Hydrogen storage in salt caverns in Portland: What are the issues and are we ready to deal with them?

UK Oil & Gas (UKOG), a UK-based onshore fossil fuel extraction company, has created a subsidiary called UK Energy Storage Ltd (UKEn) in order to promote plans for a hydrogen storage facility in Dorset. UKEn is proposing to create salt caverns beneath the Isle of Portland for hydrogen storage.

This briefing examines the feasibility of the proposal, and whether hydrogen storage caverns in Dorset would make a contribution to the much needed energy transition.

Summary

Hydrogen storage in salt caverns in Dorset could be part of a low carbon future, but as yet there are significant uncertainties and problems. These include:

- Uncertainties about the potential for storage as the extent of the salt formations is not properly understood.
- Significant environmental concerns about the mining of the salt caverns and disposing of all the salt.
- No foreseeable source of renewable electricity exists to produce "green" hydrogen, and no associated production infrastructure.
- The planned alternative use for the caverns, that is, LNG from a proposed LNG terminal, is definitely not low carbon.
- Any plans to pipe hydrogen to or from the Fawley terminal at Southampton depend on the development of the Solent Cluster. This has failed to receive essential government funding.

Hydrogen is increasingly being recognised as an important element in the transition to net zero. It is a source of energy and, at the point of use, it produces no harmful greenhouse gases. While its use in home heating and transport is increasingly disputed because using electricity directly is generally seen as more efficient, it does have many important industrial uses. These include feedstock for products such as ammonia for fertilizers and other products and energy for industries such as steel making[1].

There is no doubt that there is going to be an increasing demand for hydrogen and an increased need to store hydrogen so that it is readily available when needed. Large salt caverns are one way to store hydrogen[2]. However, on land there are only four areas in Great

[1] https://h2sciencecoalition.com/blog/hydrogen-hype-is-crashing-but-we-cant-afford-to-give-up-on-renewable-hydrogen/

[2] https://www.sciencedirect.com/science/article/abs/pii/B9780128245101000039

Britain with extensive salt formations where this could be done: Larne Lough in Northern Ireland, East Yorkshire, Cheshire and Wessex. There are also extensive offshore salt deposit areas that could be used for storage, but developing these would be a more expensive option[3].

However, while hydrogen is often touted as a silver bullet to deal with the climate emergency, and hydrogen storage is a key element of any such plans, the reality is much more complex. The development of a large-scale hydrogen industry is still beset by uncertainties, is often controversial, and includes a certain amount of greenwash[4].

Any plans for creating salt caverns in Dorset need to take careful consideration of:

- the uncertainties of the geology,
- the timescales of the industrial plans that hydrogen storage is part of (eg the Solent Cluster),
- realistic measures of the climate change consequences, positive and negative, and
- the chances of finding the large amounts of funding and long-term investment this project would require.

Salt caverns

Salt has been mined in Great Britain since Roman times and salt is now produced principally in Cheshire, but also in Yorkshire and Northern Ireland. One mining technique, and the one that is relevant to creating salt caverns, is solution mining[5]. Here a shaft is drilled until it reaches the salt deposits. Then water is pumped down under pressure, the salt dissolves and the brine is pumped out and disposed of. This process can create a very large hole, which is suitable for gas storage.

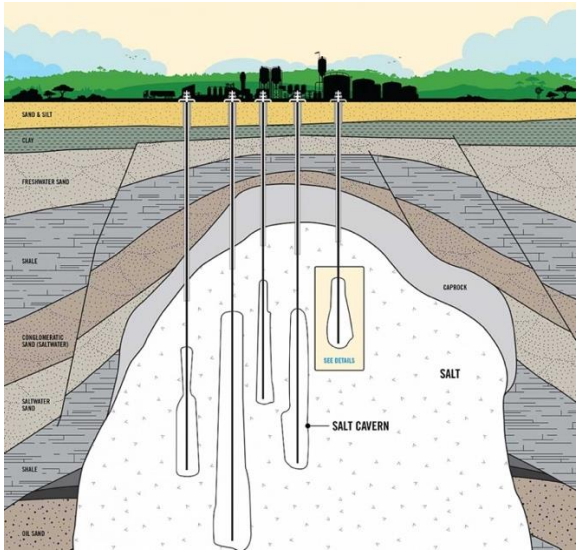

Image source: Texas Brine Company

[3] https://pure.hw.ac.uk/ws/portalfiles/portal/103909834/1-s2.0-S1364032123008596-main.pdf

[4] https://www.oxfordenergy.org/publications/hydrogen-and-decarbonisation-of-gas-false-dawn-or-silver-bullet/

[5] https://saltassociation.co.uk/education/make-salt/

This raises issues in Dorset

1. Creating salt caverns in the area will result in a great deal of brine that will have to be disposed of. One estimate for this project is "19 caverns the size of St Paul's Cathedral"[6]. That is a lot of salt and a lot of brine. In Northern Ireland a project was refused in June 2024; one of the issues in the case was the environmental harm that depositing the brine into the sea would cause[7]. The coast around Dorset has significant protected areas. Any proposals to create salt caverns must examine the issue of brine disposal very carefully. It is likely that environmental groups will oppose developments on these grounds.

