

Interactive comment on “Brine migration along vertical pathways due to CO injection – a simulated case study in the North German Basin with stakeholder involvement” by A. Kissinger et al.

Anonymous Referee #2

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Review of the manuscript “Brine migration along vertical pathways due to CO₂ injection – a simulated case study in the North German Basin with stakeholder involvement” by Kissinger et al.

This manuscript attempts to demonstrate application of an approach to incorporate stakeholder input to address the issue of brine migration during CO₂ injection operations for CO₂ storage. The authors have divided the manuscript in three sections with first section focused on the stakeholder input process, Participatory Modeling (PM). This section is followed by Geologic Modeling section and finally Numerical Modeling of brine migration. The authors’ attempt to describe each of these sections in detail but this resulted into a manuscript that is long, incoherent and un-coordinated. It is not

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clear what is the primary objective of this study. Is it to demonstrate how stakeholder involvement/input is critical? If so, the manuscript does not effectively demonstrate it and need to be restructured and rewritten.

I agree with the first referee that it will help to divide this manuscript in two focused manuscripts as part of a larger co-ordinated study. The first manuscript could focus on the details of the PM process including the steps taken to identify stakeholders, what was the objective of stakeholder input, steps take to design surveys, details of the information provided to stakeholders (in both stages, interviews and workshop), details of what information from stakeholders was used and how in the two stages (after face to face interviews and after workshop), how stakeholder input was evaluated, etc. It was not effectively demonstrated why the issues raised by stakeholders were not considered during the initial phase of study. Was it because of lack of data, expertise? What information/knowledge did the stakeholders have that was different than the “geo-modelers”? It will also be beneficial to demonstrate how the process used in PM compares with the “expert elicitation” process used for “risk assessment” of field projects, such as the ones used for Otway basin field test or Illinois basin Decatur field project. The second manuscript could focus on the geologic model and numerical models with details related to why the specific geologic model was chosen (e.g. representative geology with significant CO₂ storage capacity with potential for deploying future field projects), assumptions used to build the conceptual model and geologic model, data used for model, the differences in various versions of the models (preliminary i.e. one prior to May 2013, updated version 1 i.e. one post May 2013 but prior to Sep 2014 and updated version 2 i.e. one post Sep 2014). Similarly the various versions of numerical models with accompanying assumptions and associated numerical simulation results can be presented as well. Both of these (geologic and numerical models) can be presented to demonstrate how the stakeholders’ inputs were evaluated and used, how the results changed based on inputs from stakeholders and what if any further insights were gained because of stakeholder feedback. I think demonstrating how the stakeholder input changed the results is the critical part of this study and needs

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to be demonstrated effectively. The discussions could be used to show the implications (if any) of the changes resulting from stakeholder inputs.

There are a number of grammatical errors and confusing, awkward sentences throughout the manuscript. The quality can be improved tremendously with the help of a technical editor.

Specific comments:

Introduction: The authors have not referred to any work related to “expert elicitation” that has been done in the context of various CO2 storage projects.

Line 15 (Page 1): should include "carbon".

Lines 15-20 (Page 1): What do authors mean by "large" demonstration projects? The transition from pilot scale to large scale has already happened as noted on GCCSI website (<https://www.globalccsinstitute.com/projects/large-scale-ccs-projects>). Currently there are 15 ongoing large scale projects around the world while another seven are under construction. On a side note the GCCSI website also defines what is meant by "large scale" projects. The 22 projects include not only "demonstration" projects but also "commercial" projects. I think we are beyond the "transition to large-scale demonstration projects" stage. What we need is "significantly higher than current deployment of large-scale commercial projects to demonstrate the potential of CCS technology to mitigate global climate change". I suggest that the authors not only modify the sentence but also add the appropriate data on current number of "large-scale" projects including citation.

Line 22 (Page 1): Check the grammar.

Line 1 (Page 2): Not all the "abandoned" wells will lead to vertical displacement of brine, but only "improperly plugged abandoned wells". There are a number of peer-reviewed publications as well as field data that demonstrate that "properly plugged abandoned wells will not lead to migration of brine as well as CO2 away from primary storage

reservoir". I suggest "abandoned wells" should be changed to "improperly plugged abandoned wells".

