

PROJECT PIONEER

DEVELOPING A RISK PROGRAM FOR
A CARBON CAPTURE AND STORAGE PROJECT
A CASE STUDY OF PROJECT PIONEER

NON-CONFIDENTIAL REPORT

Produced for the Global CCS Institute | 2011 - 2012

Capital Power
Corporation



ENBRIDGE

TransAlta™



DISCLAIMER

The information contained herein (the “Information”) is confidential and (i) may only be used by the Global CCS Institute for Permitted Purposes [as defined in that funding agreement entered into by the TransAlta Corporation (“TransAlta”) and the Global CCS Institute dated 23 November 2010 (the “Funding Agreement”)] in accordance with the terms thereof; (ii) shall be held in strict confidence by the Global CCS Institute; and (iii) may not be disclosed except as permitted in the Funding Agreement.

TransAlta provides the Information “as is” and makes no representations or warranties of any kind, either express or implied, with regard to its content, its accuracy or its completeness. TransAlta, on behalf of itself and its affiliates, directors, officers, employees, contractors, consultants, agents or others for whom TransAlta is responsible at law, completely disclaims any and all liability arising from any use of the Information, including liability for any losses, damages, lawsuits, claims or expenses, consequential losses.

The Information is proprietary and may not be reproduced without the express written consent of TransAlta.

IMPORTANT NOTE REGARDING PROJECT PIONEER – APRIL 2012

On April 26, 2012, TransAlta, along with partners Capital Power and Enbridge, announced the decision not to proceed with the carbon capture and storage (CCS) project called *Project Pioneer*.

The Pioneer partners concluded that the technology works and that capital costs were in line with expectations. However, the market for CO₂ sales and the value of emissions reductions in Alberta and Canada are not sufficient, at this time, to allow the project to proceed.

While it is disappointing to be unable to achieve the result hoped for, it is important to remember that the purpose of Project Pioneer was to ‘prove out’ the technical and economic feasibility of CCS before going down the major capital investment path. That purpose was achieved: the two years of hard work by the Project Pioneer team was a major success.

The Pioneer partners come out of this with a much deeper understanding of CCS in an Alberta setting. And of course, it is the intention to share this understanding with the federal and provincial governments and the global scientific community so others can benefit from what was learned.

This decision isn’t a reflection on the long-term viability of CCS or the future of coal-fired generation. Coal is a critical fuel for power generation in Alberta and world-wide, and TransAlta believes it will continue to be a vital part of the global fuel mix.

TransAlta, Project Lead, Project Pioneer

fig. 1.0

KEEPHILLS 3 PLANT



INTRODUCTION TO THE PROJECT

Project Pioneer would have been one of the first carbon capture and storage (CCS) projects to utilize an integrated approach for CCS, and was expected to serve as a prototype for the long-term, commercial-scale application and integration of CCS technologies to achieve reductions in greenhouse gas emissions. The partners in Project Pioneer were TransAlta Corporation (TransAlta), Capital Power L.P. (CPLP), Enbridge Inc. (Enbridge), the Alberta provincial and Canadian federal governments, and the Global CCS Institute as a Knowledge Sharing Partner.

Project Pioneer was being proposed to capture 1 million tonnes of carbon dioxide (CO₂) annually from a coal fired power plant and to transport the CO₂ by pipeline to a sequestration site or to be utilized for enhanced oil recovery (EOR) in a depleted oil/gas field.

The key components of Project Pioneer were:

- Carbon capture facility (CCF)
- Pipeline from the CCF to the sequestration site
- Pipeline from the CCF to the EOR site
- Saline formation sequestration site

The Carbon Capture Facility (CCF) portion of Project Pioneer was to have been retrofitted onto the Keephills 3 coal-fired power plant. Keephills 3 is located approximately 70 km west of Edmonton, Alberta and is jointly owned by TransAlta and Capital Power.

The CCF would have treated approximately one third of the flue gas from Keephills 3 and would have captured approximately 1 million tonnes of CO₂ annually. The CO₂ would have been compressed and transported by pipeline to a sequestration site to be injected approximately 2 km underground into a saline formation known as the Nisku Formation. A pipeline was going to have been built also to transport the CO₂ to the primary EOR target, the Pembina oilfield, where the CO₂ would have been injected and used for EOR. The Pembina oilfield is approximately 80 km southwest of the Keephills 3 facility.