2. As there is no history of salt production in the Dorset area, the salt deposits are not nearly as well understood as those in the other three areas. Their presence in Dorset was established as a result of exploratory drilling for oil and gas, not salt production. Oil exploration drilling has shown that there are salt beds, but how far they extend is not known. Also, the thickness of these beds varies and they may not be continuous. All this could limit the size of any storage caverns. It also means that a large amount of expensive investigation of these salt deposits is still needed[8]. A 2022 paper on potential hydrogen storage sites in salt caverns concluded: "*Given that the geological uncertainty remains significant and there is no operational precedent for underground gas storage in the region, the Wessex Basin is considered to be something of a frontier prospect for energy storage in salt caverns."*[9]

3. In 2008, Portland Gas, a different company from the one behind the present proposal, was given planning permission to develop gas storage caverns under Portland. At the time the estimated cost of the project was £450 million[10]. The project failed because the company was unable to raise this money. The new project proposed by UKEn has an estimated cost of £895 million. Raising this kind of sum will be a considerable challenge, especially as there is likely to be a long wait for any return on the investment.

   Moreover, the 2008 project was for gas storage. This is not the same as hydrogen storage. Whereas gas storage in salt caverns is well understood, there are in fact only a few storage sites specifically for pure hydrogen in the world: three are in the United States and there is a small one in the UK, on Teesside. One of the uncertainties is the effect of frequent and rapid removal and replacement of hydrogen on the structure of the cavern.

How "green" is UKEn's hydrogen storage proposal?

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[6] https://bmmagazine.co.uk/news/vast-dorset-salt-caverns-to-store-hydrogen-under-former-royal-navy-base/
[7] https://friendsoftheearth.uk/climate/gas-caverns-n-ireland-campaigners-win-larne-lough-legal-challenge

[8] https://pure.hw.ac.uk/ws/portalfiles/portal/103909834/1-s2.0-S1364032123008596-main.pdf Page 8.

[9] https://www.sciencedirect.com/science/article/pii/S2352152X22011100?via%3Dihub
[10] https://www.investorschronicle.co.uk/content/14ebe3f5-9c3a-5df6-99ed-ad1975703bd0

One of the main reasons for developing hydrogen storage is that it saves wasting a great deal of green electricity. At present the UK grid is unable to cope with the amount of electricity generated by wind at very windy times[11]. If this electricity could be used to make hydrogen, by splitting water (H_2O), to make hydrogen and oxygen, then the stored hydrogen would be available to generate electricity at those times when the wind doesn't blow. However, this would require building a hydrogen production facility close to wind turbines and there are cost implications for this too, especially as this expensive facility would only produce hydrogen when the grid had too much electricity.

Ideally the storage sites should be close to where the hydrogen is made. Hydrogen is the smallest molecule. This means it escapes easily, especially when it is under pressure. Moreover, it is increasingly recognized that hydrogen has an indirect global warming effect. So, hydrogen leakages along the supply chain can have significant consequences[12]. Shorter distances and fewer connections in the process would reduce the opportunities for leaks. For the foreseeable future there are no plans for large scale wind turbines close to Portland.

UKEn state that green hydrogen will be supplied by an "over-the-horizon floating windfarm[13]. How realistic is this? Are there any concrete plans for such a windfarm? Are the finances available for such a large project? Even if such a project were planned, how long would it be before green hydrogen is produced ready for storage?

UKEn proposes to use sea water for the solution mining. Considering the concerns for fresh water supplies in the south of England[14] this would seem sensible. However, the salt will not dissolve as readily in water that already contains salt. Consequently, greater volumes of water would need to be pumped both in and out to create the caverns. This raises the important question of how much additional energy this would require and how this would affect the project's carbon reduction claims.

Two other UKEn proposals

In the meantime, UKEn has two other proposals. One is a liquefied natural gas (LNG) terminal[15]. LNG has a very high carbon footprint[16] and storing this in the proposed salt caverns would hardly meet the Net Zero claims made for this project. An LNG terminal would also increase the cost of the project, possibly increasing the sums needed to be raised to over £1 billion. Building a terminal risks locking us into using LNG for many more years.

