



# Site qualification and certification

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# Outline

- Storage potential,
- Site qualification:
  - CCS project lifecycle,
  - Objectives, criteria and recommendations regarding site qualification,
- Site certification,
- Conclusions.

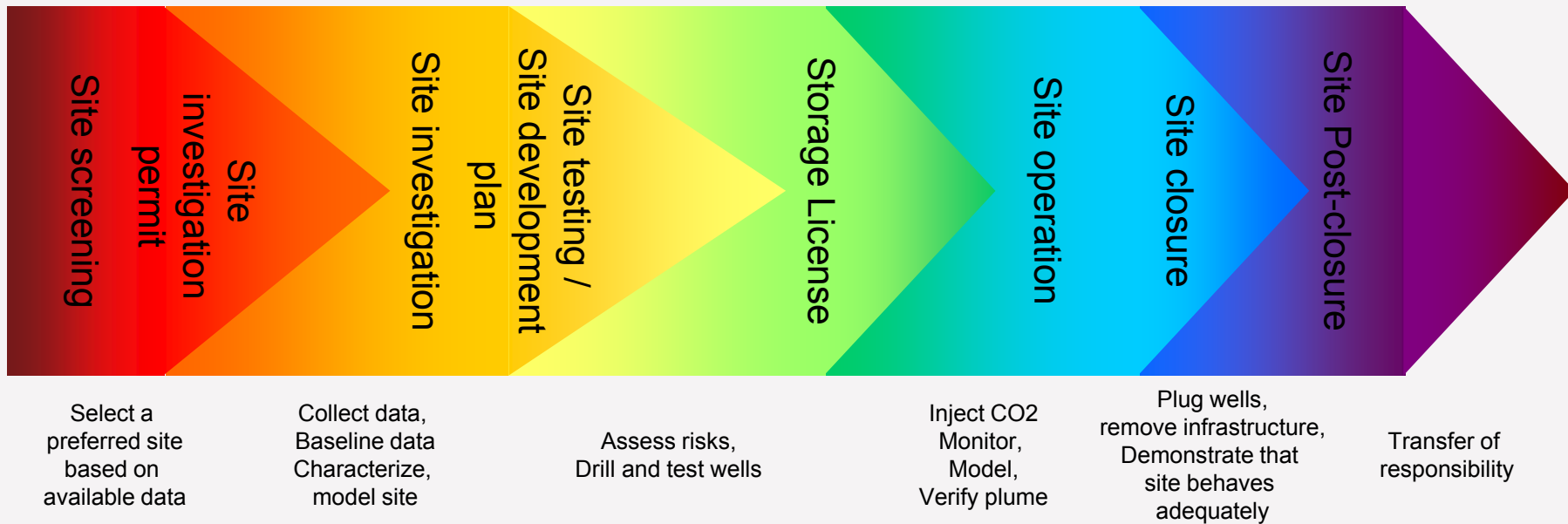


# Storage potential

- Methodologies proposed by the **CSLF, CO2CRC** and EU Geocapacity
- **Capacity estimates in Europe** and collaborative activities with China available in EU Geocapacity and COACH
- **Recommendations:**
  - Test the applicability of the proposed methodology in different settings,
  - Compare different methodologies,
  - Build on experience: assess CO<sub>2</sub> storage capacity at different scales, different storage types, different types of capacity;
  - Gather data to assess properly the storage capacity in some environments,
  - Quantify the relative importance of different trapping mechanisms in different settings, at different times and scales,
  - Quantify the net benefit of changing the scale of the CO<sub>2</sub> storage capacity assessment compared with the costs.



# Site qualification CCS project lifecycle





# Screening

- **Objective:** identify and rank candidate storage sites based on available data and analysis.
- Step mainly discussed in projects
- **Criteria:**
  - CO2 sources location and volumes,
  - CO2 storage capacity,
  - Geology, geophysics,
  - Resource usage,
  - Population,
  - Ecosystems,
  - Preliminary risk assessment,
  - Etc.
- **Recommendations:** Define a methodology using GIS and multicriteria analysis to summarize results and highlight most suitable sites. Tools enable regular updates when new data available.
- Early work in this area:  
*FutureGen, CO2ReMoVe, EU Geocapacity, CO2CRC, SACS-CO2STORE*



## Investigation

- **Objective** : Assess storage potential, provide information necessary to identify sites which perform effectively and safely and conduct a baseline study.
- **Several sub-steps:**
  - Site exploration permit,
  - Data collection,
  - Computer simulation,
  - Environmental impact assessment.



