Technology Collaboration Programme
by IEA

# IEAGHG Technical Review
## 2022-TR02
## March 2022

# IEAGHG Risk Management Network – Webinar & Virtual Discussion: The Road to CCS Project Permitting – Operators' Experiences With Risk Management During the Permitting Process

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This report describes a virtual panel discussion for the IEAGHG Risk Management Network held in January 2022. This report was prepared by Samantha Neades, IEAGHG with input from the panellists.

IEAGHG would like to thank the IEAGHG Risk Management Network Steering Committee for their efforts in facilitating this webinar:

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IEAGHG would also like to thank the panellists for their contributions to the event:

- Samantha Neades, IEAGHG (UK, moderator)
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- Bram Herfkens, Porthos Project (The Netherlands)
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The report should be cited in literature as follows: 'IEAGHG Risk Management Network – Webinar & Virtual Discussion: The Road to CCS Project Permitting – Operators' Experiences With Risk Management During the Permitting Process. 2022-TR02, March 2022.'

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# IEAGHG Risk Management Network

## "The Road to CCS Project Permitting – Operators' Experiences With Risk Management During the Permitting Process"

## Webinar & Panel Discussion

On Tuesday 18th January 2022, the IEAGHG Risk Management Network held a webinar which aimed to be a roundtable presentation of CCS / CCUS (carbon capture and storage / carbon capture, utilisation and storage) project operator experience, with risk management, during the permitting process. This webinar heard from panellists on the Northern Lights project, the Porthos project, California experiences with permitting and Oxy's recent project experiences.

The webinar attracted an audience of 138 in addition to 8 panellists and 2 IEAGHG staff.

## Welcome

Samantha Neades (IEAGHG) welcomed all to the webinar on behalf of IEAGHG and its Risk Management Network, which aims to bring worldwide experts together to discuss topics pertinent to the risk management of CCS / CCUS projects including risk analysis, risk data management, regulatory engagement and impacts of activities. This webinar was an informal roundtable discussion to learn about the experiences that project operators have had relating to risk management during the permitting process. It provided an understanding of the challenges faced and explored potential ways to overcome such issues for future permits. The virtual event welcomed speakers from CCS projects and industry to hear their views and learn more about the challenges they have faced, specifically when going through the permitting process.

IEAGHG would like to thank the following panellists for their involvement in this virtual event:

- **Samantha Neades**, IEAGHG (UK, moderator)
- **Philip Ringrose**, Equinor (Norway)
- **Per Gunnar Stavland**, Equinor (Norway)
- **Bram Herfkens**, Porthos Project (The Netherlands)
- **Preston Jordan**, Lawrence Berkeley National Laboratory (USA)
- **Caroline Huet**, Occidental Petroleum Corporation (Oxy) (USA)
- **Robert Barrow**, Oxy (USA)
- **Myles Culhane**, Oxy (USA)

## Framing the topic

### (Philip Ringrose, Equinor)

This introductory talk looked to set the scene and frame the specific topic of risk management during the permitting process of CCS / CCUS projects. Monitoring of the reservoir can be adapted and applied to $CO_2$ storage monitoring, but it also involves other methods and systems related to special concerns for injection and long-term storage. The $CO_2$ MMV (measurement, monitoring and verification) plan needs to address several issues: safe site operations; compliance with regulatory requirements to address public concerns; and secure long-term storage of $CO_2$. It must be remembered that $CO_2$ storage is a relatively new technology with immature business drivers. In the European Union (EU), the main law guiding storage developments is the EU CCS Directive 2009/31/EC on the geological storage of $CO_2$.

The timeline for $CO_2$ storage is important from initial site selection and development, to operations, to closure, then to post-closure. The post-closure period is typically around 100 years; and it must be noted that this is a much longer timescale than conventional oil and gas operations. The $CO_2$ storage risk profile is very important – the highest risk occurs during injection, then the risk decays rapidly as a function of time (as shown in figure 1, below).

