

ARB's Carbon Capture and Sequestration (CCS) Program

CCS Technical Discussion Series: Site Selection

Background on ARB's CCS Technical Discussions

The Air Resources Board (ARB) is currently developing a program to allow for the use of carbon capture and sequestration (CCS) in its climate change programs, and to advance the use of CCS as a greenhouse gas (GHG) reduction strategy generally. As part of this effort, ARB's CCS program staff seeks to better understand the ability of CCS to contribute to California's climate goals, the limitations or advantages of the technology, and the innovation and incentives necessary for adoption. To support this work, ARB is developing a quantification methodology (QM) for CCS projects. The CCS QM may be adopted for use in the Cap-and-Trade and Low Carbon Fuel Standard programs as determined appropriate in rulemaking(s) specific to these programs. For more information on ARB's CCS program and development of the QM please visit our website at <http://www.arb.ca.gov/cc/ccs/ccs.htm>.

In order to ensure staff is using the best available information and understands stakeholder concerns, we are hosting a series of technical discussions. The CCS technical discussions are topic-focused, stakeholder-led discussions. The intent is to allow interested parties to provide input that will inform development of the CCS QM, as well as the CCS program generally. ARB will identify subject areas and specific questions, with the expectation that stakeholders will provide presentations, or other materials, and participate in an open discussion.

The CCS technical discussions will be accessible via webinar, conference call, and in-person at ARB headquarters in Sacramento, California. At the discussion, ARB will provide a short overview of the identified subject area, as well as other information pertinent to the discussion if applicable, but the primary focus will be on stakeholder presentations and discussion. ARB generally will not provide a presentation or formal meeting notes, but will post all stakeholder presentations or other submitted materials to ARB's CCS website at <http://www.arb.ca.gov/cc/ccs/meetings/meetings.htm>.

Site Selection Technical Discussion

Site selection is the process of accepting or rejecting potential CO₂ injection wells and reservoirs based on specified geologic, hydrologic, geospatial, or other parameters. For the purposes of this technical discussion, "site" will refer to a geographical location in 3D space (i.e., including its underlying rock strata) that will be impacted by CO₂ injection. This will include considering all aspects of that physical area that may be affected such as, but not limited to, existing wells, CCS injection wells, the biosphere (including soils, aquifers, plant, animal, and human life), water resources, and geology. Careful site selection can minimize the likelihood of potential impact of CO₂ surface leaks and maximize CO₂ trapping in the target storage zone. A well-chosen site with reliable

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sealing layers, appropriate geology, and good spatial location¹ can significantly decrease risks and challenges encountered during the life of a CCS project. In addition, site selection requirements are one of several components of the comprehensive CCS QM being developed by ARB that will ensure that emissions reductions are real, permanent,² quantifiable, verifiable, and enforceable.

Staff conducted an extensive literature review of suggested site selection criteria including standards from the National Energy Technology Laboratory and U.S. Department of Energy,³ the California Energy Commission,⁴ the International Energy Agency Greenhouse Gas R&D Programme and Alberta Research Council,⁵ the Cooperative Research Centre for Greenhouse Gas Technologies,⁶ the World Resources Institute,⁷ and Det Norske Veritas AS.⁸ During the course of this review, ARB staff has identified three categories of characteristics as important factors for determining whether an injection site is suitable for permanent CO₂ sequestration: 1) geologic and containment factors, 2) modeling factors and plume size, and 3) site development/local factors. Each of these factors should be considered during a site suitability determination. For a CCS QM, staff will need to identify specific requirements and analysis techniques for each of these factors that can be expected to ensure permanent CO₂ containment.

The site selection technical discussion is meant to provide stakeholders with an opportunity to give input on the information and minimum requirements that should be considered when determining whether a proposed CCS injection site would be suitable for permanent CO₂ sequestration. The primary intent of this technical session, and the focus of the guidance questions at the end of this document, is to identify specific requirements and analysis techniques for factors necessary to ensure permanent CO₂ containment.