fig. 2.0

CARBON STORAGE ILLUSTRATION

Carbon Storage Illustration

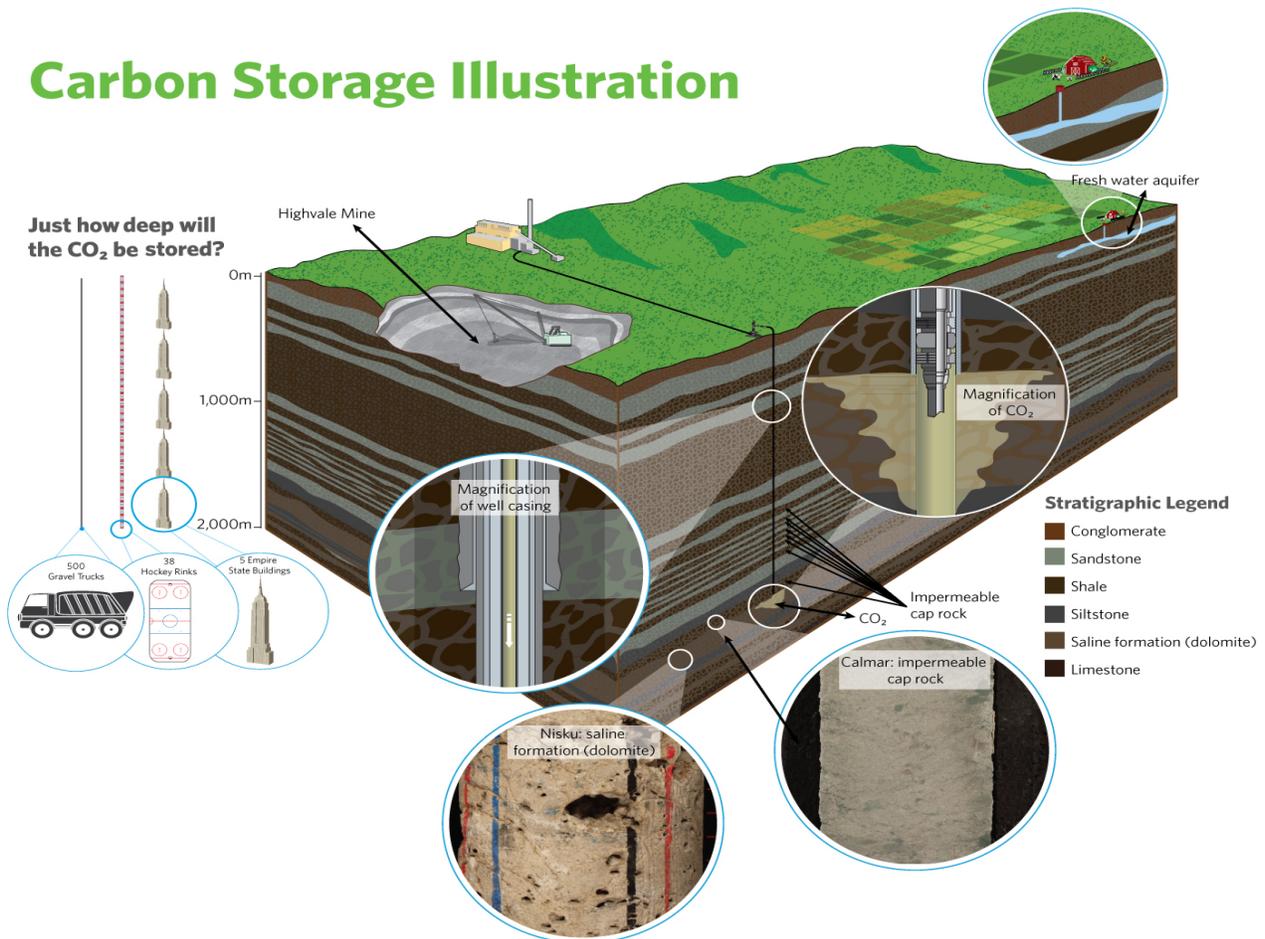


Table of Contents

1.0	Introduction	1	6.0	Identified Risks	19
2.0	Typical (Generic) Project Risk Management System of a Capital Project in Oil & Gas Industry	4		Commercial Risks	23
	Risk Management Process	4		Technical Risks	23
	Risk Identification	7		Construction Risk	23
	Assessment Before Addressing (“As-Is”)	9		Sequestration Risk	24
	Plan/Approve Response	11		Critical Risks	24
	Assessment After Addressing (“To-Be”)	11	7.0	Project Pioneer Team Members Responsibilities	24
	Implement Response	11	8.0	Risk Monitoring and Reporting	26
	Risk Monitoring	12	9.0	Lessons Learned	26
	Closing Risks	12			
	Accepting Risks	12			
3.0	Tools	12			
4.0	Organizational Context of Project Risk Management	13			
5.0	From Generic Risk Management System to the System of Project Pioneer	14			
	Risk and Contingency Identification	17			

1.0

INTRODUCTION

Carbon Capture and Storage (CCS) projects could be considered a special type of oil and gas capital project. On the one hand, the standard approach used for risk management of oil and gas capital projects is applicable to CCS projects. On the other hand, the uniqueness of CCS projects as well as the characteristics of a particular project should influence the design of the Risk Management System (RMS).

The uniqueness of CCS projects could be summarized by the following four points:

- CCS integrates several subprojects that are different in nature: carbon capture, transportation, and sequestration. The complexity of interfaces between the subprojects and between the engineering, procurement and construction work packages creates multiple additional risks.
- The technologies used in CCS cannot yet be considered fully proven despite the existence of several working CCS pilots and projects. One of the reasons for this situation is that there is no standard configuration for CCS projects. A variety of technologies are available to be used for carbon capture, transportation and sequestration. The level of maturity of some of them is low, especially in the area of carbon capture and sequestration. This creates the possibility of the existence of unknown risks.

- The commercial model for CO₂ marketing is not mature. The absence of supply gives rise to the lack of demand and vice versa. This vicious cycle has yet to be broken. Focused and coordinated efforts are required from industry and governments to resolve this stalemate.
- The economic viability of CCS projects is heavily dependent on realizing a financial benefit from the emissions reductions created. A regulatory framework does not exist to create emissions reduction instruments (credits) nor a liquid “carbon” market to provide a mechanism to monetize them.

The four challenges facing CCS projects were drivers behind recent programs by the Governments of Canada and Alberta to support several CCS projects and to provide funding for their development. Project Pioneer was one of them. In addition to the four general CCS challenges, the following characteristics of Project Pioneer added to Project complexity:

- Not only were the Federal and Alberta Governments involved. The Project required participation and contributions from TransAlta, Capital Power, Enbridge and the Global CCS Institute. The large number of partners and the complexity of their interfaces made partner management one of the sources of risks.

-
- The Federal and Alberta Governments wore two hats as related to the Project: funding partners and regulators. In the former capacity, governments worked to accelerate project development. In the latter role however, governments became a source of delays and complications regarding the permitting process and funding, the sequestration permitting process has yet to be clearly formulated and developed. The complexity of the permitting process was exacerbated by the fact that several government bodies had jurisdiction in different aspects of Project permitting and each element of the project had different permitting timelines. This complexity created risks of schedule delays, which would have been detrimental to the Project's success because of the firm deadline to have the Project in operations by 2015.
 - The CCF was to be retrofitted to the existing Keephills 3 coal-fired power plant. This type of brownfield construction approach generally entails many risks related to interfaces with existing facilities and plant operation restrictions.
 - Even when only one type of storage (geological formation vs. oil reservoir) is contemplated, a CCS project is complicated. The scope of Project Pioneer however included both types of storage. This increased the overall complexity of the Project and gave rise to several commercial risks.
 - Part of the Pioneer scope was to prove the economic feasibility of CCS through selling CO₂ to an EOR customer. Despite the fact that there is a large number of Alberta oil reservoirs that are a good fit for miscible or immiscible CO₂ flooding, the oil and gas industry has yet to book corresponding proven reserves due to the lack of economic CO₂ supply and of the required infrastructure. This became a major hurdle for Project Pioneer to overcome.
 - Four major sub-projects were to be integrated to form Project Pioneer: the CCF, the pipeline from the CCF to sequestration facilities, the pipeline from the CCF to the EOR site, and sequestration facilities. Project development and execution would have required robust coordination and interface management between the several supply, engineering and construction companies involved in the subprojects. This requirement for coordination inevitably generates corresponding risks.
 - The project spans four industries, namely power, chemical (CCF), pipeline and oil and gas (sequestration). All these industries conceptually treat risk analysis the same way but there are differences in methodology, process, criteria and priority. Trying to accommodate this into one set of risk guidelines and a master risk register was a challenge.

Both general CCS challenges and features specific to Project Pioneer were taken into account when shaping the Project RMS.

The next section describes the general approach that is usually used for capital projects in the oil and gas industry. The application of the generic RMS to Project Pioneer in particular, will follow in subsequent sections.

2.0

TYPICAL (GENERIC) PROJECT RISK MANAGEMENT SYSTEM OF A CAPITAL PROJECT IN OIL & GAS INDUSTRY

The standard approach that is used to manage risk of oil and gas projects is based on the development of a project risk management system that has three major components:

- Risk Management Process;
- Organizational context;
- Tools.

All three components of the risk management system are highly interdependent and are supposed to support each other. In the case of low integration of the components or weakness in at least one of them, the overall project risk management system could become highly inefficient. The realization of this approach for a particular project is usually introduced through a project risk management plan.

