basin amounting to 40% of the CO_2 EOR wells currently operating, the other 60% of wells being production wells. The total CO_2 injected into the Permian Basin amounts to approximately 1,200 million tons of CO_2. Almost certainly the number of injection wells that will be used for CO_2 sequestration in brine reservoirs to inject an equivalent amount of CO_2 will be far fewer. We have examined the record of blowouts associated with the CO_2 EOR industry. Only a few of the blowouts are related to mechanical problems or corrosion issues that would be relevant to brine sequestration projects. The majority of documented CO_2 well blowouts are related to operator error of a type not relevant to future CO_2 sequestration projects for CCS.

One aspect of risk facing a future CO_2 sequestration project is the risk that injection wells will inject less than estimated in planning commercial projects due to: (1) poor initial injectivity; (2) decline of injectivity over time; (3) interruptions to injection due to well problems, electrical outages, severe weather etc.; or (4) regulatory intervention related to issues resulting from mechanical integrity testing. Once injection activities at some project site are initiated a significant risk facing the operator is that the injectivity of the wells will decrease over time and that this will threaten the project’s capacity to deal with the contracted rate of CO_2 disposal. In fact it has been suggested in the literature that injectivity decline in endemic in the CO_2-EOR industry and that this phenomena will be a major impediment to CO_2 sequestration in brine reservoirs. This assertion will be examined by examining unpublished injection rate data from CO_2-EOR fields in the U.S.. In most CO_2-EOR fields the CO_2 is not injected continuously but rather is injected in alternation with water (so called WAG or Water Alternating Gas process). Continuous injection is clearly a more appropriate analogue to use for CO_2 sequestration in brine. We will present an analysis of injection rate data for several CO_2-EOR fields where CO_2 is injected continuously. This data suggests that injection rate decrease may not be a significant concern for future CO_2 sequestration projects.