As a reminder, ARB site selection requirements for the CCS QM are not permitting requirements. Injection well permitting will be completed through either the U.S. Environmental Protection Agency (U.S. EPA) for Class VI wells or through the California

¹ This phrase refers to considering the proximity of the injection well to other wells, faults, population centers, sensitive natural zones, or other important factors that may impact either the permanence of the CO₂ sequestration or the safety and reliability of the site.

² ARB has already adopted a definition for "permanent" as part of its Cap-and-Trade Regulation.

³ National Energy Technology Laboratory and U.S. Department of Energy. Best Practices for: Site Screening, Selection, and Initial Characterization for Storage of CO₂ in Deep Geologic Formations. Draft Edition. June 2010. Report DOE/NETL-401/090808.

⁴ Oldenburg, Curtis M. 2006. Health, Safety, and Environmental Screening and Ranking Framework for Geologic CO₂ Storage Site Selection. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2006-090.

⁵ International Energy Agency Greenhouse Gas R&D Programme. CCS Site Characterisation Criteria. July 2009. Report No. 2009/10. 112 pages. Summary concentrates on page 95-100.

⁶ CO2CRC, 2008. Storage Capacity Estimation, Site Selection and Characterisation for CO₂ Storage Projects. Cooperative Research Centre for Greenhouse Gas Technologies, Canberra. CO2CRC Report No. RPT08-1001. 52pp. Summary concentrates on pages 18-37.

⁷ World Resources Institute (WRI). CCS Guidelines: Guidelines for Carbon Dioxide Capture, Transport, and Storage. Washington, D.C.: WRI. Summary concentrates on pages 83-91.

⁸ Det Norske Veritas AS. Recommended Practice: Geological Storage of Carbon Dioxide. April 2012. Revised July 2013. Report DNV-RP-J203. Summary concentrates on pages 13-25.

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Department of Conservation, Division of Oil, Gas, and Geothermal Resources (DOGGR) for Class II wells. All injection wells and sites will need to meet these permitting standards in addition to any other State or federal requirements. Therefore, any site selection requirements selected for the CCS QM will be in addition to the permit requirements and will be necessary requirements for CCS actions to be recognized under California's climate programs. It should also be noted that DOGGR is currently in the process of modifying their injection well regulations.

Participating in the Site Selection Technical Discussion

DATE: Monday, September 26, 2016

TIME: 9:30 a.m. to 4:00 p.m.

To attend in person:

LOCATION: Room 550

ADDRESS: Cal/EPA Headquarters Building

1001 "I" Street

Sacramento, California 95814

To participate by webinar:

<https://attendee.gotowebinar.com/register/6341629402456391938>

To participate by teleconference:

United States: +1 (213) 929-4232

Access Code: 189-096-252

Please note that this is a toll call.

Presenting at the Site Selection Technical Discussion

If you would like to present at the Site Selection Technical Discussion, please contact Ms. Sara King at (916) 323-1009 or Sara.King@arb.ca.gov by September 16, 2016. ARB is requesting that presentations be limited to 20 minutes. Depending on interest, ARB may adjust presentation length and will communicate this to presenters ahead of time.

If you require special accommodation for the scheduled meeting or need this document in an alternate format (e.g., Braille, large print) or another language, please contact Ms. Regina Cornish at (916) 327-1493, as soon as possible. TTY/TDD/Speech to Speech users may dial 711 for the California Relay Service.

If you have questions about the Site Selection Technical Discussion, please contact Ms. Sara King, Air Pollution Specialist, at (916) 323-1009 or Sara.King@arb.ca.gov.

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Questions to Guide the CCS Site Selection Technical Discussion

The following section provides a list of questions that is intended to guide stakeholder presentations and the discussion generally. Please note that this list is not exhaustive either in topics or questions, and that, when developing site selection requirements, ARB must adhere to the requirements of Assembly Bill 32 (AB 32), the California Administrative Procedures Act, and ARB's current AB 32 regulations, such as the Monitoring and Reporting Regulation (MRR), which has specific accuracy requirements.

