

## Peer Review Report

# Review Report on A critical geological evaluation of the hydrogen storage potential in the Cousland Gas Field, Midland Valley of Scotland

Original Research, Earth Sci. Syst. Soc.

Reviewer: Richard Swarbrick

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### EVALUATION

#### **Q 1** Please summarize the main findings of the study.

This paper is written to address the conundrum of onshore storage requirements of hydrogen for Scottish power and evaluate the claim by earlier authors (Heinemann et al., 2018) that the Cousland structure may be a suitable site. The paper is well-written and documents in detail the regional/local geology and exploration/production history pertaining to the Cousland Field. It is my opinion that the early parts of the paper which document in great detail each of the wells drilled and their productivity, is unnecessary when addressing suitability for hydrogen storage. Lines 183 to 408 could be reduced to a summary of the production from the field stated over less than 50–60 lines. The observation that the structure had been evaluated in the 1950s and 1960s as storage for town gas is interesting and reveals some of the thinking about gas storage at that time, but again there does not need to be so much detail in a paper to assess hydrogen storage potential.

#### **Q 2** Please highlight the limitations and strengths.

The paper includes strong arguments for the need for hydrogen storage but in my view lacks any of the hard data to exclude (or include) this type of subsurface reservoir in any future model for the new energy mix. What is missing in the text is giving the reader an appreciation of what the sealing and storage requirements would be for hydrogen storage, especially the seal characteristics and the response to the rocks of repeated injection and withdrawal.

Salt caverns remain the most appealing type of repository but lack the same access and availability of underground reservoirs (both aquifers and depleted fields). Much attention has been given in the paper to point out reservoir thickness variations whilst accepting very poor control with the current old data. But what about the integrity of the seal and general statements (as a minimum) to give the reader a chance to appreciate what is required in any trap for storage of hydrogen? It should not be presumed that hydrogen storage necessarily follows successfully if methane and/or town gas have already been trapped/stored. The reader has not been given the information to judge these factors which are critical to the general question first posed – can hydrogen be stored underground in porous rocks for quick release when needed to generate power? Once that discussion is in play it seems appropriate to guide the reader to understand how Cousland may or may not fit the bill, so to speak. I would suggest that a review at the outset along the lines of the paper by Hassanpouyouzband et al. (2021) would be appropriate – put early in the paper as part of the general setting. The authors may also like to refer to the very recent review paper by Miocic et al (2023), whilst not likely available to the authors at the time of writing, which is an excellent source of relevant information to guide any future publication.

Hassanpouyouzband, A., Joonaki, E, Edlmann, K. and Haszeldine R.S., 2021. Offshore Geological Storage of Hydrogen: Is This Our Best Option to Achieve Net-Zero? ACS Energy Lett. 2021, 6, 6, 2181–2186.

<https://doi.org/10.1021/acsendergylett.1c00845>

Miocic J., Heinemann N., Edlmann K., Scafidi J., Molaei F. and Alcalde J., 2023. Underground hydrogen storage: a review. In: Miocic, J. M., Heinemann, N., Edlmann, K., Alcalde, J. and Schultz, R. A. (eds) Enabling Secure Subsurface Storage in Future Energy Systems. Geological Society, London, Special Publications, 528,

<https://doi.org/10.1144/SP528-2022-88>

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**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.

This paper does not provide (for this reviewer) a "critical evaluation of hydrogen storage potential" as indicated in the title, but rather a detailed description of the exploration and development of the Cousland Field which has been proposed as a potential site for hydrogen storage. There is a very comprehensive description and assessment of the quality of the data pertaining the field, which may itself merit publication if there is sufficient originality. Given the title, the reader who is expecting to know about underground hydrogen storage, in which case the introduction requires appropriate introduction to the requirements for hydrogen storage (e.g. what is the behaviour of fluid/gas and rock during repeated injection and production?; what injection rates are required for Scottish Power to make sense of using underground storage in local reservoirs?; what are the sealing requirements?).

I have no doubt from the paper that the Cousland Field is deficient in many requirements for local storage, and the authors have shown the poor data quality to define reservoir characteristics and mapping for structure and volume under closure. This paper has the potential to offer a reader on the topic a full description of the requirements for hydrogen storage (which could be its legacy) whilst using the Cousland Field as an example of an "unsuitable" candidate, despite earlier expectations. (Note: It is not clear to me whether this paper duplicates what is found in the unpublished Scafaldi PhD.

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**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?

Yes.

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

Not Applicable.

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)

Not Applicable.

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.

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

All my comments are contained in the boxes Q1 - Q3 above

## QUALITY ASSESSMENT

<b>Q 6</b> → Originality	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Q 7</b> → Rigor	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Q 8</b> → Significance to the field	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Q 9</b> → Interest to a general audience	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<b>Q 10</b> → Quality of the writing	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<b>Q 11</b> → Overall quality of the study	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>