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A New Risk Management Methodology for Large-Scale CO_2 Storage: Application to the Fort Nelson Carbon Capture and Storage Feasibility Project

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Abstract

This paper describes the application of an original, carbon capture and storage (CCS)-specific risk management methodology to the subsurface technical risks of Spectra Energy's Fort Nelson CCS feasibility project located in British Columbia:

- Phase 1: Establishment of a risk management policy utilizing input from key project stakeholders to help define a project-specific metric system (frequencies, physical consequences, severities) for the estimation of technical risks.
- Phase 2: A first-risk assessment of the subsurface technical risks, including risk mapping and evaluation of high-criticality risks.
- Phase 3: A risk treatment plan and first recommendations for a risk-based monitoring, verification, and accounting (MVA) plan based on the results of the risk assessment.

Keywords: CO_2 storage; risk assessment

Introduction

The Energy & Environmental Research Center (EERC) at the University of North Dakota directs the Plains CO_2 Reduction (PCOR) Partnership, one of seven regional partnerships funded by the

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U.S. Department of Energy (DOE) National Energy Technology Laboratory's (NETL's) Regional Carbon Sequestration Partnership Program and a broad range of project sponsors. The PCOR Partnership is a diverse group of public and private sector stakeholders working together to better understand the technical and economic feasibility of capturing and storing carbon dioxide (CO_2) emissions from stationary sources in the central interior of North America.

In order to move the carbon capture and storage (CCS) industry forward and assure stakeholders that the geologic storage of CO_2 can be done safely and reliably, it should be demonstrated that the risks associated with a specific CCS project can be consistently identified, treated, and monitored throughout the life of that CCS project. The management of potential risks that may arise from the long-term effects of storing large amounts of CO_2 in a particular geological formation starts with proper site selection, followed by a more rigorous risk-based examination of the site, including consideration of the uncertainty of the storage capacity and injectivity in relatively unevaluated, noncommercial deep saline formations.

Although some large-scale enhanced oil recovery projects such as Weyburn use CO_2 and apart from a few existing large-scale operations such as Sleipner and In Salah, to date, very few projects designed specifically for CO_2 storage have reached the commercial scale necessary to validate CCS as a viable technology. One of the PCOR Partnership Program's Phase III demonstrations is Spectra Energy's Fort Nelson CCS feasibility project. Spectra Energy is examining the feasibility of deploying CCS technology to mitigate plant emissions by sequestering the sour CO_2 that is removed from natural gas-processing activities. With an anticipated storage volume of 1.3 to 2 Mt/yr of CO_2, the Fort Nelson CCS feasibility project is among the most promising industrial-scale CCS projects being considered in North America. It is important to demonstrate to local and federal governments that sour CO_2 can be safely injected and stored long-term. To that end, the Fort Nelson CCS feasibility project presents an opportunity for the implementation of a comprehensive risk management approach. The PCOR Partnership has taken the lead in the development of a risk management plan to control the subsurface technical risks of the project.

The main objective of risk management is to support decision making. In CCS, numerous issues need to be considered as large-scale projects move forward. Risk management strategies help to address these issues. Also, risk management policies can be used to help assure the public, regulators, and other stakeholders that the CCS project is safe and any potential risks are being mitigated.

Background

Located in northeastern British Columbia, the Fort Nelson gas plant is the largest sour gas-processing facility in North America. Spectra Energy is examining the feasibility of adding CCS to help reduce the plant's emissions by sequestering the sour CO_2 that is removed from the natural gas. The Fort Nelson CCS project is projected to store between 1.3–2 Mt/yr of sour CO_2, which will make it one of the largest CCS projects in the world.

British Columbia has large reserves of natural gas, and as shale gas resources continue to be developed, the province of British Columbia sees CCS as a key component to managing the emissions from increased processing activity. As a result, Spectra Energy is taking steps to proactively address potential risk during the feasibility stage of the proposed project by implementing a comprehensive risk management framework.

The scope of the risk management work performed included all subsurface, technical risks resulting from the geologic storage of CO_2. Potential impacts including financial, environmental, health and safety, public perception, corporate image, legal, and regulatory were considered as part of the first-round risk assessment. The risk management work was conducted in three phases over a period of 5 months.