## Investigation

### Site exploration permit

- To undertake surveying activities and outline issues related to sub-surface property rights,
- Required in few regulatory documents,
- Recommendations:
  - Merits of having a phased permit framework ?
    - Give exclusive exploration rights to an operator,
    - Ensure operator qualification to conduct such a work.
  - Include it in storage permit although goals differ ?



# Investigation

## Data collection

### Characterize storage complex:

- Cap rock (extensivity, thickness, penetrations, faults),
- Reservoir characteristics (capacity, injectivity, trapping mechanisms, orientation, faults properties,...)
- Hydrogeology,
- Geochemistry,
- Geomechanics,
- Geophysics,
- Seismicity,
- Geography,
- Potential CO<sub>2</sub> sources,
- In-situ pressure,
- Biology,
- Economic factors

### Characterize transfer pathways:

- Various levels;
- Faults mapping;
- Natural transfer pathways: regional and local faulting, stratigraphic discontinuities, transmissive fractures, structural spill points, pore system;
- Man-made transfer pathways: active, inactive and abandoned wells, location, depth, age, conditions, probability of leakage;

### Characterize potential receptors:

- Various levels;
- Population,
- Land-use,
- Natural and marketable resources,
- Potential interactions with other activities,
- Aquifers, springs, marine environment,
- Seasonal, sensitive, endangered species or habitats,
- Etc.



# Investigation

## Data collection

- **Observations:** discrepancies in the criteria, accuracy required, possible/potential methods of acquisition, definition of the area and depth extent to consider.
- **Recommendations:** develop an agreed list of criteria and a reference guideline document to answer 4 main questions:
  - What data are required to assess a storage complex potential and characterize it,
  - How can these data be collected and potential data transfer to competent authorities,
  - Where should the data be collected: how to define the area of review?
  - What is the acceptable accuracy? Interpolation, heterogenities, variability?
- Early work in these areas:
  - *CO2 capture project: A Technical Basis For Carbon Dioxide Storage – January 2009,*
  - *Futuregen: Environmental Information Volume – Mattoon Site – December 1, 2006.*
  - *CO2CRC Otway*
  - *CO2STORE*



# Investigation

## Computer simulation

- **Objective:** predict the fate and transport of the CO<sub>2</sub> stream.

Others: Determination of potential leakage pathways, secondary effects of CO<sub>2</sub> storage, potential magnitude of leakage events for identified leakage pathways, critical parameters affecting potential leakage, factors that could pose a hazard to human health or the environment, maximum suitable fluid pressure.

- **Input parameters include:** geology, CO<sub>2</sub> properties, storage injectivity, reactive processes, fracturing, fracture propagation, leakage scenarios,
- **Outputs include:** pressure-volume behaviour, areal and vertical CO<sub>2</sub> plume extent, nature of CO<sub>2</sub> flow in the reservoir, trapping mechanisms, rates, storage capacity, pressure gradients, storage integrity, changes in formation fluid chemistry, etc.
- **Model updates** crucial to better and more accurately predict CO<sub>2</sub> behaviour in the subsurface (start model early- during site screening or investigation).



# Investigation

## Computer simulation

- **Recommendations:**

- Continue improving and standardizing modelling techniques to predict injected CCS stream movements,
- Develop reference guideline document to include:
  - Data inputs: need of field data collection, degree of accuracy, data available in the literature,
  - Codes available, advantages and limits,
  - Outputs that can legitimately be expected, sensitivity, timescale, potential for improvement if more data are collected,
  - Benefits of developing a model at an early stage and updating the model as more data are collected.



# Investigation

## Environmental Impact Assessment

- Result of site investigation and basis for approval of a CCS project.
- Includes: baseline study, exposure assessment, effects assessment and risk characterization, uncertainty management plan,
- See WP3 – Safety and Liability.



Site

Development

Plan

- **Objective:** identify the risks and the strategies for dealing with them to ensure safe and secure permanent storage.
- Can include: Environmental Impact assessment, risk management plan, operation plan (including wells), site closure plan,
- Tightly linked to storage licence,
- Refer to next section.



**Storage  
Licence**

- Can be divided into:
  - Application requirements,
  - Conditions of acceptance,
  - Content,
  - Duration,
  - Conditions of changes.



