OVERVIEW, STATUS, AND FUTURE OF THE FORT NELSON CCS PROJECT

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The Plains CO_2 Reduction (PCOR) Partnership, led by the Energy & Environmental Research Center (EERC), and Spectra Energy Transmission (SET) are investigating the feasibility of a carbon capture and storage (CCS) project to mitigate carbon dioxide (CO_2) emissions produced by SET's Fort Nelson Gas Plant (FNGP) as a waste stream from natural gas processing. The FNGP is located near the town of Fort Nelson in northeastern British Columbia, Canada. The gas stream produced by the FNGP will include up to 5% hydrogen sulfide (H_2S) and a small amount of methane (CH_4) and, as such, is referred to as a "sour" CO_2 stream. The sour CO_2 gas stream would be injected into a deep saline carbonate formation. Currently, the SET's FNGP is running at reduced capacity. Because of recent production development of Horn River Shale Gas, it is anticipated that FNGP will return to full capacity and become the largest point source of CO_2 emissions in British Columbia, Canada. Successful implementation of one of the first large-scale CCS projects in North America will enable SET to maintain its leadership in the growing natural gas-processing and transmission business by demonstrating its ability to process sour gas in a safe and environmentally friendly manner. Thus SET has a strong incentive to find a technology that allows the continued expansion of its gas-processing operations while maintaining its already safety-focused and environmentally conscious image.

The Fort Nelson demonstration project provides a unique opportunity to develop a set of cost-effective, risk-based monitoring, verification, and accounting (MVA) protocols for large-scale (>1 million metric tons a year) storage of sour CO_2 in a deep saline formation. The likely injection target will be a carbonate formation in the Devonian Presqu'ile reef complex, with the 500-m-thick shales of the overlying Muskwa and Fort Simpson Formations serving as seals. The effectiveness of the MVA activities will be at least partially dependent on developing a thorough geologic characterization, modeling, and risk assessment effort. The results of the Fort Nelson activities will provide insight regarding 1) the behavior of dense-phase sour CO_2 in a deep brine-saturated carbonate reservoir environment; 2) the impact of dense-phase sour CO_2 on the integrity of sink and seal rocks; 3) the effects of large-scale sour CO_2 injection and storage on wellbore integrity; 4) the effectiveness of selected MVA techniques; and 5) the use of an approach that combines iterative geologic characterization, modeling, risk assessment, simulation, and MVA planning to safely and cost-effectively inject and store large volumes of sour CO_2.

The role of the PCOR Partnership is to provide the project with reservoir modeling and simulation, risk assessment of subsurface technical risks, and an MVA plan to address these risks. The PCOR Partnership applies a philosophy of integration that combines geologic

characterization, modeling, risk assessment, and MVA strategies into an iterative process to produce superior-quality results during the project feasibility and development periods. Elements of any of these activities are crucial for understanding or developing the other activities.

To date, a variety of regulatory permitting, public outreach, site characterization, modeling, risk assessment, and MVA planning activities has been conducted. Key activities include:

- The acquisition of existing well data, 2-D and 3-D seismic surveys, log analyses, and core testing results.
- Studies on various aspects of the hydrogeological, geochemical, petrological, and geomechanical characteristics of potential sink and seal formations.
- The drilling, coring, and testing of an exploratory well.
- Iterative development of static geologic models that include not only the potential CO_2 storage area but also neighboring natural gas fields.
- The dynamic modeling and simulations include base case and initial scenario explorations, modeling optimizations and validations (history matching), and predictive simulations with sour CO_2 injection before and after history matching.
- Two iterations of a comprehensive risk assessment of the geologic risks associated with the Fort Nelson CCS project.
- Collection of baseline data for shallow groundwater characteristics in the Fort Nelson CCS project study area.
- Development of key permitting application documents.
- Development of public outreach products, including posters and fact sheets developed specifically for the general public.

Results to date suggest that the geology and hydrogeology in the vicinity of the FNGP are amenable to large-scale, long-term geologic storage of CO_2. However, to properly implement an effective, economical, and optimized commercial-scale CCS project at the Fort Nelson site, an iterative update process between site characterization, modeling and simulation, risk assessment, and MVA must be conducted so as to ensure regulatory compliance and project safety. Currently, first- and second-round risk assessment evaluations have been performed and are being used to identify additional characterization activities that are beneficial to the project. The results of the risk assessments also provide a basis for updated simulation work in order to help guide the selection of a site-specific injection strategy. Upon completion of the current and planned site characterization and modeling activities, specific injection scenarios can be evaluated in terms of criteria set forth by SET.

Once a final injection strategy has been defined, the risk assessment will once again be updated to include risk criticality rankings for the specific selected injection strategy based on simulation results, which will, in turn, be used to guide a specific MVA strategy. The updated MVA plan will include specific technologies, spatial locations of measurements, acquisition frequencies, and baseline data necessary to address critical project risk and regulatory requirements and identify potential deviations from expected conditions in a timely manner. Once the updated assessment has been completed, the injection program can begin. However, the MVA plan will be periodically updated as characterization, modeling, and risk assessment activities are completed to ensure overall project success. The data collected and analyzed over

the course of the MVA activities will be used to periodically calibrate the reservoir model throughout the duration of the CCS operation. Although specific techniques and procedures may change as the project proceeds, the project's integrated philosophy of geologic characterization, modeling, and risk assessment will ensure that MVA strategies remain fit for purpose, cost-effective, and efficient and have the greatest potential for success throughout the lifetime of the project.