Two reference periods were chosen for the purposes of the risk assessment: 0–50 years and 50–100 years. These correspond to the injection and postinjection periods, respectively. Although these were chosen for the purposes of the risk assessment, they are simply estimates as Spectra has not officially said it plans to inject for 50 years.

The risk management process used by the PCOR Partnership for managing the subsurface technical risks of the Fort Nelson CCS feasibility project, illustrated in Figure 1, complies with International Organization for Standardization (ISO) 31000, an international standard for risk management. The risk management methodology described in this paper seeks to integrate the ISO 31000 framework with existing Spectra Energy risk management processes, practices, and risk tolerance standards. Additionally, a risk-reporting tool (Simeo™-ERM) was implemented that allowed the risks to be mapped and documented.

The framework starts with establishing the context of the risk management work. The risk management policy defines rules and guidelines designed to guide the risk management process throughout the life of the project, e.g., communication and reporting schedule, the scope of the risk management work, and the frequency and severity scales used for the risk assessment. The risk assessment consists of identifying, analyzing, and evaluating the risks. Critical risks can then be treated. Communication and reporting happen in conjunction with all of this, and the process can be reviewed and modified as needed.

Because of confidentiality, the specific results of this work will not be enumerated here, but the methodology applied will be addressed.

Phase 1: Risk Management Policy

The risk management policy defines the organization and rules that will be used to manage the technical risks throughout the life of a CCS project, including any existing regulations. The

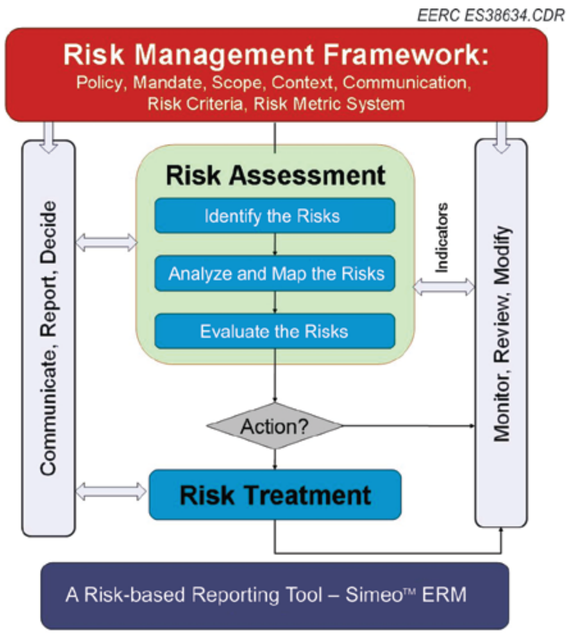

Figure 1 Risk management framework used at Fort Nelson CCS feasibility project.

cornerstone of the risk management policy is the early involvement of all major stakeholders, through an interview process, in order to identify their concerns and level of risk aversion. The material collected is essential for the definition of the risk management policy, which features:

- Scope and objectives of the risk management process.
- Definition of the risk management process itself, used to assess the risks on a continual basis.
- A reporting and communication schedule.
- Frequency of updates and evaluations of the risk management policy itself.

The internal and external context of the Fort Nelson CCS feasibility project was analyzed to determine the groups and stakeholders involved. This allowed for the identification of various concerns, for example, financial, environment, health and safety, legal, etc., that could potentially be impacted by technical risk.

A key component of the risk management policy is the project-specific metric system used during the risk assessment. This includes a frequency matrix that defines frequencies of occurrence over a reference period and a severity matrix that defines severity levels for the relevant strategic elements (e.g., environment, finance, and health and safety) of the project.

A common challenge of technical risk assessments is linking technical risks such as CO_2 leakage, to a strategic impact (e.g., public perception). For the Fort Nelson CCS feasibility project, a unique method was used to relate a measureable physical consequence resulting from subsurface technical risk to a strategic impact. A series of transfer matrices was developed to make this possible. During the risk assessment, a probability of occurrence and a level of physical consequence are determined for each risk. The value for the physical consequence is then entered into the transfer matrix, where it is converted into a value for the level of a strategic consequence. This value corresponds to a certain level of strategic impact, like public perception. The transfer matrices were developed through interviews with various stakeholders.

