PLAINS CO_2 REDUCTION (PCOR) PARTNERSHIP (PHASE II) – ZAMA FIELD VALIDATION TEST REGIONAL TECHNOLOGY IMPLEMENTATION PLAN

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EXECUTIVE SUMMARY

A comprehensive, monitoring, verification, and accounting (MVA) plan is critical to the success of any geological carbon sequestration project utilized as a method of reducing carbon dioxide (CO_2) emissions to the atmosphere. From October 2005 through September 2009, the Zama oil field in northwestern Alberta, Canada, has been the site of acid gas (approximately 70% CO_2 and 30% hydrogen sulphide [H_2S]) injection for the simultaneous purpose of enhanced oil recovery (EOR), H_2S disposal, and sequestration of CO_2. The Plains CO_2 Reduction (PCOR) Partnership has conducted MVA activities at the site throughout this period, while Apache Canada Ltd. has undertaken the injection and hydrocarbon recovery processes. This project has been conducted as part of the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) Regional Carbon Sequestration Partnership Program and has been recognized by the Carbon Sequestration Leadership Forum as being uniquely able to fill technological gaps with regard to geological storage of CO_2.

One of the primary purposes of the PCOR Partnership Phase II Program is to develop a Regional Technology Implementation Plan (RTIP) based on the experiences and results generated at Zama. The purpose of the RTIP is to provide technical guidance on approaches for conducting baseline surveys, MVA, and assessing the overall success of injecting CO_2-rich acid gas into deep carbonate oil reservoirs for the purpose of simultaneous CO_2 storage and EOR. The RTIP presents a series of key observations, insights, and recommendations, based on the experiences at Zama, that are intended to be broadly applicable to the injection of acid gas for simultaneous CO_2 storage and EOR operations at locations throughout the United States, Canada, and even the world.

Acid gas has been obtained as a by-product of oil production in the Zama Field and subsequent fluid separation process at the on-site facilities. During the separation process, oil and gas are sent to market while acid gas is redirected back to the field for utilization in EOR operations. Previously, CO_2 was vented to the atmosphere and sulfur was separated from the H_2S and stockpiled in solid form on-site. This project has enabled the simultaneous beneficial use of each of these processing by-products and effective mitigation of two environmental concerns.

The Zama project has been designed to address the issue of monitoring CO_2 sequestration at EOR sites, in this case utilizing H_2S-rich acid gas as the sweep mechanism, in a cost-effective and reliable manner. The primary issues that were addressed include 1) determination of CO_2 and/or H_2S leakage, or lack thereof, from the pinnacle; 2) development of reliable predictions regarding the long-term fate of injected acid gas; and 3) generation of data sets that will support the development and monetization of carbon credits associated with the geologic sequestration of CO_2 at the Zama oil field.

To address these issues, a variety of research activities have been conducted at multiple scales of investigation in an effort to fully understand the ultimate fate of the injected gas. Geological, geomechanical, geochemical, and engineering work has been used to fully describe the injection zone and adjacent strata in an effort to predict the long-term storage potential of this site. Through these activities, confidence in the ability of the Zama oil field to provide long-term containment of injected gas has been achieved. While this project has been focused on one of the hundreds of pinnacles that exist in the Zama Field, many of the results obtained can be applied not only to additional pinnacles in the Alberta Basin, but to similar structures throughout the world.

Monitoring the site has been achieved primarily through fluid sampling and pressure monitoring in both the target pinnacle reef and overlying strata. A gas-phase perfluorocarbon tracer, designed to mimic the injected gas, has been used in an effort to identify any leakage into overlying stratigraphic horizons. Pressure is also being measured at the injection zone and overlying productive zones to ensure 1) overpressurization of the target is not occurring and causing undue stress on the overlying cap rock that could potentially lead to failure and 2) leakage along wellbore pathways is not occurring. Certifying the integrity of the system has been a critical focus area, with tests being completed on the cap rock and injection zone to determine the nature of potential geochemical and geomechanical changes that may occur as a result of acid gas exposure under supercritical pressures and temperatures.

Geological investigation was focused on the reservoir, local, and regional (subbasinal) scales. Results of these investigations indicate that natural leakage from this system is unlikely and regional flow is extremely slow, on the order of thousands to tens of thousands of years to migrate out of the basin. The potential for leakage through existing wellbores was also evaluated and found to be very low. Geomechanical evaluations, including 3D modeling, were completed on the injection zone and adjacent stratigraphy. This series of tests confirm that the geological structures that are being utilized are excellent candidates for sequestration. The cap rock is considered to be extremely stable, has extremely low permeability, and is not likely to fracture when subjected to injection pressures well beyond the maximum allowed. Geochemical modeling aids in the understanding of the long-term fate of acid gas injected into carbonate rocks. Evaluations of the Zama system indicate that the impact of mineralization on the overall storage capacity of the system is negligible and will occur very slowly over geological time scales.

Continuous injection has taken place at a depth of 4900 feet into the carbonate pinnacle reef structure since December 2006. As of May 30, 2009, approximately 33,500 tons of acid gas had been injected into the pinnacle reef, of which approximately 25,000 tons was CO_2. Incremental oil production from the pinnacle reef over the course of the project, as of May 30, 2009, was approximately 11,600 barrels.

Project results indicated that a robust, yet practical, MVA program can be developed. Given the proper geologic setting, MVA activities can be relatively inexpensive and not adversely affect commercial EOR operations.

To access the full report, click here:
http://www.undeerc.org/PCOR/newsandpubs/pdf/RTIP-Zama-Acid-Gas-EOR-CO2-Sequestration-and-Monitoring-Project.pdf