Lines 5-10 (Page 2): The authors should clearly note that the large extent of brine migration is within "primary storage" reservoir.

Line 16 (Page 3): Does the warmer formation water mean "deeper saline aquifer water" referred to in the previous sentence? Need to be consistent.

Line 18 (Page 13): The sentence is confusing and needs to be reworded.

Line 19 (Page 13): "The later is the most relevant. . ." what is the later as there is only reference to NGB in the previous sentence.

Line 24 (Page 24): You talk about "public acceptance and understanding" yet it looks like all the stakeholders used in this study are "technical and scientific experts" and also the PM process is designed such that only "technical inputs are sought and used". This needs to be better clarified. Also, public acceptance is not required for site identification process but rather during permit application process once a site is chosen.

Figure 1 (Page 4): should be updated to show what was done prior to May 2013.

Lines 20-24 (Page 4): It will be really beneficial to give additional information related to NGB that will justify its use for this study. It could be details related to its valuation as long-term CO2 storage target or other similar information.

Line 5 (Page 5) should be "an elongated anticlinal structure".

Lines 12-15 (Page 5): Please check the grammar.

Lines 5-6 (Page 6): It will be beneficial to give additional information about the interviewees? What public authorities? Who from science community or independent experts (i.e. what was their technical background)?

Lines 11-12 (Page 6): This sentence is confusing. What does it mean that the stake-

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holders favored an absolute understanding? Does it mean that the stakeholders think that any intrusion of brine is considered damage implying a zero-risk tolerance?

Lines 15-17 (Page 6): Do the authors imply that the unsolved issue related to brine intrusion in groundwater and resulting salinity change was ignored subsequently? I got the feeling that this issue was just left hanging in the manuscript. How to regulate salinity change due to leakage one of the most critical issues related to risks of leakage in groundwater aquifers. There is debate on whether it should be no-impact or some threshold. This has significant cost implications.

Lines 18-20 (Page 6): This comment is applicable to the entire process of Stakeholder interviews as described in Section 2.2.

Table 1 (Page 7): It will be beneficial to add another column to show how the stakeholders suggestions were implemented (if they were).

Line 1 (Page 7): The authors need to be clear that wellbores, faults or hydrogeologic windows are “hazards” not risks. The risks results from leakage and impacts.

Line 1 (Page 7): What criteria was used to agree that “man made risks are less relevant”? A proper justification needs to be provided rather than one sentence.

Line 8 (Page 7): What are the details of preliminary simulations? What did they include? What were the results? What was presented to the stakeholders prior to the interviews? The questions described on Page 8 are very technical. What background did the stakeholders have to evaluate these questions?

Lines 24-26 (Page 8): Check grammar

Line 31 (Page 8): Why did the authors consider brine injection instead of CO₂ injection and proposed it? Is it to reduce the simulation time? Is it to simplify analysis?

Line 1 (Page 9): This sentence is confusing, what does it mean?

Section 2.4: I suggest making a table to effectively describe the feedback to modelers.

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The text and description is not clear.

Figure 6: I think it will be extremely effective to show the differences in the two versions (initial and post-interview) of the geologic models in the same figure.

Overall thoughts on the scenarios considered in the numerical simulations: I think these scenarios should have been considered irrespective of stakeholder inputs, given various uncertainties. Is there any specific reason they were not?

Table 4 (Page 16): Why was the CO₂ injection rate of 0.5 MT/year chosen? Given that the brine migration is strongly linked to injection rate, why was the scenario with variable injection rate not considered?

Figure 10 will benefit greatly with better marking of contours (may be through contour numbers on the figure)

Figure 11: Needs to be better explained. What are the figures on the left?

The results of numerical simulations described in section 5 are fairly intuitive and do not effectively demonstrate how the stakeholder input has helped to improve understanding/characterization of salt migration.

Page 27: First main finding says that participatory modeling raised issues that “were originally not intended for implementation”. I don’t think the study has effectively demonstrated this. There is no description of what issues were not intended for implementation, why and what led to changes. These are important points to demonstrate effectiveness of PM (expert elicitation) process.

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