The second proposal is to transport hydrogen by pipeline, presumably from the proposed 'Solent Cluster'[17] at Southampton. The lead company in this cluster is ExxonMobil, who already produce hydrogen in Southampton for their oil refining and chemical processing.

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[11] https://www.bbc.co.uk/news/business-67494082
[12] https://acp.copernicus.org/articles/22/9349/2022/
[13] https://www.nsenergybusiness.com/company-news/ukog-portland-port-hydrogen-ready-energy-storage-project/
[14] https://www.dorsetcouncil.gov.uk/w/water-technical-paper
[15] Ibid
[16] https://www.bbc.co.uk/news/science-environment-63457377
[17] "The Solent Cluster brings together private, public and non-governmental organisations who wish to collaborate to decarbonise the Solent region and beyond." See: https://www.thesolentcluster.com

However, this hydrogen is “grey” hydrogen, made from natural gas through a process that releases a great deal of carbon dioxide. ExxonMobil’s Fawley refinery complex could, in theory, be a source of hydrogen and also a large-scale consumer of hydrogen.

Part of the Solent Cluster’s plans is a proposal to produce “blue” hydrogen. This means the carbon dioxide produced when making grey hydrogen would be collected and stored in saline aquifers in the English Channel. There are many questions around Carbon Capture and Storage (CCS). Recent scientific studies report that in some cases blue hydrogen could have an even higher carbon footprint than traditional grey hydrogen[18], especially if it is produced from fracked gas that has been transported as LNG from the US.[19]. Some argue that the main advantage of blue hydrogen is to support the oil and gas industry and that it would lock us into depending on these fuels for years to come[20]. Proponents of the Solent Cluster project have also been accused of Greenwash. Its success depends largely on a bid for government funding, and, for the moment, this has failed[21]. How likely and how quickly the Solent Cluster plans will proceed is therefore another big question.

UKEn: who are they?

UKEn is a relatively new subsidiary of UK Gas and Oil (UKOG). UKOG is a company whose background is in oil and gas exploration. UKOG has a history of failure and of overpromising and under delivering[22]. Its Horse Hill oil site, dubbed the “Gatwick Gusher”, that was due to turn the area into a “mini Dallas” in 2016, produced only 0.31% of UK onshore oil in April 2024.[23] As onshore oil is a small part of national oil production, this amounts to 0.0058% of UK production. UKOG’s financial stability is another concern. Its share price has fallen by 99.6% in the last five years, and after recent restructuring, which reduced its shares to 9.78 billion shares, the share price is a mere 0.04 of a penny.

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[18] Blue hydrogen have a higher carbon footprint than burning gas directly:

1. Hydrogen made from heating gas (methane) needs a lot of energy. About 25% of the gas is used up in the conversion process. Consequently, you need that much more gas to do the work.
2. Carbon capture and storage does not store all the carbon dioxide. The maximum possible storage is 95% but this is very expensive to do. Usually, a much lower percentage is successfully captured and stored.
3. The more complex a process, the more opportunities there are for the carbon dioxide to leak. Recent studies show that there is much more leakage than originally thought, probably four to five times more than in official government figures.
4. LNG is gas that has been liquified under pressure by cooling it to -161^{0}C. This uses a great deal of energy, both in liquifying the gas and keeping it at that temperature. Transporting requires yet more energy and it is also prone to leakages.

[19] https://onlinelibrary.wiley.com/doi/epdf/10.1002/ese3.956

[20] https://www.independent.co.uk/climate-change/news/blue-hydrogen-association-chair-quits-b1905437.html

[21] https://www.theguardian.com/uk-news/2024/mar/31/exxonmobil-accused-of-greenwashing-over-carbon-capture-plan-it-failed-to-invest-in

[22] https://www.theguardian.com/business/2016/feb/16/hopes-rise-again-for-gatwick-gusher-as-oil-flows-to-surface

[23] https://drillordrop.com/2024/07/01/uk-onshore-oil-and-gas-production-in-charts-april-2024/

This raises important questions. How much of the millions of pounds that this project requires is likely to be raised by a company that has no experience of hydrogen storage and that does not have a particularly successful history in the area that it does have some experience in? Moreover, how much trust will there be in a company that presents such a simple picture of an industry that still has levels of complexity and uncertainty that need to be managed so carefully?

In conclusion

There are significant uncertainties and problems with the proposal, as summarized above.

The development of this form of hydrogen storage would take many years. It would require a great deal of investment with a long wait for any return. There are alternative forms of storage and these are likely to be located closer to the source of hydrogen production and/or the industries that can use the hydrogen. Finding the finance for this project will be difficult and would need commitment from a financially stable company.