Dear Mr Pridham

Halite Energy Group Limited – Re-determination of application for Development Consent Order in respect of underground gas storage facility at Preesall, Lancashire
Halite response to DECC letter of 31 July 2014

Further to your letter of 31 July 2014, we enclose Halite’s response to the latest round of consultation. The response comprises two documents:

1. "Halite response to the independent geological assessment produced by Senergy (GB) Limited", given document reference "H43". Document H43 considers the Senergy report and Halite’s further geological data in the context of Section 104 Planning Act 2008. It also includes at Appendix 2 a technical response to the Senergy report, produced by Mott MacDonald in conjunction with the British Geological Survey and Geostock. Please note that document H43 includes an Overview at Section 1, which the Department may find a helpful starting point for reviewing the documents.

2. "Halite’s comments on first round redetermination representations", given document reference H42. Document H42 sets out Halite’s response to representations received by the Secretary of State from other interested parties or otherwise in response to his letter of 8 April 2014.

We trust that documents H42 and H43, and the information contained within them, is clear. If you, or the independent geological assessor (Senergy), require clarification of any matters, please do not hesitate to contact me in the first instance and I will endeavour to assist.

As requested, a single hard copy of the above will be posted to you today.

Please note that we will send through an updated Index of examination and re-determination documents submitted by Halite in the next couple of days for your convenience.

Yours sincerely

Paul Grace

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THE INFRASTRUCTURE PLANNING
(EXAMINATION PROCEDURE) RULES 2010

Preesall Underground Gas Storage Facility,
Lancashire

Halite Response to the “Independent Geological Assessment” produced by Senergy (GB) Limited

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1 OVERVIEW

1.1 The Department of Energy and Climate Change ("DECC") appointed geological consultants, Senergy (GB) Limited ("Senergy"), to review and produce an independent report ("Senergy Report") on the further geological data submitted by Halite Energy Group Limited ("Halite") pursuant to the redetermination of its application for a Development Consent Order ("DCO") for an underground gas storage facility at Preesall (near Fleetwood), Lancashire (the "Project"). This document is Halite’s response to the Senergy Report. This Section provides an overview of the main response (which can be found in Sections 2 to 6 below).

Suitability of the geology at the Project site for the purposes of NPS EN-4

1.2 The key findings from the Senergy Report provide confirmation of the following central matters in the redetermination of the DCO application:

(a) that the geology at the Project site is suitable for the type of gas storage proposed; therefore, the Project complies with National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines EN-4 ("NPS EN-4"), including paragraph 2.8.9 of NPS EN-4;

(b) that the geology can accommodate a very large underground gas storage facility, comprising 19 caverns, that can be operated on a fast cycle basis (see Figure 1 below paragraph 1.9 below); and

(c) that Halite has obtained a reasonable set of geological data, including seismic-reflection data.

Compliance with National Policy Statements - statutory presumption in favour of grant of DCO under section 104 of the Planning Act 2008

1.3 Senergy’s confirmation that the geology is suitable for an underground gas storage facility, with 19 caverns, is of fundamental importance in policy terms as it reinforces Halite’s case that the proposed development is in accordance with National Policy Statements ("NPSs") EN-1 and EN-4 and, in particular, NPS EN-4 paragraph 2.8.9; which was the only basis on which the Secretary of State had previously concluded that the proposed development was not in accordance with the NPS. This is a major change from the basis on which the DCO application was originally decided by the Secretary of State.

1.4 It is a central tenet of the Planning Act 2008 regime that where a development is in accordance with the relevant NPS, as is the case with the Project (see paragraph 1.2(a) above), there is presumption in favour of development consent being granted. Within the context of that presumption in section 104, the Secretary of State is required to consider whether there are any adverse impacts of the Project of such a magnitude that they outweigh the benefits of the Project, including the need for the Project as identified in the NPSs. This planning balance is summarised below and it is considered that the relatively modest adverse impacts (visual impacts on an undesignated landscape) do not come close to outweighing the benefits of the Project.

Summary of benefits of Project

1.5 Policy benefits - the NPSs are unequivocal in setting out the need for underground gas storage facilities in the UK. NPS EN-1 makes the point that the UK is “highly dependent on natural gas” (paragraph 3.8.1 of EN-1) with “strong seasonal
variations in demand” (paragraph 3.8.3 of EN-1) such that it needs a diverse mix of gas storage and supply infrastructure to respond effectively to increasingly large daily and seasonal changes in demand and to provide endurance capacity during a cold winter (paragraph 3.8.7 of EN-1).