The technical parameters of the project were reviewed to determine what the potential physical consequences resulting from the technical risks could be, e.g., leakage to other formations, loss of injectivity. Several stakeholders and project team members were interviewed to determine their perceptions of the project and potential risks. Existing regulations which would be applicable to the project were reviewed. This allowed for the development of a risk management policy. The policy includes communication guidelines, the organization of the risk management team, and the project-specific metric system to be used during the risk assessment.

Phase 2: Risk Assessment

A first-round risk assessment was performed using three steps: identification, estimation, and evaluation. The first step in developing the initial risk assessment is risk identification. For this effort, three methods were used to identify risks. First, a failure mode and effects analysis (FMEA) was performed. The Fort Nelson CCS feasibility project was broken up into subsystems and functions; for example, a subsystem could be the sealing formations, while their function is to prevent leakage from the reservoir. This allowed for the development of a clearer picture of what could be at risk within the project system. Next, publicly available risk databases were examined, including the features, events, and processes (FEP) database (Quintessa, 2009). Lastly, a workshop was held that gathered a cross-disciplinary CCS expert panel to provide insight on potential risks. The end result of these three activities was a project-specific risk register of potential risks.

The second part of the risk assessment included analysis and evaluation of the identified risks. Subsurface modeling and simulation work were performed utilizing two types of modeling. A detailed geological model of the project area, including dynamic simulations, allowed a first evaluation of the potential behavior of sour CO_2 during the injection and postinjection periods. Additionally, simplified leakage models were used to estimate risk of leakage outside of the reservoir model area. Another workshop was then held, and experts were given the task of assigning a frequency of occurrence and a level of physical consequence to each identified risk. This was completed using the frequency and severity tables created in Phase 1, while the modeling and simulation work were used to support their estimations. When data availability was limited and the quality of the data was too uncertain to allow an accurate estimation, a range of values was assigned. The risks were then mapped according to their frequency and severity, and critical risks were identified. Lastly, an action plan was created with priority put on the critical risks. The action plan mainly consisted of methods to gather additional data to reduce the uncertainty of the assessed risks.

Phase 3: Risk Treatment Plan and Risk-Based MVA

In Phase 3, the results of the risk assessment were used to make preliminary MVA recommendations. First, the critical risks were selected. Then, each risk was broken down into causes, failure modes, and consequences. This allowed us to identify the individual parameters related to that risk that could be monitored, e.g., pressure and temperature.

Once the parameters that could be monitored to recognize the critical risks were identified, the available technologies that could monitor the parameters were examined. Then, taking into account the site-specific characteristics of the Fort Nelson CCS feasibility project, a list of recommended technologies to monitor the critical risks was created. Also taken into account were the different project phases (preinjection, injection, postinjection), and technologies were recommended for each phase in accordance with the relevant risks.

As is typical of the exploratory nature of evaluating noncommercial, deep, saline formations, the risk treatment plan contained recommendations for further studies and data acquisition to reduce the uncertainty of the critical risks. Additionally, a preliminary risk-based monitoring, verification, and accounting (MVA) plan was proposed by identifying available monitoring techniques and analyzing their relevance for monitoring the project-specific high-criticality risks.

Conclusions

Geologic storage risk assessment provides a more accurate understanding of the relevant, project-specific technical risks while establishing a robust framework designed to mitigate subsurface risk throughout the life of the project. By identifying knowledge gaps in current data, risk assessment activities can provide direction for future studies and characterization work. Additionally, geologic storage risk assessment supports the development of a project-specific, risk-based MVA plan.

As a project progresses, the risks can change. The risks that were once estimated to be high can diminish, becoming negligible, and conversely, risks that were once not relevant can become critical. As a result, the risks must be monitored to ensure they are successfully controlled throughout the lifetime of the project. Because risk management is an iterative process, as the details of a project change, the risk management plan may need to evolve to fit its needs. The risk management plan can be reviewed to ensure that it is still effectively controlling the risks for the project and can be modified if necessary.

The successful application of this original risk management framework to the Fort Nelson CCS feasibility project provides a step forward for the development of CCS. It supports the idea that a risk management framework, including technical risk assessment, can be effectively implemented for large-scale CCS projects. The risk management framework also provides an invaluable decision-making and communication tool that can validate project planning, educate stakeholders, and demonstrate project safety and reliability—all essential for the success of CCS.

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References

Quintessa, 2009, CO_2 FEP database: www.quintessa.org/co2fepdb/PHP/frames.php (accessed 2009).