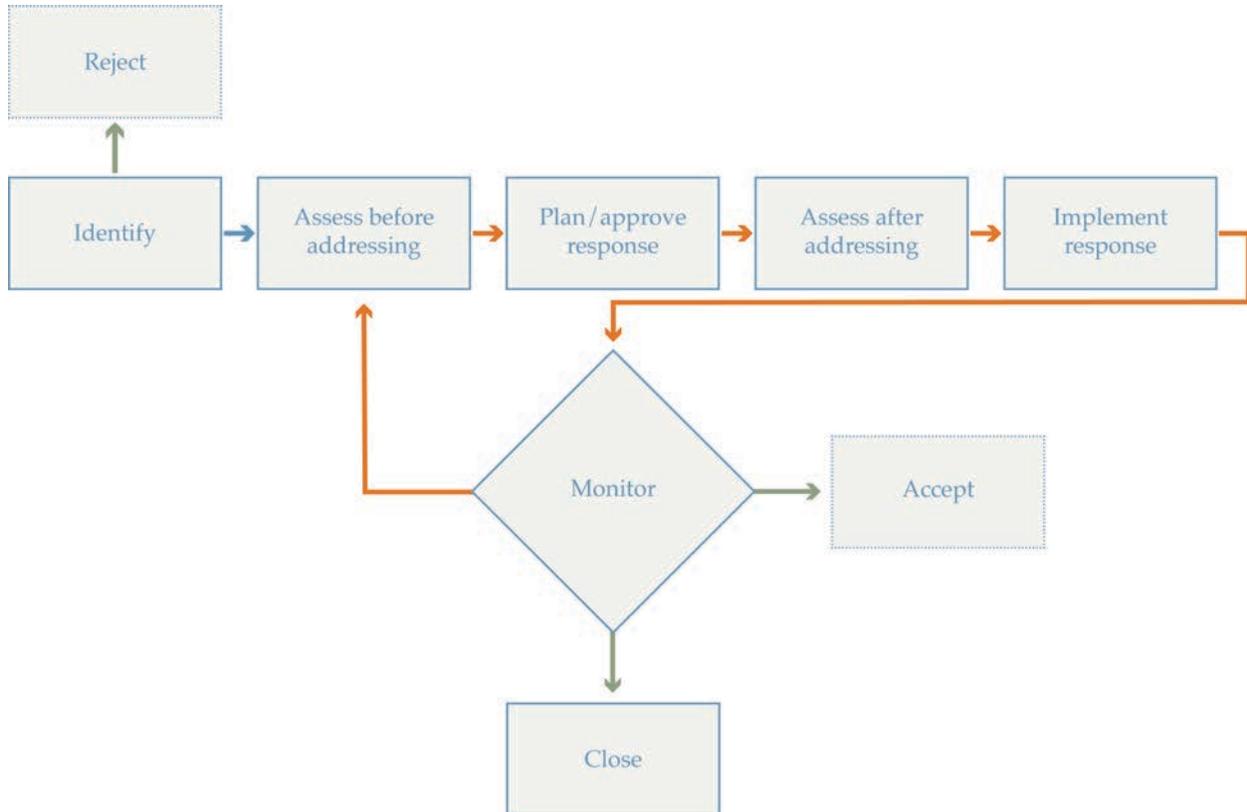
A project risk management plan is a major document that stipulates all project risk management activities and shapes the three components of the project risk management system. The plan establishes the fundamental approach towards risk management of a project. It should be regularly updated throughout the course of project development, and when risks move from one phase to another.

Risk Management Process

Several approaches to the Project Risk Management Process can be found in the literature, including their graphical representation. In essence, project risks need to be identified, assessed, addressed and monitored. One approach is presented in Figure 3. The process loop shown in Figure 3 usually repeats itself several times. Eventually risks are either closed or accepted as residual.

fig. 3.0

PROJECT RISK MANAGEMENT PROCESS

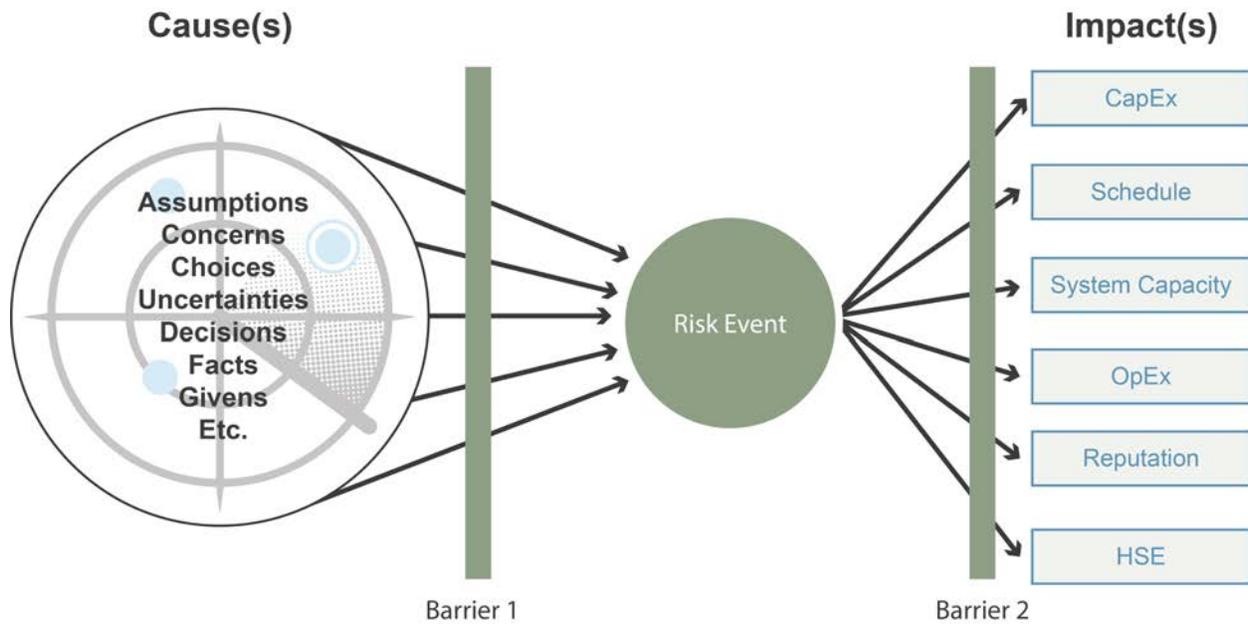


A Bow-Tie Diagram (Figure 4) is also a powerful tool. It is employed for risk identification as it helps to link causes of potential risks (assumptions, decisions, givens, etc.) with risk events and their impacts on project objectives. The project team should systematically “scan” the internal and external environments of a project in order to firstly pin down causes of risks, secondly define possible risk events and thirdly assess impact on project objectives. This logically structured three-step approach to risk naming is a standard in the industry. Its benefits for risk identification are as follows:

- Risk relevance to the project;
- Specific and clear definition of a risk;
- Same understanding by specialists of different backgrounds;
- Same understanding by the same person overtime; and
- Two “lines of defence” (barriers) and better risk assessment.

fig. 4.0

“BOW-TIE” DIAGRAM FOR RISK IDENTIFICATION AND MITIGATION



Risk Identification

The initial identification of project risks is usually done upon a project initiation, during brainstorming sessions. Sessions could be devoted to main deliverables (sub-projects). Additional sessions should be held to identify risks common for all sub-projects. The former is devoted mostly to non-technical risks. Representatives of all disciplines involved in project development should attend these sessions.