1.6 Capacity benefits - on Senergy's assessment, the Project would result in a underground gas storage facility that would be amongst the largest of its kind in the country. Senergy's Base Case is that the Project can achieve a working gas storage capacity of 203 Mcm. This would be significantly above the threshold of 43 Mcm, the capacity at which underground gas storage facilities are considered to be Nationally Significant Infrastructure Projects ("NSIP") under the Planning Act 2008 regime.

1.7 Furthermore, Senergy agrees that fast cycling (i.e. quick injection and withdrawal of gas to meet demand), for which the Project was designed, is entirely possible: using Senergy’s Base Case, an effective annual capacity of 2434 Mcm is achievable. Again, this is a very large contribution to national need.

1.8 Whilst there is much common ground between the British Geological Survey, Mott McDonald and Geostock (Halite’s team of geological advisors) and Senergy regarding the suitability of Preesall for the development of a substantial fast cycle gas storage project, there are differences regarding assessment of the exact potential working gas storage volume from the proposed 19 caverns. Halite’s geological advisors consider that, on a conservative assessment, the Project would have a static working gas storage capacity of 324 Mcm and, taking account of cycling, an effective annual capacity of 3888 Mcm. The alternative working gas volumes proposed in the Senergy Report (base case static capacity of 203 mcm and effective annual capacity of 2434 Mcm), substantial though these are, are considered by Halite to be unduly pessimistic (see Section 4 below for Halite’s response to Senergy’s storage gas capacity analysis). Nevertheless, the overriding conclusion to be drawn from the Senergy Report is that a very large underground gas storage facility can be constructed.

1.9 To illustrate this, Figure 1 below shows a comparison of the static working gas capacity for the Project against other salt cavern gas storage facilities within the UK, both on Halite/the British Geological Survey’s assessment (in green) and Senergy’s (in red):
Figure 1 (the same as Fig. 4.1 in Appendix 2) highlights that, whether on Senergy’s base case or the Halite/British Geological Survey assessment, a very large underground gas storage facility can be constructed. The difference between the two assessments regarding potential working gas volume is principally a commercial matter for Halite and should not significantly affect the planning balance.

Moreover, in considering the capacity of the Project, it is of great significance that Senergy’s assessment of capacity is based on the Project being a fast-cycle facility. This is because whilst static working capacities are lower in a fast cycle facility, the volume of gas stored over time becomes higher overall than in single cycle facilities. Accordingly, the static working gas capacity alone does not reflect the Project’s capability in meeting UK gas demand needs but must be considered alongside its ability to ‘cycle’. The fast cycling effective annual capacity of the Project (3888 Mcm on Halite’s conservative figures and 2434 Mcm on Senergy’s figures) reinforces the already overwhelming need case for the Project.

Locational Benefits - in addition to its policy and scale benefits, the Project has a number of site specific or locational benefits (see paragraphs 5.5.51 to 5.5.69 below for further details of these):

1.12.1 Gas from Preesall would enter the NTS at a location that is close to five existing, and three planned, combined cycle gas turbine (“CCGT”) electricity generating stations. There is substantial offshore wind generation in the vicinity of the Preesall site, which is intermittent. The CCGTs make up for the intermittency of the offshore windfarms. Thus the Project is located at a strategically important point in National Grid’s gas National Transmission System (“NTS”) where it can quickly support CCGT electricity production and thus the use of intermittent off shore windpower.

1.12.2 The Project’s proposed caverns are relatively shallow. The facility will therefore operate at gas pressures closer to those in the NTS, allowing it to have a fast reaction (i.e. injection/withdrawal) time. This is, again, important in supporting a flexible gas supply market in the UK.

1.12.3 The western leg of the NTS has three main sources of supply: Fergus in Scotland, Barrow from Morecambe Bay and Burton Point from Liverpool Bay. These terminals are in decline. The Project would add capacity to the western leg of the NTS and assist the replacement of some of the lost terminal capacity. Indeed, for the same reason there is spare capacity in this part of the NTS and thus the Project is an efficient and sustainable use of existing gas transmission infrastructure.