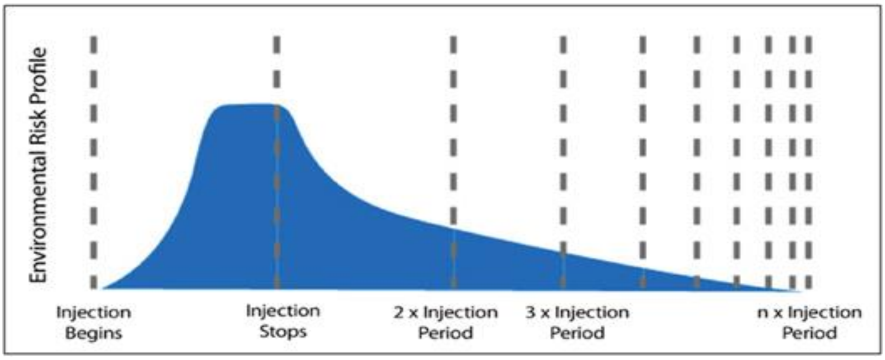


Figure 1. **Conceptual $CO_2$ Storage Risk Profile** (Benson, 2007)

Many projects have been delayed or cancelled because the process of getting the project off the ground was too onerous, or due to public opposition. The Sleipner project, which started in 1996, addressed the regulatory risk by being permitted under the hydrocarbon regulations. However, once the new EC directive was introduced, the project underwent a re-permitting process to ensure the project was compliant with the EU Directive.

The big questions for CCS / CCUS projects are:

- What are the actual project risks?
- What needs to be measured, where and when?
- Regulations and permitting is about linking these questions and then making decisions based on detailed science and engineering.

In discussing the relative benefits of CCS versus the potential risks, there are five types of argument that are used to build confidence in storage safety:

- The climate protection argument, that storing $CO_2$ is better than putting it into the atmosphere;
- The physical basis argument, that $CO_2$ is trapped in microscopic rock pores in the same way it has trapped natural gas for millions of years;
- The operational experience argument, that operations at projects worldwide have shown that CCS works;
- The monitoring argument, that $CO_2$ can be tracked (with some uncertainty) and demonstrate that it is safely stored in the intended reservoir;
- The regulatory compliance argument, that conformance with regulatory requirements with CCS legislation at projects around the world can be demonstrated.

## Northern Lights Risk Management During the Permitting Process

### (Per Gunnar Stavland, Equinor)

The Northern Lights project, a Norwegian full-scale CCS project, uses a shared $CO_2$ sink. The project starts with ship transport of liquid $CO_2$ to a temporary storage on Norway's west coast, before being transported via pipeline onto the permanent offshore geological storage site. The project began by establishing the relevant requirements by utilising existing experience, using generic requirements from onshore and offshore developments, removing the hydrocarbon and other elements not required for $CO_2$ storage regulations, before adding the requirements specific to CCS developments. Their first step was to understand these requirements, starting early and establishing a risk list before moving on to engagement with authorities. Early and repeated information were offered early to initiate discussions and grow relationships with regulators. Dialogue and collaboration have been key to help with the application process and timeline, draft applications, feedback on new legislations and keeping the risk list updated.

The Northern Lights development team was prepared for surprises and breaking new ground, for example, the zoning area was much larger for this project than it would be in typical hydrocarbon operations. The EU CCS legislation (EC Directive) needed to be followed including an exploitation permit. $CO_2$ injection, storage and consent permits were also needed. The exploitation permit was granted in 2019. The consent to plan for development, installation and operation was granted in early 2021 and the exploitation permit was transferred from Equinor to the Northern Lights JV in 2021. Permitting and consent for injection and storage is currently underway and is on track to be granted before start-up.

## Risk Management at the Porthos Project

### (Bram Herfkens, Porthos Storage)

The Porthos $CO_2$ storage plan involves injection into three depleted gas reservoirs, with injection starting in gaseous phase followed by supercritical injection. A storage capacity of 37 mega tonnes has been estimated. The permit application for the project contains preliminary plans for risk management, monitoring, corrective actions and closure, with the plans to be updated 3 months prior to the first injection and then after the first injection along with model calibration. The monitoring periods in the licence require a commissioning / calibration period of 6 months and at the end a signalling period over 12 months to prove stability. In this particular case, the permit approval lead time is around 15 months which is a challenge for the project as permits are needed prior to the final investment decision (FID) is taken.

Risk management in $CO_2$ storage consists of four key types of risk: containment risk (migration, leakage – permit required), seismic risk (seismicity and leakage – permit required), operational risk (flow assurance and control), and commercial risk (injectivity, storage capacity). Porthos used the bow-tie method as their main approach for risk management which helped them structure their risk management plan into four main sections: the HAZID (HAZard IDentification, identifying top risk events); risk assessments using the bow tie analysis; establishing risk controls (preventative barriers); and risk recovery (corrective barriers).