Project leadership should be responsible for the concise set of basic project objectives to be used in the risk management process. Preliminary developed baselines can be put forward as short statements, as they relate to:

- Scope/Quality;
- Budget;
- Timelines;
- Safety;
- Environment;
- Reputation.

Project risks should be understood as deviations from selected baselines or basic objectives. The first three traditional project objectives are easily quantifiable, whereas the rest of them (“soft” objectives) should be treated as constraints with “Zero” type goals excluding negative consequences. The budget objective is understood as a capital expenditure (CapEx) meant to deliver the project plus the present value of the project lifecycle operational expenditures (OpEx).

Risks are deviations from objectives, in case of “soft” objectives risks are deviations from “zero” levels.

Some additional objectives could also be at play; such as stakeholder management, legal issues, communities, security, asset integrity, etc. However, the list of basic objectives should be relatively short (5 – 7 items) as some additional objectives could be represented as combinations of basic objectives.

When a set of basic project objectives are agreed upon, only impacts of risks on selected project objectives should be considered during risk identification. This approach is illustrated by the “Bow-Tie Diagram” in Figure 4. The six project objectives introduced above are used in the diagram.

The Bow-Tie Diagram is a powerful tool for risk identification as it helps to link causes of potential risks (assumptions, decisions, givens, etc.) with risk events and their impacts on the project objectives. The Project team should “scan” the project’s internal and external environment systematically in order to pin down causes of risks first, define possible risk events second and assess the impact on the project objectives third.

This logically promoted three-part risk naming (cause(s)-risk event-impact(s)) is a standard within industry. Benefits of the three-part naming for risk identification are as follows:

- Risk relevance to the project;
- Specific and clear definition of a risk;
- Common understanding by specialists of different backgrounds;
- Same understanding by the same person after time has passed;
- Two “lines of defense” (barriers) and better risk addressing (See section 2.1.4).

Special attention is paid to risks that have very low probability of occurrence but very high, devastating impacts on objectives, if they occur. Making a 'dramatic impact' means that those risks could destroy the project objectives. Because of these reasons, such risks are called "show stoppers". Usually identification and management of such risks is the project's responsibility, however their consequences are often assumed by the organization at large.

After the initial risk identification workshops, identified risks should populate the project risk register; risk owners should be assigned and become fully responsible for particular risk groupings. It should be noted that additional risks could be identified throughout the course of project development, meaning that none of this is a static process.

Common risks identified after the fact, often happen through:

- Regular risk reviews;
- Through design, PHA/ HAZOP, value engineering, constructability, etc. reviews;
- Safety workshops;
- Bid evaluations;
- Quality audit(s) of vendor(s);
- Review meetings with stakeholders and top management.

A valuable tool towards identifying risks in a consistent fashion is to develop a project risk break-down structure (RBS). Project RBS could resemble projects WBS at a higher level and also include external environments. This is to ensure that there are no gaps in "scanning" of a project environment to identify relevant risks.

Typical RBS categories:

- Permitting
- Engineering
- Interfaces
- Technology
- Procurement
- Commercial
- Construction
- Commissioning
- Operations
- Stakeholders
- Organizational
- Economic
- Political

The RBS categories could be organized in two or three level hierarchies to ensure the proper level of detail.

As risks are understood to have both upsides (opportunities) and downsides (threats) to project objectives, they should both be part of the risk identification process.

Assessment before Addressing (“As-Is”)

The initial assessment of a risk should be done right after its identification, taking into account any existing addressing measures and controls in place (assessment “As-Is”). However, to do this consistently, a “measuring tool” is required. Deviations from basic project objectives should be measured as introduced in the previous section.

A standard scoring approach used for risk assessments utilizes a project risk assessment matrix (RAM). Figure 5 introduces a sample of a RAM for CO₂ sequestration projects. It has five ranges for each project objective, as well as five ranges for probabilities of risk occurrence. The overall risk score is a product of impact score and probability score.

Usually three or four categories of risk are introduced to distinguish risks of various scores and to introduce levels of risks (Figure 6). These scores are widely used to manage risks (see section 2.4 on organizational context).

It is not unusual that an initially identified risk has a high score and that it be reduced to an acceptable level.

fig. 5.0

PROJECT PIONEER'S RISK ASSESSMENT MATRIX

% Probability	Qualitative Assessment	Score	Impact					Probability
>75%	Very High <i>(almost certain, may occur in every project)</i>	5	5	10	15	20	25	
50-75%	High <i>(more likely than not, occurs in most projects)</i>	4	4	8	12	16	20	
20-50%	Medium <i>(fairly likely, occurs in some projects)</i>	3	3	6	9	12	15	
5-20%	Low <i>(low but not impossible, occurs in few projects)</i>	2	2	4	6	8	10	
<5%	Very Low <i>(rather unlikely, occurs in no projects)</i>	1	1	2	3	4	5	
		Score	1	2	3	4	5	
	Qualitative Assessment		Very Low	Low	Medium	High	Very High	
	CAPEX, CAD**		<\$1M	\$1M – 5M	\$5M – 15M	\$15 – 25M	>\$25M	
	Schedule, Mos		<0.5 Mos	0.5 – 1 Mos	1 – 3 Mos	3 – 6 Mos	>6 Mos	
	System Capacity, Mega Tons (mt)		<0.05 mt	0.05 – 0.1 mt	0.1 – 0.3 mt	0.3 – 0.5 mt	>0.5 mt	
	OPEX, %**		<1%	1 – 3%	3 – 5%	5 – 10%	>10%	
	Reputation		Slight Impact <i>(Some Public Awareness)</i>	Limited Impact <i>(Local Media)</i>	Considerable Impact <i>(Regional)</i>	National Impact	International Impact	
	Health, Safety, Environment (HSE)		Slight Injury or Health Effect/Slight Environmental Effect	Minor Injury or Health Effect/Minor Environmental Effect	Major Injury or Health Effect/Localized Environmental Effect	PTD* or One Fatality/Major Environmental Effect	More Than One Fatality/Massive Environmental Effect	

* PTD – Permanent & Total Disability ** Currently project team is focused on cost risks

fig. 6.0

FOUR LEVELS OF RISKS, THEIR ASSIGNED RESPONSIBILITY, AND FREQUENCY OF REVIEW

Level of Risk	Small/Very Low	Material/Medium to Low	Severe/High	Critical/Very High
Score vs. Level of Risk	1 – 4	5 – 9	10 – 16	20 – 25
Responsibility	Team Member	Team/Disciplines Lead	Project Managers	VP/Senior Management
Frequency of Review	Monthly	Tri-Weekly	Bi-Weekly	Weekly

Plan/Approve Response

Addressing risks requires resources. An owner of a risk should come up with a risk response plan, and have it discussed and approved by project leadership. Cost and timelines of addressing the risk(s) as well as any required specialists in solution and/or mitigation should be also be approved. Addressing a risk should be economically viable. In some cases, acceptance of a risk could be preferable to addressing it, unless impacts on “soft” objectives are unacceptably high.