Adverse impacts of the Project

1.13 To be weighed against the extensive benefits of the Project described above, there was only one material adverse impact identified by the Examining Authority in its report: landscape and visual impact on an undesignated landscape. This would be caused primarily by a gas compressor compound which will form part of the above ground infrastructure necessary for the transmission of gas between the caverns and the NTS.

1.14 The landscape at Preesall is not designated as being of national, regional or even local importance. Furthermore, in terms of the weight to be given to landscape and visual impact, NPS EN-1 acknowledges that “virtually all nationally significant energy infrastructure projects will have effects on landscape”. Furthermore, the NPS and planning policy recognises that minerals can only be worked where they are found. NPS EN-4 recognises Preesall is one of a limited number of opportunities in the UK where the geology is able to support underground gas storage.
1.14.1 Put shortly, the landscape and visual impacts are modest, compared to the importance of addressing the urgent national need for gas storage capacity, and cannot conceivably be considered to be of such a magnitude so as to outweigh the benefits of the Project.

1.15 In considering visual impacts, the 300 Mcm threshold adopted by the Examining Authority is of very little, if any, relevance for the purposes of the Secretary of State’s redetermination of the DCO application. It was itself based in part on the assumption (not put to Halite during the Examination) that at below 300 Mcm capacity the above ground structures for the Project would be smaller and, therefore, that at below 300 Mcm capacity the benefits of the Project would not outweigh the impacts of the (what were wrongly thought to be oversized) above ground structures. That assumption is simply incorrect. The above ground infrastructure is required for 19 caverns and a fast cycling facility, which Senergy has confirmed can be delivered. There is no linear relationship between static storage capacity and the scale of the gas compressor compound. In this context, it should also be understood that the limit of up to 600 Mcm for static storage capacity is nothing more than the maximum static storage capacity for a slow cycle operation of the caverns and was set an absolute maximum for the purposes of the Hazardous Substances Consent. The capacity limit in the draft DCO was set as the same level.

Whether the adverse impacts of the Project outweigh its benefits in the context of the statutory presumption in favour of granting the DCO

1.16 The critical issues for the Secretary of State are therefore:

1.16.1 whether the Project is compliant with the relevant national policy statements; and

1.16.2 whether the adverse impacts of the Project are of such a magnitude that they outweigh its benefits and overcome the statutory presumption.

1.17 In relation to the first of the issues above, the Senergy Report has removed any doubt that the geology at Preesall is “suitable” for the type of underground gas storage proposed and, indeed, the Senergy Report confirms that the geology is sufficient to accommodate 19 caverns. On this basis the Project is in accordance with the NPSs and the presumption in section 104(3) applies.

1.18 In relation the second of the issues above, the policy benefits, the capacity benefits and the locational benefits of the Project hugely outweigh the limited visual impacts of the Project on an undesignated landscape.

1.19 In the context of section 104 Planning Act 2008, therefore, development consent should be granted for the Project.
THE PURPOSE OF THIS DOCUMENT

2.1 An overview summarising the key points made in this document can be found above. This is the start of the substantive document and this section now sets out its purpose.

2.2 On 31 July 2014 the Department of Energy and Climate Change wrote to interested parties, including Halite, to request representations on the Independent Geological Assessment dated July 2014, the Senergy Report.

2.3 The Senergy Report was produced by Senergy for the Secretary of State in the course of his redetermination of Halite's application for a DCO to construct and operate an underground gas storage facility of up to 900 million cubic metres of gas, to provide an operational working capacity of up to 600 million standard cubic metres, and associated infrastructure at Preesall, Lancashire.

2.4 This document is Halite's response to the Senergy Report. It will explain:

2.4.1 how the Senergy Report reinforces the case for consent being granted. This is because of its support for the fundamental elements of Halite's geological data and assessment work (see Section 3 below);

2.4.2 differences between the British Geological Survey, Mott MacDonald and Geostock who jointly advise Halite, on the one hand, and Senergy/KBB on the other hand. In short, the analysis capacity analysis of Halite's consultants, based on detailed local knowledge and experience of developing underground gas storage caverns in Cheshire, which is the same salt body that extends to Preesall, is that the capacity of the proposed facility will be much higher than that indicated in the Senergy Report and that the Senergy Report is, therefore, unduly pessimistic (see Section 4 below);

