



Site qualification and certification

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Outline

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

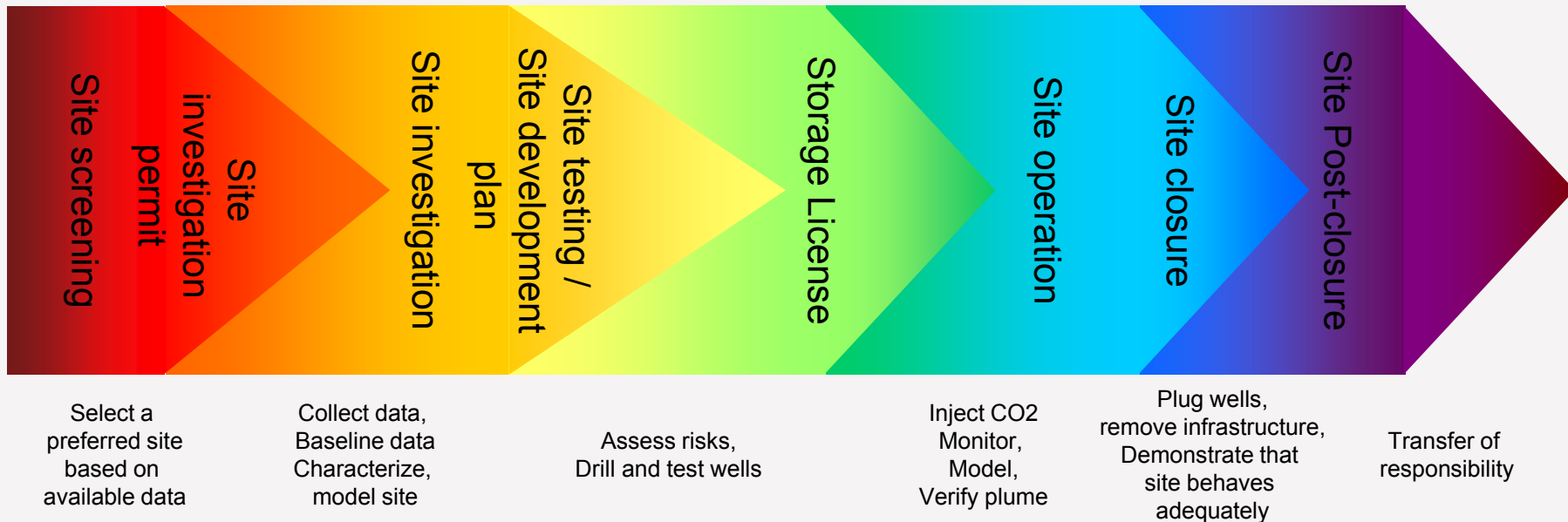


Storage potential

- Methodology proposed by the CSLF and EU Geocapacity
- Capacity estimates in Europe and China available in EU Geocapacity
- Recommendations:
 - Test the applicability of the proposed methodology in different settings,
 - Compare different methodologies,
 - Build on experience: assess CO₂ 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 CO₂ 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.
- **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, Results of site offeror proposal – Proposal Evaluation – July 21, 2006.*



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 CO₂ 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.*



Investigation

Computer simulation

- **Objective:** predict the fate and transport of the CO₂ stream.

Others: Determination of potential leakage pathways, secondary effects of CO₂ 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:** CO₂ properties, storage injectivity, reactive processes, fracturing, fracture propagation, leakage scenarios,
- **Outputs include:** pressure-volume behaviour, areal and vertical CO₂ plume extent, nature of CO₂ 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 CO₂ behaviour in the subsurface.**



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, 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 CO₂ to be injected and stored,
 - composition of CO₂ streams and injection rates,
 - proposed monitoring plan,
 - corrective measures 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 CO₂ 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 CO₂ storage volume, changes in CO₂ 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,
 - CO₂ 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 and CO₂ capture project: *A Technical Basis For Carbon Dioxide Storage – January 2009.*
- **Recommendations:**
 - Develop standards for CO₂ injection well drilling, testing and maintenance.



Site operation

CO₂ stream injection

- Large variability in **CO₂ stream composition**,
 - Recommendations:
 - experience feeds back discussions over CO₂ stream composition,
 - Regulations specify where the quality and quantity of the CO₂ stream should be monitored.
- Injection pressure



Site operation

Monitoring

- **Monitoring objectives:** ensure that CO₂ plume is confined in the intended subsurface formations, to detect migration and leakage and to detect significant adverse effects
 - Recommendations:
 - Emphasize the need to compare actual and modelled CO₂ plume behaviour and need to update the model and its predictions regularly,
 - Emphasize the need for public information.
- 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,
 - Variable frequency of monitoring.



Site operation

Monitoring and reporting

- **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?
- **Reporting:** quantity and quality of CO₂ 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.),
- **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 documents,
 - Conditions leading to license termination in some documents,
 - Activities regulated and activities to be covered,
 - Requirements 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, etc.
 - **Recommendations:**
 - Standard 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 documents,
 - Recommend record keeping to inform future generations of plume location(s), well location(s), geology and potential mitigated impacts,
- **Closure and post-closure monitoring objectives** include:
 - Monitor CO₂ 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.
- No requirement regarding **parameters to monitor**;
- 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? Create a guarantee fund? 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: no techniques, values, thresholds, methods of evaluation given,
- **Site certification:**
 - On-going !