Any risk response plan should be based on one of five (or combination of several) generic strategies:

- Avoid
- Mitigate by Preventing
- Mitigate by Recovering
- Transfer
- Accept

These strategies are introduced as two barriers of the “Bow-Tie” diagram. In essence, they are not fully independent, transitioning to each other in some cases, for full or partial success(es).

Assessment after Addressing (“To-Be”)

Despite knowing that mitigation actions will likely be initiated per risk, the assessment should nevertheless be done as part of their approval process. This allows for the evaluation of efficiency of the proposed actions and review of possibilities that proposed actions become causes of new risks.

Assessment “To-Be” should be done using RAM, as introduced above. Action owners should be proposed by the risk owner and approved by the appropriate project leadership.

Implement Response

Approved mitigation actions should be included in the project risk register. Action owners as well as the action’s start and completion dates are important pieces of information to be included in the risk register.

Actions should be implemented with a timeline, and should become part of routine project work and development plans.

Risk Monitoring

Through the natural course of project development, and mitigation work, some risks could change status. That is why the regular monitoring of risks as well as an evaluation of them is required. Risk monitoring should be done during regular risk review sessions. One of monitoring outcomes is re-assessment of a risk “As-Is”. The difference with section 2.3 is that a new “As-Is” status should be taken into account that would include newly implemented measures. The other two outcomes are accepting and closing of risks.

Closing Risks

Risk could be closed in three cases:

- When the time of a risk happening is over;
- When the scope of a project is amended and a risk becomes irrelevant (avoided);
- When a risk is addressed well and reduced to acceptable level.

Closed risks become part of a project’s legacy system. Otherwise a risk should stay active.

Accepting Risks

If all planned, and economically viable response actions are implemented, and a risk is still considered as high, it should be accepted. Risk acceptance means allocation of an adequate contingency for a case of its happening.

3.0

TOOLS

A standard approach in the industry is to use web-based multi-user risk management software packages for development and maintenance of project risk registers.

There are several adequate options available in the market. The benefit is that these software packages allow for collaborative and simultaneous work between disciplines, offices and differing geographic locations. However, they also require proper maintenance and IT support by trained technicians.

A low-end/cost alternative to this approach would be to use something like a Micro Soft Excel based project risk register template. Functionalities are similar to commercial packages; however, a major hurdle is the inability for simultaneous work and the likelihood of proliferation of multiple risk register versions. This could become a major obstacle in developing and implementing an effective risk management system.

A risk assessment matrix and risk break-down structure should be carefully selected to ensure it can be fully integrated with the risk register.

A reporting module of the risk register (which is either part of a commercial package or developed in-house) should support agreed upon reporting and visualization requirements.

4.0

ORGANIZATIONAL CONTEXT OF PROJECT RISK MANAGEMENT

The roles of the project team members as well as the type and frequency of risk reviews and risk reporting are defined by the organizational context of risk management.

Responsibilities and accountabilities of project team members should include general rules on how risk and action owners are assigned. A general rule is usually that the risks of higher levels and their mitigation actions are assigned to more senior people (Figure 4). A risk owner is usually more senior than action owners. A risk owner's responsibility is to coordinate action owner's activities to assure proper risk mitigation.

Normally high level risks and their actions are reviewed more frequently. Certainly, full reviews of the risk register are required prior to major decision gates.

Roles of top management, project leadership, discipline leads and a project risk coordinator should be clearly defined.

As a rule, a monthly risk reporting cycle is adopted by capital projects. This includes the following:

- Executive Summary;
- Statistics on the number of risks of various RBS categories and of various levels as well as on corresponding mitigation actions;
- Five to seven key points on major risk events and developments (workshops, newly identified or closed risks, risk upgrades/downgrades, action's implementation, concerns, occurred risks, etc.);
- Risk visualization charts (usually based on 5x5 RAM to plot risks of various severities).

Clearly defined organizational context of the project's risk management system is crucial for the success of the project risk management activities in particular and for a project at large.

5.0

FROM GENERIC RISK MANAGEMENT SYSTEM TO THE SYSTEM OF PROJECT PIONEER

Principles outlined in previous sections were used to develop the project risk management system of Project Pioneer. This system was well defined according to industry standards.

First, it was agreed that Project Pioneer could be adequately represented by four sub-projects:

- CO₂ Capture
- Pipeline
- Sequestration
- CO₂ Commercial

Second, it was decided that following six basic objectives and impacts on them should be considered in the project's risk management:

- Capital Expenditure (EPC costs);
- Schedule (Schedule meets the government commitment in operation by end of 2015);

- System Capacity (System capacity meets project perspective);
- Operational Expenditure (Operation costs);
- Reputation (communication with actual or potential public, customers or with their representatives);
- Health, Safety and Environment or HSE (Goal "Zero" in terms of negative impacts on health, safety and environment during construction and operation).

The system capacity objective covers all four integrated sub-projects.

Third, preliminary analyses of the four sub-projects as well as external environments allowed for the proposal of the Project Pioneer risk break-down structure, as introduced in Figure 7.

Fourth, it was agreed that six project objectives should be included in the Project's risk assessment matrix (Figure 5).

Fifth, the risk management process of Figure 3 could be used in Project Pioneer.

fig. 7.0

RISK BREAK-DOWN STRUCTURE PROPOSED FOR PROJECT PIONEER

Stakeholder Relations & Consultations

General Public & Communities

Joint Venture

Industry

Government & Regulatory

Government of Canada

Government of Alberta

Economic & Agreements

Commercial & Commodity

Funding Agreement

Test Criteria

Economic Model (*incl. IRR, Taxation, FX, etc.*)

Project Delivery (Engineering & Construction)

Capture

Pipeline

Wells

Contracting

Integration

Organizational

Start-up

Operations

Capture

Containment

Injectivity

Capacity

MMV

Integrity (Plant, Pipeline, Wells)

The approach to risk management evolved over the term of the Project Pioneer. There were three distinctive phases of implementation of the risk management system:

Phase A: Project initiation through to technology assessment;

Phase B: Technology assessment;

Phase C: Alternative technology assessment.