2.4.3 that there can be no serious question, even on the basis of the unduly pessimistic Senergy figures, that the geology of the site is suitable for the type of underground gas proposed in the Project, which therefore complies with paragraph 2.8.9 of NPS EN-4, and engages the statutory presumption in its favour (see Section 5.4 below);

2.4.4 the considerable benefits offered by the Project which are, in summary:

(a) the urgent need for and benefits of underground gas storage facilities as stated in NPSs "Overarching National Policy Statement for Energy (EN-1)" ("EN-1") and "National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4)" ("EN-4") (see paragraphs 5.5.6 to 5.4 below); and

(b) the scale of the Project (see paragraphs 5.5.31 to 5.5.50 below)

(c) the scheme specific benefits of this Project (see paragraphs 5.5.51 to 5.5.69 below).

2.4.5 that there is only one material disbenefit of the Project, namely its effect on an undesignated landscape (see Section 5.6 below);

2.4.6 how the planning balance falls to be considered in light of the limited landscape impact of the Project, when compared with its considerable importance in addressing national energy needs (see Section 6 below).
2.5 Separately, the Secretary of State received on 9 May 2014 a number of representations from other Interested Parties in response to his letter of 8 April 2014 notifying Interested Parties of the matters on which he required further representations to be submitted. In DECC’s letter of 31 July 2014, as well as requesting representations on the Senergy Report, it also requested comments on the representations which the Secretary of State had received by 9 May 2014, i.e. during that first consultation round. Halite’s comments on those first round consultation representations can be found in the separate document entitled “Halite’s comments on first round redetermination representations”, which has been given document reference H42 and has been submitted to DECC on the same date as this document.

2.6 A glossary of terms used in this document is set out at Appendix 1.

2.7 In this document all emphasis in quotations is added.
3 KEY FINDINGS OF THE SENERGY REPORT WHICH SUPPORT DEVELOPMENT CONSENT BEING GRANTED

3.1 Halite’s team of geological experts (the British Geological Survey, Mott MacDonald and Geostock) have reviewed the Senergy Report. Their detailed technical response to the Senergy Report is contained in Appendix 2, “Halite’s Geological Technical Appendix”.

3.2 For the purposes of the Secretary of State’s determination of the application, further independent confirmation has been provided by Senergy of the critical, overarching elements of Halite’s geological data and assessment work. The Senergy Report strongly reinforces the case for consent being granted.

3.3 Halite’s geological experts do have certain disagreements with Senergy’s approach to the interpretation of the base halite and its treatment of uncertainty, which give rise to differences between Halite and Senergy as to the volume of gas that could be stored by the Project; Halite also has a number of more minor detailed observations and criticisms of the assessment. These matters do not detract, however, from the overall support provided by the Senergy Report but are set out in Halite’s Geological Technical Appendix and summarised in Section 4 below.

3.4 The Senergy Report confirms the following matters in particular:

Data coverage

3.5 A significant volume of subsurface data has been acquired by Halite. The database of seismic lines provides reasonable data coverage within the Planning Polygons. The interpretation by Halite is valid and the conclusions are broadly acceptable (Sections 2.2.3, 2.3, 3.7 of the Senergy Report).

3.6 See paragraphs 2.1.1 and 2.1.2 of Halite’s Geological Technical Appendix for more detailed discussion of the findings on the Senergy Report on this issue.

Top salt

3.7 The quality of the database of seismic lines is considered good down to top salt, with the consequence being that the interpretation of the top salt is of good quality with little or no uncertainty (Sections 3.2.1 and 3.2.3 of the Senergy Report).

3.8 See paragraphs 2.1.5 to 2.1.7 of Halite’s Geological Technical Appendix for more detailed discussion of the findings on the Senergy Report on this issue.

Integrity of overlying strata

3.9 The integrity of overlying strata is important for the conceptual design of the caverns and subsidence modelling. Halite therefore notes that Senergy confirms as follows:

3.9.1 The conceptual design of the caverns is “state of the art” and appropriate (Section 4.1.2 of the Senergy Report).

3.10 Subsidence modelling follows “state of the art” concepts (Sections 4.4 and 4.5 of the Senergy Report).
See paragraphs 2.1.17 to 2.1.20 of Halite’s Geological Technical Appendix for more detailed discussion of the findings on the Senergy Report on this issue.