The key technical storage risks are twofold: the $CO_2$ leaves the storage complex; and seismicity. Key threats to these risks identified in the bow tie analysis include thermal fracking (potentially affecting seismicity and containment). To mitigate this potential impact the temperature and flow will be controlled and injectivity monitored. Another threat could be cold front propagation to any faults (affecting seismicity), which can be controlled by careful well selection and pressure increase compensating for the fault stress.

Porthos has learned several lessons pertaining to risk management as the project has developed. The timelines for the licence application did not match with the project maturation. The original seismic risk analysis requirements for the gas fields were not sufficient so geomechanics research and thermal modelling were added. The team also noted that if secondary seals are part of the storage complex, the overburden containment needs to be modelled (in the absence of data or models). Hydrostatic pressure is considered a barrier, but pressure inside the well needs to be higher to fill the reservoir, and a key question is whether or not to keep the storage site and wells open for injection after monitoring. Other questions that arose were whether the project should consider a production or geological timescale, whether a seismicity model should be calibrated for a non-seismic area, and whether any other leakage (such as methane) out of the complex would be accepted.

## A California Perspective

### (Preston Jordan, Lawrence Berkeley National Laboratory)

This talk gave a geologist's perspective on the issue of risk management and the permitting process, with a focus on activities in California. There is a requirement by law to decrease the carbon intensity of transportation energy in the state and there is a credit market to help accomplish this, the Low Carbon Fuel Standard (LCFS), a programme run by the California Air Resources Board (CARB). The price of the monthly LCFS credit price has increased of late, which is improving interest in the geological storage of $CO_2$ but currently there is only one project that has applied for a credit generation certification in the state of California.

The LCFS has pre-construction application elements for a project to proceed and achieve credits, with several factors and requirements to consider. The risk part involves site-based risk assessment, a risk management plan and emergency and remedial response plan. What is required by the state so far is rather site specific, elaborate and non-standardised so there are not many examples for guidance.

The US UIC (Underground Injection Control) Class VI rules are also applicable to CCS projects in the United States that are planning sequestration without utilisation. This legislation is controlled by the federal government and has some similar application elements to the LCFS, but this federal permitting doesn't require an explicit risk management plan, only the emergency and remedial response plan. Both require financial responsibility to be proven but in different ways. There are several projects that have applied for permits under Class VI, particularly in recent years.

## CARB-1 – Oxy's Risk Assessment Approach

### (Caroline Huet, Robert Barrow & Myles Culhane, Oxy)

The CARB-1 project in Texas is operated by Oxy and is designed to store $CO_2$ in an existing enhanced oil recovery (EOR) field in accordance with the LCFS. The application was submitted for a permanence certification to CARB in November 2019 and is currently in the final stages of approval. After receiving permanence certification, CARB-1 is scheduled to receive $CO_2$ from two ethanol plants (approval has been received for the pathways for ethanol production with CCS).

The CARB LCFS requires project applicants to use appropriate tools to characterize potential risks of adverse impacts on the environment, health, or safety, by combining the assessment of the probability of occurrence and the magnitude of the adverse impacts of identified project risk scenarios. Identified risk scenarios must be classified high risk, medium risk, or low risk, according to the combination of probability of occurrence during a 100-year period, and the severity of potential consequences, as shown in Table 1, below. The severity of identified potential consequences must be classified as having a consequence that is insubstantial, substantial, or catastrophic. Any project with risk scenarios that are classified as high risk that cannot be mitigated to medium or low risk will not receive CARB approval. Risk scenarios classified as high or medium risk must be included in a project's emergency and remedial response plan. Risks of $CO_2$ leakage must be evaluated, and only sites in which the fraction of $CO_2$ retained in the storage complex is very likely (greater than 90% probability of occurrence) to exceed 99% over 100 years post-injection, will be eligible to receive CARB approval.