The risk management System in Phase A had features as follows:

- Senior risk analysts embedded within the project team to work with the Subject Matter Experts (SME's) to facilitate the initial identification, analysis, and evaluation of project risks, opportunities and treatments;
- Risk management worked with project leads to formalize key risk categories and establish the context for assessment criteria (i.e., low, med, high impact and likelihood of occurrence);
- Two senior risk analysts coordinated the initial population of the risk register. Key components of the risk register included: description of risk, impact and likelihood, risk owners, action owners; impact of mitigation and/or transfer strategies; dependencies with other risks (inherent and residual);
- Facilitated sessions for cross functional discussion / brainstorming of risks and opportunities were held (identified dependencies and critical risks);
- Researched other complex projects to identify lessons learned, potential risks, approaches to mitigation (e.g., other carbon capture projects, projects involving the adoption of new technology - FutureGen, etc);

- Leveraged risk management tools and processes from project vendors associated with the carbon sequestration component of the processes (i.e., project team participated in a hosted risk identification and qualitative assessment session that engaged a wide range of industry and academic experts);
- Actively participated in industry and NGO forums/conferences;
- Risk analysts worked closely with key project lead(s) to implement an effective refresh cycle for risk register elements associated with the technical and construction components of the project;
- Risk analysts worked with the key project leads to develop a 'high-level ' register that aggregated risks and responses for those risk events identified as having a high (or above) implications for the project (i.e., schedule, funding, show stoppers).

In Phase B (technology assessment):

- Resources were refocused to provide framework, support, and modeling for technology risk assessment;
- Resources were deployed to provide Monte Carlo simulation for key project drivers (financial model).

Phase C (alternate capture technology):

- Enterprise Program Management Office (EPMO) and risk management acted upon an opportunity to engage a contract risk resource that had in-depth experience in complex projects like Pioneer;
- The contract risk resource provided a review of the existing Pioneer risk register and identified areas for enhancement. Suggestions included: expand the risk assessment matrix to include reputation and safety risk; modify the risk register to enable tracking of actions; proposed modifications to the risk break-down structure (risk categories);

- The contract risk resource was engaged to assist TransAlta with the formalization of a risk management program for major projects. (A key element of a successful risk management program is clearly defined roles and accountability for risk management activities within the project team);
- An experienced resource was hired by the project to track and report on risks (project risk resource). The contract risk resource was engaged to enhance specific sections of the Pioneer team's original risk register to be used as the go-forward template by the Project risk resource (i.e., enhanced risk register with additional risk assessment categories and sections for tracking actions);
- The project risk resource required significant direction and support in areas such as: facilitating risk identification and refresh sessions with risk owners; distinguishing between risks, events, issues; identifying dependencies/key drivers; and, communicating/reporting key risks;
- Roles and accountabilities of Project Leads were formalized and they were assigned specific risks and actions to manage.

The points above mostly describe internal risk management activities.

An early issue was identified as it related to the Project Pioneer partner's engagement, that is that engagement and incorporation of the project partners and external stakeholders would be challenging with various risk cultures and program/requirements across the stakeholder groups.

Risk and Contingency Identification

Pipeline risks were evaluated using an Enbridge Contingency Planning Process to establish and help quantify the amount of contingency. The output of the risk sessions were used to determine the contingency percentage assigned to the base cost estimate. Contingency planning is anticipating possible threats due to unforeseen situations and planning a way to ensure that the project is brought back to normal condition. In general, contingency planning involves a few important steps as follows:

- Identification of both favorable and unfavorable events that could possibly impact the planned strategies;
- Specifying the triggering factors and assessing their likely probability of occurrence;
- Assessment of cost and schedule impact due to each event;
- Development of a contingency plan with alternative strategies to be followed in the event of an unforeseen situation; and
- Identifying the key early warning signals for each event.

Both Schlumberger and Enbridge presented a full risk analysis and contingency assessment to TransAlta in April 2012. Pricing variability was estimated to determine the probabilities of meeting prices in the cost estimate, with the intention of including all three risk analyses (TransAlta, Enbridge and Schlumberger) into a map to depict risk severity and probability. Risk thresholds differed between each contributor due to large cost differences, such as the \$80 million of capital costs for the pipeline system in comparison with \$475 million cost for the CCF. From these assessments, a comprehensive Risk Register was compiled, from which risks were to be filtered such that high-level or main project risks could be identified in order to reduce the register to a reasonable number of risks. This reduction in complexity was required for the partners to officially accept risks for the Project to proceed. Section 6 of this report provides details about the individual risk assessments made for the CCF, the pipeline system and the sequestration facilities.

If the Project had proceeded, detailed studies of contingencies and associated risks would have been completed, and work strategies developed. The use of contingency funds would have been tracked against these established criteria. The contingency allowance was an integral part of the estimate and needed to be controlled accordingly.

All active risks were to be reviewed on a periodic basis by the Project Manager, Risk Coordinator, Risk Owners, and Discipline Leads to review the status of selected risks, changes in probability and/or impacts, and mitigation plan status. Risks and opportunities were considered as deviations (negative or positive) from declared project objectives. Critical risks and “show stoppers” including related response actions would have been reported to and monitored by Senior Management. The Project Manager was to monitor the severe/high risks and their actions. All moderate/medium risks would have been reviewed and monitored by Discipline Leads and reported to the Project Manager. Small/very low risks were to be monitored by Project’s team members. Frequency of reviews was to be based on a risk level, which was to be established at the time of Project execution.

6.0

IDENTIFIED RISKS

An MS Excel based template was developed to document Project risks. The main categories and risk count are as follows. The list is in alphabetical order and does not indicate any priority:

- Commodity (13)
- Environment (5)
- Project delivery basically engineering and construction (4)
- Event (1)
- Financial (32)
- Funding and partnership (25)
- Human resources (7)
- Knowledge transfer (1)
- Legal/contractual (2)
- Operating and maintenance (0)
- Process technical (37)
- Procurement (11)
- Project management (5)
- Regulatory framework (15)
- Reputation/external communication (13)
- Safety (1)

The numbers of risks belonging to each category are shown in brackets. The definitions of each category are included in table 1 below. The risk register was a “living” document and was continually being updated. Hence the risk numbers are a reflection of the FEED stage of the project only, with relatively high number of risks for funding, process, commodity and regulatory and less developed risk for operating, project delivery and event risk. A final execution approval version of the risk register was not completed before project cancellation; hence the register was not completed and could not be used as a basis for project approval nor could it be construed as representing all risks in a CCS project. The above applies mainly to the CCS portion of the project, the pipeline and sequestration work was at the execution approval phase and their risk registers were completed and were used in contingency analysis.

Some risks were duplicates, unclear or not fully defined. This resulted from the initial approach to populating the register, in which all SME’s were polled for their input. SME’s generated risks outside of their area of expertise which resulted in numerous duplications or variations of the same risk item. This resulted in these duplicate risks not being developed and the team was in the process of removing these duplicates when the project was cancelled. For all other risks that were addressed and assessed, response actions were included. The following were high level project risk impact areas anticipated for the Execution Phase:

- Engineering, Procurement, and Construction (EPC) capital costs;
- Mandatory operation by the end of 2015;
- Adequate system capacity required to meet project commitments;
- Operating costs;
- Upholding Project reputation with the public, customers and their representatives through adequate communication;
- HSE, including injuries or environmental impacts during construction or operations.

