Peer Review Report

Review Report on Evaluating the Economic Potential for Geological Hydrogen Storage in Australia

Original Research, Earth Sci. Syst. Soc.

Reviewer: Johannes M Miocic
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EVALUATION

Q 1 Please summarize the main findings of the study.

- Salt caverns are economically much more likely to play a major role for hydrogen storage in Australia than depleted gas fields
- For different scenarios of the hydrogen origin (renewables, SMR+CCS) different spatial areas are highlighted as being economically more viable.

Q 2 Please highlight the limitations and strengths.

Limitations:
- The methodology of how hydrogen storage is implemented in the model is not clear
- It seems that it all comes down to three numbers on levelized costs of storage published in a technical report, not taking the individual properties of storage sites into account

Strengths:
- Spatial analysis of economics of hydrogen storage on a continent level

Q 3 Please comment on the methods, results and data interpretation. If there are any objective errors, or if the conclusions are not supported, you should detail your concerns.

I feel that the methodology needs to be described better - it is hard to justify to call the paper "potential of geological hydrogen storage" and not taking the individual storage site aspects into account.

Q 4 Check List

Is the English language of sufficient quality?
Yes.

Is the quality of the figures and tables satisfactory?
Yes.

Does the reference list cover the relevant literature adequately and in an unbiased manner?
No.

Are the statistical methods valid and correctly applied? (e.g. sample size, choice of test)
Yes.

If relevant, are the methods sufficiently documented to allow replication studies?
No.

Are the data underlying the study available in either the article, supplement, or deposited in a repository? (Sequence/expression data, protein/molecule characterizations, annotations, and taxonomy data are required to be deposited in public repositories prior to publication)

No.

Does the study adhere to ethical standards including ethics committee approval and consent procedure?
Yes.

If relevant, have standard biosecurity and institutional safety procedures been adhered to?
Not Applicable.

Q 5 **Please provide your detailed review report to the editor and authors (including any comments on the Q4 Check List):**

Review of
Evaluating the Potential for Geological Hydrogen Storage in Australia by Walsh et al.

In the proposed manuscript the (economic) potential of geological hydrogen storage in Australia is evaluated using a open source modelling software which estimates the economic potential for salt cavern hydrogen storage and hydrogen storage in depleted gas fields. The work thus addresses the important question of which types of hydrogen storage will be viable in the future. In the results several high-potential regions are identified, predominantly for salt cavern storage.
While the paper addresses a very important aspect, I have several issues with it which need to be addressed before the paper can be published:
1. The implementation of hydrogen storage sites into the Bluecap software is not well described. It is not clear how exactly a storage site is modelled and what costs are assumed. All costs are taken from a single non-peer reviewed technical report and it is not clear how these costs are calculated.
2. How the individual characteristics of depleted gas fields or natural gas storage sites (geological properties, working gas ratios, number of wells, maximum injection and production rates,...) are included in the software is not indicated in the methodology. It is also not clear what kind of salt cavern is used - the costs will very depending on cavern size and shape.
3. Overall most numbers needed for the calculations seem to come from the one report mentioned above, there should be a wider use of the literature to argue for the costs.
4. It is not clear how depleted gas fields, which would need to be retrofitted to a much larger extend, are distinguished from natural gas storage sites which would likely be cheapter to retrofit to hydrogen storage sites.
While I agree with the current results, that salt caverns are likely the best option, given the gaps in the methodology I can not recommend publishing them without detailed description of the methodology.
Other comments, which can also be found in the commented pdf version:
Title: I would suggest to add “economic” to the title as it is currently a bit misleading - the geological storage potential would be volumes of hydrogen that can be stored. “Evaluating the economic potential for geological hydrogen storage in australia”
Line 34: There is not a single independet study that says hydrogen should be used for residential heating. residential heating is also not hard-to-abate.
Section 2 in general could use a diverse use of references, currently it is mainly four technical reports by the IEA and BNEF.
Line 108: Aquifer hydrogen storage is just as well established as depleted gas field storage - not at all.
Line 149: As far as I know there is not a single hydrogen storage project in operation. There were two test sites, one in Austria and one in Argentina, where 10% H2 was mixed with CH4, but these were only run for a couple of months. There are various reviews on expereinces with hydrogen storage out there which could be cited here instead of the same reports over again.
Line 163; What about the need for replacing some of the steel with hydrogen safe steel and/or lining of pipes?
Line 173: There is a lot more that we do not know yet about hydrogen storage in porous media: There seems to be a depth restriction due to wettability behaviour, there are some indications that there are fluid-rock interactions which may impede the reservoir integrity ect. It would really be good to add some more references to this section which highlight these issues.

Hydrogen storage in depleted gas fields is definitely different from storing natural gas in depleted fields.

Line 178: will also depend on… Storage is just one of many aspects which have to be right.
Table 1: I wonder if uncertainty ranges for salt caverns would not also make sense. There must be other sources for LCoS as well?
Line 244: How is the number of wells and injection/withdrawal rates, which are site specific, reflected in the LCoS?
Line 249: Not sure how porosity would limit gas injection? If anything permeability is the controlling factor.
Line 399: in these sections it is not clear if depleted gas fields or depleted gas fields which are already acting as natural gas storage sites are used.
Line 406: Why? Please elaborate.
Line 453: If it is an open source model the code availability should be highlighted here and a link to a repository added.

Johannes Miocic

QUALITY ASSESSMENT

Q 6	Originality	
Q 7	Rigor	
Q 8	Significance to the field	
Q 9	Interest to a general audience	
Q 10	Quality of the writing	
Q 11	Overall quality of the study