**Capacity**

3.12 Senergy’s Base Case is that the Project can achieve a working gas volume of 202.8 Mcm (Table 5.3 of the Senergy Report).

3.13 Senergy’s Monte Carlo simulation produces a 100% probability of achieving a working gas volume of 82.1 Mcm (Table 5.4 of the Senergy Report); section 17(4)(a) Planning Act 2008 defines a *nationally* significant infrastructure project as having a working gas volume of 43 Mcm.

3.14 Senergy confirms that an injection rate for the purposes of cycling of 10-12 days is possible (Sections 4.1.1 and 5.2 of the Senergy Report). Assuming conservatively 12 cycles per year and 10 days’ standby time *per cycle*, using Senergy’s Base Case, this would imply a total effective working gas storage capacity of the Project of 2434 Mcm a year.

See paragraph 2.1.21 to 2.1.25 and 2.2.6 to 2.2.7 of Halite’s Geological Technical Appendix for more detailed discussion of the findings on the Senergy Report on this issue.

**Faulting**

3.16 The location of the Burn Naze Fault has been a key concern raised by objectors to the DCO application. Senergy confirms that the Burn Naze Fault would not have an effect on the likely capacity of the Project because it is well away from the southern Planning Polygon (Section 3.3.1.1 of the Senergy Report).

See paragraph 2.2.1 of Halite’s Geological Technical Appendix for more detailed discussion of the findings on the Senergy Report on this issue.

**Gas tightness**

3.18 The salt body is “gas tight” (Section 3.5 of the Senergy Report).

3.19 See paragraph 2.2.3 of Halite’s Geological Technical Appendix for more detailed discussion of the findings on the Senergy Report on this issue (Section 3.5 of the Senergy Report).

**Wet rockhead and wild brine runs**

3.20 The cavern design rules captured in Requirement 6 mean that wet rockhead or wild brine runs from historical workings should not impact upon cavern design (Section 3.6 of the Senergy Report).

3.21 See paragraph 2.2.3 of Halite’s Geological Technical Appendix for more detailed discussion of the findings on the Senergy Report on this issue.

**Cavern development plan**

3.22 The methodology applied by Geostock in the Conceptual Design Study is appropriate, and all 19 proposed caverns can be achieved (Sections 4.1.1 and 5 of the Senergy Report).
3.23 See paragraph 2.2.4 of Halite’s Geological Technical Appendix for more detailed discussion of the findings on the Senergy Report on this issue.

**Safety**

3.24 No concerns are raised in the Senergy Report, by Senergy or by KBB, regarding the safety of construction or operation of the Project.

3.25 This accords with the findings of the ExA Report and the determination of the SoS Decision Letter, who were satisfied that there were no safety concerns which could not be controlled through the application of appropriate health and safety regulations and consents.

3.26 See paragraph 2.2.5 of Halite’s Geological Technical Appendix for more detailed discussion of the findings on the Senergy Report on this issue.

4 **SUMMARY OF DIFFERENCES BETWEEN THE BRITISH GEOLOGICAL SURVEY/MOTT MACDONALD/GEOSTOCK AND SENERGY APPROACHES**

4.1 As a general point, Halite notes that Patterson J commented that an applicant for planning permission is not required to prove the case for his proposed development to a criminal standard (paragraph 32) and that it is therefore inappropriate to look for extreme scenarios, to prove matters “beyond reasonable doubt” or to require a need for “certainty” or “full demonstration” (paragraph 99). Instead the appropriate standard is “the balance of probabilities”.

4.2 Even in that context, Senergy still identifies a “base case” of a working gas capacity of 203 Mcm. It suggests a 50% probability of a static working gas capacity of 190 Mcm and 100% probability of achieving 82.1 Mcm. Any of these would result in an underground gas storage facility that would be one of the largest of its kind in the country (see Table 1 below paragraph 5.5.45 below) and, indeed, one with particular beneficial features not shared by many other underground gas storage facilities (see paragraphs 5.5.51 to 5.5.69 below). These capacity figures are so large that the benefits of the Project far outweigh any adverse impacts identified.