At the time of Project cancellation, the Project Risk Register was being simplified in a manner such that the partners could review a more manageable list for approval (Table 1).

table 1.0

SELECT RISK CATEGORIES AND DEFINITIONS FOR PROJECT PIONEER'S RISK REGISTER

Risk/Opportunity Category	Subcategory	Definition
Commodity	Avoided Emissions Costs	The risk associated with changes in the absolute or differential prices of commodity product outputs and the cost/availability and long term reliability of purchased commodity inputs.
	Emissions Reductions Instruments	
	CO ₂ Sales for EOR	
	Electricity Supply	
Environment – Permitting/Licenses	Equipment & Plant Technology	Risk associated with equipment and plant in regards to technical issues, reliability and performance.
	Civil/Structural	
	Construction	
	Electrical	
	Geotechnical	
	Mechanical	
Financial	Accounting/Reporting	The risk associated with changes in new and existing accounting requirements.
	Cash Flow	The risk related to the timing and amount of cash inflows and outflows. Also economic modeling for business case.
	Credit	This risk is of counterparties fulfilling their financial obligations to us, or the ability or willingness to fulfill operational obligations, resulting in financial exposure.
	FX	The risk associated with exposure to various currencies, primarily as a result of the acquisition of equipment and services from foreign suppliers.
	Interest Rate	This risk describes the variability in short and long term interest rates which may impact the cost of the project.
	Tax	Tax risk describes the business risk associated with changes in new and existing tax requirements.

Risk/Opportunity Category	Subcategory	Definition
O&M	CCF Pipeline Sequestration	The risk associated with the operation of the of the pilot CCF, pipeline and sequestration site.
Process	Integration	The risk associated with integrating to the K3 plant and the operating impact to K3 availability.
	CCS Technology	The process and performance risk associated with the amine scrubbing pilot. Identifying unknowns, assumptions and areas of weak knowledge base.
	Sequestration	The technical risk associated with underground permanent storage of CO ₂ . Identifying unknowns, assumptions and areas of weak knowledge base.
Project Management	Project Schedule	The risk associated with the project schedule.
	Project Construction	The risk associated with project construction.
	Regulatory Framework	The risk associated with existing and changes to regulatory and reporting requirements (including environmental).
	Reputation/External Communication	The risk associated with changes in opinion from general public, private and government stakeholders, investors and other entities.

Risk/Opportunity Category	Definition
Event	Unplanned events risk causing impacts to cost and/or schedule.
Safety & Loss Control	Loss control describes the potential and risk for causing injury to people, damage to property or impact to the environment.
Funding & Partnerships	Funding Agreement risk is associated with Pioneer's ability to obtain funding for the project.
Human Resources	Describes the uncertainty of achieving business objectives caused by the workforce, including: availability staffing, training, development, motivation, and retention issues.
Knowledge Transfer	Risk related to knowledge transfer requirements and limitations.
Legal/Contractual	Legal risk describes the risk associated with legal and contractual obligations to other commercial entities and governing bodies.
Procurement	This risk resides in the ability to access and secure materials, components, equipment, skilled labour, engineering services, and other such resources in a timely manner, balanced with cost.

Commercial Risks

While Project Partners were motivated by the opportunity to demonstrate a strategic option for the coal fleet and by opportunities in emerging markets, commercial arrangements had to be structured in order to limit the project risk. A good example of the structuring of commercial arrangements to limit risk is found in the engineering, procurement, construction, commissioning and performance of the CCF. Financial risks arose from the potential of cost overruns, for these were to be covered only by the industry partners as government funding amounts were fixed.

Milestones and annual funding amounts were set by contract, and were difficult to modify if any unplanned event occurred that affected the schedule. Additionally, funds were required to be returned to their respective government source if the Project did not proceed or perform as expected, setting a high standard of performance for facility construction and for the operational phase.

Furthermore, arrangements with the EOR customer would have required the delivery of guaranteed minimum quantities of CO₂ or penalties would be suffered by the Project. Finally, realization of the expected value of emission reductions, an important economic driver for the Project, was contingent on the expected performance of the CCF. These factors stressed the importance of selecting a technology provider with a strong expertise in order to protect against the accompanying risks.

Establishing a construction contract to account for the above factors was challenging. To protect the partners, risks were mitigated in part by the negotiation with MHI of a fixed price EPC construction agreement that contained strong completion and performance guarantees. This effectively transferred a good portion of the commercial risk to the party best equipped to handle it – the technology supplier.

Technical Risks

In comparison with commercial risks, technical risks were comparatively small. The CCF was intended to have a scale-up factor of almost 6 from the Southern Company Plant Barry in Alabama, in which the MHI amine process has been demonstrated at scale for over a year. Pioneer's scale-up was modest in comparison as the scale-up factor which is typically used in industry is 10 times.

In addition to the successful demonstration at Plant Barry, amines had been successfully used in the past in the petrochemical industry, albeit at smaller volumes. MHI was confident enough to give guarantees to the Partners that the CCF technology could be scaled up while meeting performance and cost targets. Pipelines in general are well tested in North America. Transportation of CO₂ for the Project was viewed as being relatively routine and the risks considered manageable.

Technology guarantees could not be obtained for the sequestration facilities due to the nature of the activity, but the partners had confidence in the prior successes and experience of the technology partner for this component.

Construction Risk

Due to oil sands development and rapid growth in Alberta, construction risk due to lack of skilled tradesmen was identified early, as a challenge for the Project. This coupled with the government funding requirements led to the need for a fixed price lump sum turnkey (LSTK) contract with the technology provider.

In the first FEED phase a construction advisory committee was established to advise the Pioneer team on how best to mitigate construction risk.

By negotiating a fixed price lump sum turnkey contract with MHI, the Pioneer team mitigated a considerable amount of project construction risk to the point where it was acceptable to the industry partners.

In a previous report to the Global CCS Institute, the construction execution strategy is discussed.

Sequestration Risk

Due to the lack of regulation, unknown aquifer characteristics in the immediate vicinity to the site, no MMV regulations or guidelines and the potential public interest in long term storage of CO₂, sequestration was identified as another high risk for the project. TransAlta hired best in class experts, highly regarded in the Alberta oil industry, to be our advisory team; this team was instrumental in locating a site for CO₂ sequestration field.

None of the partners had experience or expertise in sequestration; hence Schlumberger Carbon Services were retained as the project manager for this work and executed, coordinated and reported on all aspects of the sequestration effort.

Their experience in CO₂ well field development, design, public consultation, test well drilling, data analysis was of great assistance in reducing mitigating sequestration risk.

Critical Risks

The master risk register was considered to be too cumbersome to be used as an effective tool in final project assessment. Hence a separate risk register of critical risks and “show stoppers” only was produced. It was anticipated that these risk items would be fully developed to include all mitigation strategies and costing of such.

This would be presented to the Partners for project approval. The costing of the mitigation strategies would also have been used to determine the risk probability curve and hence be used in determining the contingency for the project. These last items were not started due to the late design and costing of the CCS and project cancellation.