Factors for Determining Suitability of CCS Injection Sites

After a broad literature review, we identified three key categories and developed a list of factors for determining the suitability of a CCS injection site for permanent CO₂ sequestration:

- Geologic and Containment Factors
 - Knowledge of injection formation characteristics: depth, porosity, permeability, thickness, max capacity, fracture pressure, and heterogeneity (vertical and horizontal)
 - Knowledge of confining formation characteristics: porosity, permeability, thickness, continuity and integrity, fracture pressure, and heterogeneity (vertical and horizontal)
 - Identify pre-injection background for characteristics such as groundwater chemistry, seismic levels, pressure/temperature conditions, etc.
 - Identify trapping mechanisms
 - Identify potential leakage pathways
 - Identify the amount and need of corrective action for the site
 - Determine potential injectivity: planned injection rate and total injection volume
 - Identify and define pressure limitations for the site
 - Evaluate geomechanical response to anticipated pressures
 - Evaluate hydrological response and communication in reservoir
 - Perform geochemical interaction analysis
 - Evaluate existing and anticipated seismic concerns
- Modeling Factors and Plume Size
 - Define minimum modeling parameters required
 - Define acceptable limitations or uncertainties in the model used
 - Model should determine how reservoir boundaries will affect the plume
 - Model should determine anticipated plume extent, pressure front extent, and help set area of review boundaries
 - Model should identify any areas of seismic concern

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- Site Development/Local Factors
 - Determine proximity to sources of CO₂
 - Determine proximity to protected environmental areas and environmental justice communities
 - Determine proximity to population centers
 - Required consideration of existing resource development (impact on local aquifers, oil/gas fields, mineral resources, etc.)
- 1. Are there any factors or information not included in the bulleted list above that should be included? Why?
- 2. Are there any factors or information included in the bulleted list above that should not be included? Why?

Minimum Requirements

1. What minimum requirements, if any, should be placed on injection formation characteristics such as depth, porosity, permeability, bed thickness, bed heterogeneity, fracture pressure/rock strength, and overall reservoir maximum capacity?
2. What minimum requirements, if any, should be placed on confining (caprock) formation characteristics such as porosity, permeability, bed thickness, bed heterogeneity, bed continuity and integrity, and fracture pressure?
3. How should the existence and proximity of large faults to the injection site be evaluated? Should there be proximity limits to how close injection can occur to a large fault?
4. How should risk factors based on these geologic characteristics impact monitoring requirements?

Determining Suitability of Sites Based on Modeling or Other Techniques

1. Background information collected prior to site disturbance in regards to local seismic activity, groundwater chemistry, and soil gas may be useful for comparison when making later determinations about whether an injection project is polluting or damaging the region in any way. Is there any other scientific background data that stakeholders think should be collected for a site? At minimum, how long prior to injection should background data be gathered?
2. Can analysis and/or modeling determine estimated percentages of CO₂ that will be isolated by the different trapping mechanisms (structural, dissolution, residual, and mineral)? If possible, should such an analysis be required? Why or why not?

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3. U.S. EPA Class VI injection well permitting currently requires that injection pressure does not exceed 90% of the fracture pressure of the reservoir zone(s). DOGGR Class II injection well permitting currently requires that injection pressure remain below the fracture pressure of the injection zone. Are these sufficient safeguards to ensure containment or should more stringent standards be required? Why or why not?
4. What types of models currently exist that can help evaluate a CCS injection site based on geomechanical, hydrological, and/or a geochemical basis? What are the pros and cons of each model?
5. How much uncertainty is common in these types of models? What would be some methods and/or requirements to prevent biases being produced in the model results?
6. How should the modeling results influence monitoring techniques?
7. U.S. EPA Class VI injection well permitting currently requires computational modeling to determine the area of review. DOGGR Class II injection well permitting currently requires the Supervisor to decide based on minimum space, in acres per well, and on the geologic geometry of the pool. Should we require more stringent area of review requirements? If so, what should they be and why?

Other Concerns

1. Should there be restrictions on the allowable proximity to sensitive areas such as protected wildlife zones, heavy population centers, or other valuable resources? Why or why not? If so, what kind of distance would be sufficient in each case?
2. What data should be required to evaluate faults and fractures in the CCS project area? What data should be required to evaluate induced seismicity risks? What technology is available for acquiring this data?
[Note: While ARB staff recognize that seismicity evaluation is a site selection issue, this subject will primarily be discussed in our following technical discussion on Health and Environmental Risks and Environmental Justice.]