Long Term Probabilistic Risk Assessment of Underground Storage Of CO_2

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1. Introduction

- CO_2 Capture and Storage (CCS) in geological reservoirs is an important option to reduce global anthropogenic CO_2 emissions.
- Globally, emissions of CO_2 from fossil-fuel use in the year 2000 totaled about 23.5 $GtCO_2$/yr.

- CO_2 storage in geological reservoirs is the 3rd and last step of (CCS).
- Capture
- Transport
- **Storage**
- Risks, associated with underground CO_2 storage, should be analyzed if CCS is to be applied as safe and effective greenhouse mitigation option.
- 3 Main underground storage options are considered.
- *Deep Saline Aquifers*
  The main type of trapping will occur with the dissolution of CO_2 in the brine solution. The injected CO_2 rises up and is sealed under the cap rock. The suitable depth for injection would be deeper than 800m whereas CO_2 is in supercritical condition.
- *Depleted Oil and Gas Reservoirs*
  CO_2 injection is already in use for Enhanced HC Recovery. The depleted HC reservoirs can trap CO_2 where, these mechanisms have held HC for geological timescales. As the depleted HC reservoir is mostly water saturated, CO_2 will be trapped as it does in aquifers.
- *Unmineable Coal Seams*
  Injected CO_2 will be trapped in 2 ways into the coal matrix: Sorption on the coal surface displacing absorbed CH_4 and physical trapping in the cleats within the coal. CO_2 will be trapped either gas state or supercritical condition depending on the depth.

Storage Option	Global capacity $GtCo_2$
Deep Saline Aquifers	1000-10000
Depleted Oil & Gas Reservoirs	675-920
Coal Beds	10-200

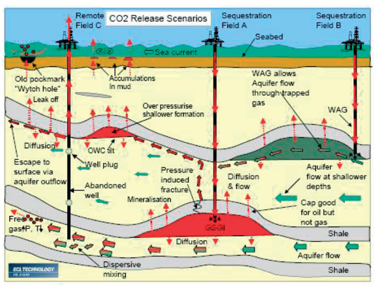
Table 1: Estimated global capacity of CO_2 for the underground options. (IPCC, 2005)

2. Problem Definition

- Large scale underground CO_2 storage is required to timely achieve long-term stabilization of the atmospheric CO_2 concentration at a safe level.
- At present quantitative tools for assessing risk of underground storage do not exist. Regulators need such tools to evaluate HSE risks of proposed CCS activities.

We focus on:

- *Local/Regional environmental consequences of CO_2 leakage.*
  Health, safety and ecological risks may occur in case of sudden release of CO_2 in high concentrations. Prolonged exposure to high CO_2 levels, above 15% can be lethal. Extensive monitoring measures should be implemented to proposed CCS area.
- *Global Environmental consequences.*
  Storage effectiveness is a crucial parameter in the storage phase as the CO_2 leakage from a selected reservoir should be in an acceptable leakage rate. (< 0.1%) in order to prevent climate change. The stabilization target is around 350 to 550 ppm.



Pathways:

1. Underlying Aquifer
2. Cap and Overburden
3. Wells

Figure 1: CO_2 release Scenarios. (IEA, 2004)

3. Objectives

- To develop a methodology to assess the long term effectiveness of CO_2 storage.
- Building further on TNO's FEP approach, develop Quantitative Risk Assessment tool
- To implement, demonstrate and test the tool for an existing site using available monitoring. Such as:
- Weyburn Oil Field
- K12 field -Gaz de France

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4. Methodology

- Develop aggregated risk indicators.
- Individual Risk
  Probability that an average unprotected person permanently present at that point location would get killed due to a CO_2 storage activity.
- Societal Risk
  Probability that group of more than N persons would get killed due to a CO_2 storage activity.
- Ecological Risk
- Health Risk
- Socio-Economic Risk
- FEP database will be used for the developing CO_2 risk scenarios. (Fig.2)
- Risk Assessment methodology is summarized in the Fig. 3. Part of this method can be applied for modeling and HSE impact quantification.
- Our aim is to focus on integration and uncertainty modeling. Therefore we have less precision and work with more simplified models to quantify FEP scenarios. (Fig. 4)
- We will use two approaches to analyze uncertainty.
- Monte Carlo Simulation
- Pedigree Analysis (NUSAP Method)
  Pedigree analysis evaluates the underpinning and scientific status of quantified information, using qualitative criteria such as empirical basis, theoretical understanding, colleague consensus, and validation.

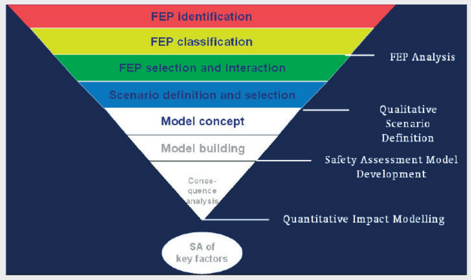

Figure 2: Features-Events-Processes (FEP) Methodology. (CO_2Geonet-2005)

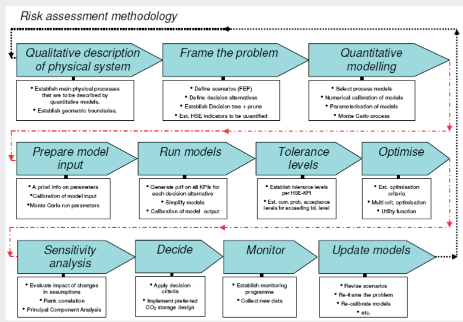

Figure 3: Risk Assessment methodology flowchart used for decision-making and monitoring. (CO_2Geonet-2005)

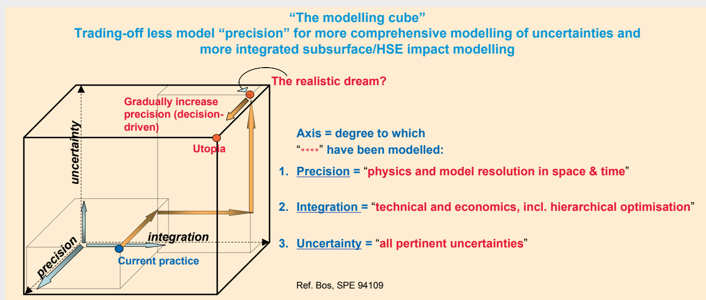

Figure 4: The Modelling Cube (Bos, 2005)

5. Expected Results

- Generic conceptual modeling framework for risk assessment of CO_2 storage sites that can be integrated with existing FEP by TNO.
- Numeric implementation of the modeling framework for specific storage site.
- Insight in key-characteristics that determine reservoir safety.
- Insight in what factors should be monitored for early detection of leakage risks.
- Contribution to CATO project, UCG geo-energy project and to EU's Network of Excellence "CO_2GeoNet" in the development of Risk Assessment and monitoring framework.

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For further information

http://www.chem.uu.nl/nws/www/nws.html
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