7.0

PROJECT PIONEER TEAM MEMBERS RESPONSIBILITIES

Responsibilities of Project Pioneer team members were declared keeping in mind general guidelines of Figure 4 on level of risks vs. responsibilities as follows:

1. Management (Decision Executive/VP):
 - Sets project objectives;
 - Endorses the RAM and RMP;
 - Resources the risk management system;
 - Approves risk responses for critical risks and “show stoppers” and assigns resources;
 - Approves closing/taking of critical risks and “show stoppers”;
 - Uses risk information in decision making.
2. Project Manager:
 - Champions the risk management system;
 - Owns project risk register;
 - Approves the RAM and RMP;
 - Approves risk responses for severe risks (excluding “show stoppers”) and assign resources;
 - Approves closing/taking of severe risks (excluding “show stoppers”);
 - Uses risk info for evaluating options and preparing decisions.

3. Risk Coordinator:

- Trains and supports risk and action's owners;
- Maintains project risk register;
- Consult project team;
- Writes and updates RMP;
- Facilitates risk workshops;
- Maintains the quality of the risk register;
- Screens proposed risks;
- Proposes risk owners;
- Reports risk info to management;
- Reports on issues and health of risk management system to project leadership.

4. Discipline Leads:

- Approves risk responses for material (excluding "show stoppers") and small risks related to the discipline and assign resources;
- Approves closing/taking of material (excluding "show stoppers") and small risks of the discipline;
- Coordinates efforts of Risks and Action owners of the discipline.

5. Risk Owners:

- Describes and assesses the risk and proposes suitable risk responses;
- Obtains approval and resources (Action Owners) for planned responses;
- Coordinates efforts of Action Owners to address particular risks.

6. Action Owners:

- Executes actions as agreed with risk owner;
- Records action status to the risk register log.

7. Project Team Members:

- Identifies risks and proposes them to the risk register;
- Feeds back effectiveness of risk responses to risk owner.

8. Risk Advisor:

- Provides overall support of the project risk management system;
- Advises risk coordinator, project team and top management on various aspects of risk management;
- Advises top management on overall health of the project risk management system;
- Plays a role of risk technical authority and assures compliance with corporate risk processes;
- Facilitates risk workshops;
- Develops and runs probabilistic schedule and cost risk analysis when required.

Responsibilities of team members introduced above could be considered well defined according to industry standards.

8.0

RISK MONITORING AND REPORTING

Another important aspect of the organizational context – risk monitoring and reporting – was clearly defined in the Project Pioneer risk management plan.

It was decided that all active risks should be reviewed on a periodic basis by the Project Manager, Risk Coordinator, Risk Owners and Discipline Leads. The purpose of these activities should be reviewing of the status of the selected risks, changes in probability and or impacts as well as progress of implementation of mitigation actions and their status.

The frequency of reviews was based on a risk level as follows:

- Critical/Very High Risks: Weekly;
- High Risks: Bi-Weekly;
- Medium to Low Risks: Every three weeks;
- Very Low Risks: Monthly.

Critical risks and “show stoppers” and related response actions, should be reported and monitored by senior management. The project manager should monitor the severe risks and their actions. All moderate risks should be reviewed and monitored by disciplines leads and reported to the project manager. Low level risks should be monitored by the project's team members.

9.0

LESSONS LEARNED

Because risk management was an area of the Project that required considerable time investment, and was of crucial importance to the Project and its success, it was felt to be very important to capture and record an evaluation of the successes and challenges of the risk program. The following are the conclusions and recommendations as ‘lessons learned’ from the experience with the risk program of Project Pioneer:

1. *Project Complexity.* When undertaking the risk assessment, the complexity of the project cannot be underestimated; in the case of CCS projects it may be multi-dimensional. There is the technical novelty in that large-scale integrated CCS projects are truly first-of-a-kind. Moreover, there is the commercial risk due to the low level of maturity of CO₂ markets, particularly as they relate to EOR projects, uncertainties regarding realization of avoided emissions values and the meeting of terms and conditions imposed by external funding bodies. When there are multiple levels of complexity the risks increase exponentially potentially leaving some risks inadequately addressed, or even undiscovered. A staged approach could be beneficial that zeroes in the CCS technologies first; a second phase would be devoted to developing reliable CCS commercial arrangements.
2. *Balanced Approach to Risks.* Technical risks tend to be more readily identified than non-technical risks, hence may be treated as a higher priority. A balanced approach based on consistent implementation of the project's risk break-down structure (360 degree scanning of project environment) is recommended to assure that all types of relevant risks are identified and properly managed.

-
3. *Consistent Implementation of a Risk Management System.* Even with a high quality, carefully designed risk management system, if it is inconsistently implemented, it will fail. Modifications to the risk breakdown structure need to be properly incorporated to ensure the integrity of the system. Training of risk management resources is important to enshrine the culture of risk management into the organization. Project risk management should be a priority for any capital project, especially when developing CCS projects which are characterized by a high level of novelty and unknowns.
 4. *Accountabilities and Engagement of Team Members.* Team member's responsibilities as risk and action owners must be fully understood and be a first priority. Implementation of formalized responsibility and accountability risk management matrix should be a must for any CCS project. It is recognized that some team members will have other responsibilities; the priorities among these responsibilities need to be identified.
 5. *Staffing.* The risk coordinator's role for a complex project requires not only advanced risk management knowledge and experience, but also strong leadership skills, both conditions are mandatory for effective engagement of a project team. Special attention to risk management staffing and training on the objectives of the risk management process is essential.
 6. *Engagement of Project Partners.* When several partners are engaged in a project of this magnitude and complexity, an integrated risk management system that engages all partners should be deployed. This requires the use of a multi-user web-based platform to maintain the project risk register that should be accessible by all partners and team members.

Some other highlights based feedback from the Risk Management team:

- The register should not be too large or too complex such that it becomes unwieldy;
- Ownership of each risk needs to be clearly identified;
- Staffing needs to be completed early; and priorities need to be assigned;
- Resources must be properly trained;
- Buy-in to the risk process is essential to its success;
- The project management team must use the tool to hold team members accountable to mitigate risks;
- The risk management plan must clearly define the approach for effectively performing risk management on the project;
- Reports must include coordination of the team's comments, management interpretation of the situation and recommendations for proposed actions – review, refresh, aggregate;
- Project partners, vendors and consultants must be engaged in the Risk Management System.

These main lessons learned should certainly be taken into account when undertaking CCS projects in future.

Case Study Written by

Yuri Raydugin, P.Eng., M.B.A., Ph.D.
Principal Consultant at Risk Services
& Solutions Inc.

Yuri is a *Subject Matter Expert* in Risk Management of capital mega-projects in the Oil and Gas and Energy industry, as well as the author of two technical papers on Risk Management, and is a reviewer of Risk Management publications in the International Journal of Project Management.

Case Study Edited by

Stacey Hatcher, Knowledge Transfer Specialist,
Project Pioneer



www.projectpioneer.ca

CONTACT US

Don Wharton – Vice President of Sustainability & Policy
TransAlta Corporation
Calgary, Alberta, Canada
Don_Wharton@TransAlta.com

Stacey Hatcher – Knowledge Transfer Specialist
Project Pioneer
Calgary, Alberta, Canada
Stacey_Hatcher@TransAlta.com