4.3 However, there are differences between the British Geological Survey/Mott MacDonald/Geostock, on the one hand, and Senergy/KBB on the other. These can be broadly characterised as falling under two headings:

1. Interpretation of the base salt;
2. Senergy’s treatment of uncertainty.

4.4 These are discussed in detail in Section 3 of Halite’s Geological Technical Appendix but are summarised below:

**Interpretation of the base salt**

*Selection of Base Salt pick*

4.5 Halite adopted the shallowest (i.e. most conservative) of all the plausible interpretations of the seismic reflection data to establish a “pick” defining the Base Salt depth within the Planning Polygons, correlating the pick extensively across sections of the seismic reflection data and tying it to known depths of salt from boreholes.
4.6 The Senergy Report accepts that the conservative pick of Base Salt adopted by British Geological Survey is appropriate, and “not incorrect”, but then suggests another pick at a much higher level (i.e. shallower depth and even more conservative) as being “equally plausible”. This alternative base salt pick is in fact only a partial pick, with no evidence that it has been carried around the grid of seismic lines and tied to boreholes.

4.7 The British Geological Survey has now carried this Senergy partial pick around the grid of seismic lines and tied it to boreholes, and it confirms that the reflection upon which Senergy’s alternative pick is based is actually associated with an interval of muddier salt and thicker interbedded mudstone (termed the intra-salt mudstones in the Senergy Report), within the Preesall Halite, i.e. there is salt proved beneath the reflection in the boreholes. Senergy has thus incorrectly identified this pick as the base salt; despite accepting (section 3.4.1 of the Senergy Report) that intra-salt mudstones exist and can, based upon geophysical log correlations, reasonably and appropriately be extended across the Planning Polygons.

4.8 Senergy’s pick is, therefore, not a plausible interpretation of a higher Base Salt level (shallower depth). Senergy has, therefore, completely misidentified the Base Salt. See paragraphs 3.2.2 to 3.3.7 of Halite’s Geological Technical Appendix for more detailed discussion.

4.9 This complete misidentification of the Base Salt becomes a key reason for what the British Geological Survey, Mott MacDonald and Geostock consider to be Senergy’s unduly pessimistic Monte Carlo simulation of the probabilities of achieving different levels of working gas capacities. This is because Senergy’s own partial Base Salt pick is used in that simulation as a lower parameter in its uncertainty range for the location of the Base Salt, even though it itself is a complete misidentification of the Base Salt - and Section 5.2 of the Senergy Report states that “uncertainty in the Base Salt pick contributes 39% to the overall uncertainty”. See paragraphs 4.15 to 4.16 below for more detail.

4.10 Separately, Halite notes that whilst the Senergy Report’s overall conclusion at Section 2.3 is that the overall data coverage of the Planning Polygons is good, it mentions that the “Base Salt has only been penetrated in two of the recent boreholes adjacent to the planning polygons (the deviated Burrows Marsh #1 and Hay Nook #1 boreholes)” and that this “is a cause for concern in mapping the Base Salt horizon, particularly in the deeper parts of the basin where loss of seismic resolution is greatest.” It is worth, at this juncture, considering what is appropriate at the planning stage. The Project has four site-specific salt exploration boreholes, with comprehensive downhole geophysical log suites and, in two of the boreholes, in situ pressure tests. The Project therefore has a great deal more borehole data (and indeed seismic reflection data) than any other onshore salt cavern scheme, some of which had none, at the planning consent stage (e.g. Holford, King Street and Whitehill). Moreover, even on Senergy’s independent assessment, the Project would be a very large underground gas storage facility. The current boreholes, including the legacy ICI wells, are immediately adjacent to the Planning Polygons and sufficiently constrain the seismic lines and their interpretation. As identified during the High Court proceedings, inserting boreholes into the Halite body creates additional migration pathways and hazards. Unless a cavern can be created there, this effectively sterilises a location and body of salt and thus does not represent a sustainable activity or use of the mineral resource. In other words, a borehole at any cavern location will provide the final information for cavern design and construction during the FEED stage but to require further boreholes at this stage is unnecessary, unhelpful to the Project’s potential to contribute towards national need and would be inconsistent with the High Court’s judgment that requiring
absolute certainty is inappropriate in the context of land use planning decisions. In any event, even after Senergy has factored into its Monte Carlo probabilistic analysis uncertainty as to the Base Salt (39% of its overall uncertainty – see Section 5.2 of the Senergy Report), its assessment still confirms a very large underground gas storage facility can be constructed in Preesall.