### **Storage Licence**

#### Application requirements

- In most documents:
  - characterization of storage site and complex,
  - assessment of expected security and effects of the storage on the environment,
  - quantity of CO<sub>2</sub> to be injected and stored,
  - composition of CO<sub>2</sub> streams and injection rates,
  - proposed monitoring plan,
  - corrective measures plan / contingency plan,
  - proposed provisional closure plan / post-closure plan,
- Additional information required in some documents. Level of details different depending on the document.



# Storage Licence

## Conditions of acceptance

- Can include:
  - Approval process,
  - Adequacy of injection zone to total anticipated volume of CO<sub>2</sub> stream,
  - Reservoir integrity,
  - Permanent storage,
  - Proper monitoring plan,
  - Proper impact evaluation,
  - Minimization/no significant risks.



## Storage Licence

Content and duration  
Conditions of changes

- **Content** mentioned in only 2 documents,
  - Enable to homogenize the licences and their requirements.
- **Duration:** in some documents, from 5 years to the duration of the facility operation.
- **Conditions of changes** (in 2 documents): changes in areal extent, in reservoirs, increase in permitted CO<sub>2</sub> storage volume, changes in CO<sub>2</sub> stream, significant irregularities, other failures.



# Storage Licence

- **Observations and recommendations:**
  - Requirements for storage licence application, its duration, its conditions of acceptance largely vary in their phrasing and level of details.
  - Absence of values, thresholds, standard criteria for storage site suitability, storage licence evaluation and acceptance.
  - Absence of consistent framework may be the cause of quasi-absence of site certification process and may strengthen the need of such a certification process.
  - Property rights, potential conflicts between storage operators in the same storage or adjacent storage, cross-boundary storages, compensation of surface property owner in case of damages rarely mentioned.



# Site operation

- Several sub-steps:
  - Construction,
  - CO<sub>2</sub> stream injection,
  - Monitoring,
  - Reporting,
  - Measures in case of significant irregularities or leakage.



### Site operation

### Construction

- Limited to **well drilling and testing and injection well construction**;
- **Includes:** operational practices, materials used, number and age of wells, potential geophysical changes, pathways in case of leakage, storage duration;
- In US documents, CO2 capture project and FutureGen.
- **Recommendations:**
  - Develop standards for CO2 injection well drilling, testing and maintenance.



### Site operation

CO<sub>2</sub> stream injection

- Large variability in **CO<sub>2</sub> stream composition**,
  - Mention mostly in the policy documents, rarely in the projects (except OTWAY: 80% CO<sub>2</sub>, 20% methane)
  - Recommendations:
    - experience feeds back discussions over CO<sub>2</sub> stream composition,
    - Regulations specify where the quality and quantity of the CO<sub>2</sub> stream should be monitored.
- Injection pressure



### Site operation

### Monitoring

- **Monitoring objectives:** ensure that CO<sub>2</sub> plume is confined in the intended subsurface formations, detect migration and leakage and detect significant adverse effects
  - Additional objectives: reassure the public, document injection well control and storage performance, demonstrate the robustness of long-term predictions regarding plume behaviour.
  - Recommendations:
    - Emphasize the need to compare actual and modelled CO<sub>2</sub> plume behaviour and need to update the model and its predictions regularly,
    - Emphasize the need for public information.
    - Emphasize the need for monitoring at **all steps** of a CCS project
    - Define how and when monitoring can stop.



# Site operation

## Monitoring

- What and which **parameters should be monitored** ?
  - Differences in the parameters to monitor: injected fluid, volume injected, reservoir pressure frequently mentioned, geochemical changes, corrosion monitoring, integrity of injection wells, environment more rarely cited.
  - Technology required / advised rarely mentioned in policy documents, but mentioned in most projects,
  - Variable frequency of monitoring.
  - **Recommend developing a reference document regarding storage site monitoring:**
    - How to build a conceptual model?
    - How to define the area to be monitored? How often to re-evaluate it?
    - How to design a monitoring program?
    - Which entities can/need to be monitored?
    - Which parameter(s) to follow/monitor, what is the BAT? What is its accuracy? What is the appropriate frequency of monitoring?



### Site operation

### Reporting

- **Reporting (in policy documents):** quantity and quality of CO<sub>2</sub> stream – Frequency varies.
- **Routine and non-routine inspections** (in the draft EU CCS directive).  
At least once a year.
  - Recommend developing standards to carry out inspections in a similar manner.