Table 1. **Risk Scenario Classification**

| | Insubstantial[1] | Substantial[1] | Catastrophic[1] |
|---|---|---|---|
| >1%[2] | Medium Risk | High Risk | High Risk |
| 1-5%[2] | Low Risk | Medium Risk | High Risk |
| <5%[2] | Low Risk | Medium Risk | Medium Risk |

1 Probability of occurrence over 100 years
2 Severity of potential consequence

Oxy's risk approach developed and used in-house tools to assess and model risk scenarios, leveraging over 40 years of EOR operations and subsurface knowledge and experience within the Permian basin. It was based on Oxy's robust and experienced multiple disciplines. Oxy found that no evaluated risk scenarios were ranked as high. The medium risk scenarios were addressed in the Emergency and Remedial Response Plan (ERRP). Oxy identified no scenarios that would result in substantial $CO_2$ leakage and calculated that the fraction of $CO_2$ retained in the storage complex is very likely to exceed 99% over 100 years post-injection.

## Q&A and Discussion Session – Summary

The below points summarise the question and answer / discussion portion of the webinar:

- It is important that operators and authorities are aware of their respective roles and provide balance in professional relationships; the Northern Lights Project has been prudent about this.
- The Porthos project dealt with potential leakage rates in the storage application by using bow tie analyses but didn't submit specific percentages or probabilities. Leakage risk was quantified by modelling to be very minimal and acceptable for the application.
- The key component that Oxy looked at when considering long-term liability was the reservoir and the site selection, which is the primary aspect of liability. Oxy selects their reservoirs very carefully and benefits from a great deal of history and data because of their past development in oil and gas applications.
- In a $CO_2$-EOR operation such as Oxy's CARB-1 site, diligence is required with wells and identifying wells not only that are currently operating but also those abandoned or orphaned wells. Operators must locate and properly assess all wells and perform any corrective action that is needed which will help to limit the liability.
- In terms of liability, the California standard requires more than the Class VI programme because it requires the risk assessment, part of which must be demonstrated through modelling as well as reservoir and well assessment, whilst also demonstrating there is a very high likelihood (greater than 90%) that over 99% of the injected $CO_2$ is maintained in the storage complex.

- During the development phase at the Porthos project they looked at the wells and carried out risk assessment and modelling (in particular thermo modelling) to see if there would be any integrity issues with cooling effects. The developers could not rule out the potential of micro annuli or debonding existing between the well casing and cement, so they have limited the maximum pressure in the field to the hydrostatic pressure so there will always be higher pressure in the overburden. Porthos is familiar with the wells in the area as they have been operating in the area for 30 years. There are some examples of other wells that have been decommissioned and came out clean. The site developers have also accounted for any remedial work needed if issues are encountered once the wells are converted from gas production to $CO_2$ injection.
- A key risk to $CO_2$ storage projects is undoubtedly offset or legacy wells, particularly with uncased borings that were dry exploration wells that have been plugged above the base of groundwater which requires protection. These wells can't be readily re-entered for proper plugging.

## Key Messages

- $CO_2$ storage monitoring is similar to conventional reservoir processes but involves additional methods and systems related to special elements for injection and long-term storage.
- The $CO_2$ MMV plan needs to address several issues: safe site operations; regulatory requirements; public concerns; and secure long-term storage.
- $CO_2$ storage is still a relatively new technology with immature business drivers.
- The $CO_2$ storage risk profile is important and shows that the highest risks occur during injection, then the risk rapidly decays as a function of time.
- Risk management in storage involves four key technical areas: containment; seismic; operational; and commercial.
- A key initial step in the risk management and permitting process is to start early and thoroughly understand the requirements.
- Dialogue and collaboration between operators and regulators can be beneficial.
- Operators should be prepared for surprises throughout development and breaking new ground.
- The bow-tie method can be a valuable approach for risk management.
- Leveraging subsurface and operational knowledge and experience is very valuable.
- Long-term liability is an important factor to consider early on in the permitting process.
- The key affecting components of long-term liability are the reservoir and legacy wells, so site selection and well location, assessment and remediation (if needed) are crucial.

## Previous Risk Management Network Meetings

The previous Network webinar was held in December 2020 and was a panel discussion looking at 'Risk Management Over Time at Operating and Future CCS Projects'; a copy of the report from this event can be requested from IEAGHG by emailing tom.billcliff@ieaghg.org, quoting report number 2021-TR01.

The last in-person Risk Management Network meeting was held in combination with the Modelling Network in 2018; for a copy of the report from this meeting, please contact tom.billcliff@ieaghg.org quoting report number 2018-07. For more information on the IEAGHG Risk Management Network, please visit our website at https://ieaghg.org/networks/risk-management-network.

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