### Site operation

Measures in case of  
significant leakage

- Person to inform and procedure to follow vary,
- Potential mitigation measures rarely cited (recapping wells, repairing faults in cement, drilling intersecting wells, lowering injection pressure or well pressure, halting injection, etc.); projects analysed don't deal with this aspect.
- **Recommend developing guidance document:**
  - What are the potential significant irregularities or leakage?
  - What are their potential impacts (qualitative and quantitative)?
  - What are the possible mitigation measures?



**Site closure**  
**Post-closure**

- **Closure plan** required in most policy documents,
  - Conditions leading to license termination in some documents,
  - Activities regulated and activities to be covered,
  - Requirements/recommendations for site closure greatly vary: plants and equipment decommissioning, reduce residual risks, flushing each well, test mechanical integrity, plug, record pressure differential between pre-injection and anticipated post-injection pressures, predicted plume position, revisions of performance assessment and remediation plans, etc.
  - **Recommendations:**
    - Standard/guidance document: Content of a closure plan, best practices for plant and equipment decommissioning,
    - Report comparing environmental status before and after injection.



Site closure  
Post-closure

- Site closure registration/record required in half the policy documents and 2 projects,
  - Recommend record keeping to inform future generations of plume location(s), well location(s), geology and potential mitigated impacts, to avoid future subsurface activities disturbing the CO<sub>2</sub> reservoir.
- **Closure and post-closure monitoring objectives** include:
  - Monitor CO<sub>2</sub> plume position and pressure front, no source of drinking water endangered,
  - Acquire confidence in long term fate of injected fluids and accuracy of long-term modelling scenarios,
  - Secure well heads and ensure site integrity.



Site closure  
Post-closure

- No policy requirement regarding **parameters to monitor**;
- In projects: monitor CO<sub>2</sub> plume movements, reservoir pressure, temperature, composition and well integrity; conduct seismic and atmospheric monitoring survey.
- Differences in the **length of the post-closure monitoring period**;
- **Financing** of the post-closure monitoring addressed in few documents.



**Site closure**  
**Post-closure**

- **Recommendations:**

- Brain storm on:

- The objectives of the post-closure monitoring,
- What/which parameters should be monitored?
- What to do in case of significant irregularities? If predictions do not fit the observed plume behavior?
- How long and how often should the site be monitored? Which criteria should be decisive for the end of the monitoring?
- Who should finance? Should a guarantee fund be created? As suggested in the US and in CO2 Capture Project ?



# Site certification

- Rarely mentioned,
- Certification = validation of data/reports by a third-party.
- **Recommendations** (see also CO2Qualstore):

CCS Project phase	Verification Operator and Competent Authority	Certification Third-Party
Site investigation	Storage permit	Certify that site selected based on agreed criteria and process
Site operation	Monitor - Report	Certify that site performed as expected.
	Monitor CO2 captured/injected / stored - Report	Certify the quantity of CO2 stored, potential link with the CDM
Site closure	Requirements – Monitor - Report	Certify that site closed and plume behaves as expected
Site post-closure	Monitor – Assess performance - Report	Certify that CO2 safely and securely stored – Transfer responsibility based on agreed criteria



# Conclusions

- **Site qualification:**
  - Agreed objectives for each step of a CSS project,
  - Differences in the level of details required / reached,
  - Approach adopted by most documents: allow flexibility; no techniques, values, thresholds, methods of evaluation given,
  - Develop guidance documents for available and best technologies, advantages, drawbacks, type of settings, costs, stage of development...
  - Suggestion: develop guidance documents for the EU CCS directive implementation, as done for the EU WFD
- **Site certification:**
  - On-going !



# Questions ?

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# Relevant Institutions

- **National Development and Reform Commission (NEB)**
- **The State Council of the People's Republic of China**
- **Ministry of Environmental Protection (MEP)**
- **Ministry of Land Resources (MLR)**
- **Ministry of Water Resources (MWR)**
- **General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ)**
- **Provincial Governments, Autonomous Regions and Municipalities**



# Existing Regulation

- London Convention
- Project Approval Report (Exploration and Operation Licenses)
  - Mining Law (Operation rights, Duration), EIA , Water regulation, Oil and Gas regulation, Energy Regulation (Capture ready?), Waste regulation (exclusion of CO<sub>2</sub>?)