4.11

Senergy adopts a theoretical, unexplained and inconsistent approach towards a margin of uncertainty for the Base Salt pick, which does not reflect the local knowledge of areas of known depths of salt, e.g. from bore holes. See paragraphs 3.2.8 to 3.2.16 of Halite’s Geological Technical Appendix for more detailed discussion.

Senergy’s treatment of uncertainty

Senergy’s Base Case

4.12

The Senergy Base Case uses the British Geological Survey Base Salt interpretation but makes changes to the cavern diameters and cavern heights by the application of an unduly pessimistic and arbitrary approach:

One-off impacts on the physical cavern size

4.12.1

Halite has adopted cavern separation distances calculated from numerical analysis using site specific data from Preesall and using Geostock’s design experience of P/D ratios, separation distances, for the Holford underground gas storage caverns in Cheshire, which are in the stratigraphically equivalent strata to the Preesall Halite and are already in operation. Halite has applied the results of these analyses and experience to:

(a) separation distances between caverns;
(b) separation distances between cavern roof and the top salt surface
(c) separation distances between cavern base and the base salt surface.

4.12.2

In contrast, it appears that Senergy has arbitrarily increased these separation distances to reduce the diameters of 13 caverns and the heights of all of them. The combined effect of these changes is to reduce the geometrical cavern volume by 21%. See paragraphs 3.3.8 to 3.3.11 of Halite’s Geological Technical Appendix for more detailed discussion.

Shape and insolubles impacts on cavern size

4.12.3

Geostock based Halite’s cavern shape factor on its experience in developing caverns at Holford in Cheshire, the same salt body that extends to Preesall, and other sites, with insoluble content and rock mass density having been estimated from site specific data and not based upon general assumptions. However, the Senergy Report instead uses arbitrary factors and assumptions on these matters to reduce the useable volume of the proposed caverns by 39% (note that this is a separate matter to the 39% uncertainty factor which Senergy attributes to the Base Salt pick in its separate Monte Carlo simulation described at paragraph 4.16 below). See paragraphs 3.3.12 to 3.3.15 of Halite’s Geological Technical Appendix for more detailed discussion.
Miscellaneous Factors

4.13 Senergy applies other miscellaneous factors on cavern volumes which are negative (see paragraphs 3.3.16 to 3.3.19 of Halite’s Geological Technical Appendix) but no specific details are presented. Halite is therefore unable to comment on these factors.

Senergy’s Monte Carlo Simulation

4.14 Senergy’s Monte Carlo simulation to assess probability uses a range of parameters based on unjustified and pessimistic KBB recommendations. In contrast, Halite’s equivalent values are based on the large body of site specific data available for the Preeall site and from actual experience gained developing underground gas storage caverns in Cheshire, which is the same salt body that extends to Preeall.

4.15 Most importantly, in applying an uncertainty range within its Monte Carlo analysis to represent its perception of uncertainty as to the location of the base of salt, Senergy appears to have adopted:

(a) as the median value (i.e. midway point) in its uncertainty range the Base Salt pick which the British Geological Survey considered represented its view of the worst credible case; and

(b) Senergy’s own partial (and incorrect) Base Pick as the lower end of the uncertainty range.

4.16 For the reasons described in paragraphs 4.5 to 4.8 above, the Senergy alternative pick is not considered to be plausible at all, but a misidentification of the Base Salt. This means that Senergy’s lower end of the uncertainty range is much shallower than the British Geological Survey Base Salt pick. More than that, it means that Senergy has relied on that misidentification of the Base Salt to create what effectively becomes a worst of worst case of where the Base Salt pick lies. Halite therefore considers the Senergy Monte Carlo Simulation to be unduly pessimistic and that it seeks to establish a minimum working capacity “beyond reasonable doubt” (i.e. to a criminal standard of proof). This is important because Section 5.2 of the Senergy Report states in respect of its Monte Carlo Simulation that “uncertainty in the Base Salt pick”, alone, “contributes 39% to the overall uncertainty”. This must represent a substantial element of the difference between the capacity figures of the British Geological Survey, Mott MacDonald and Geostock on one hand, and Senergy on the other. See paragraphs 3.3.22 to 3.3.37 of Halite’s Geological Technical Appendix for more detailed discussion.

Discussion of outcomes on capacity

4.17 For the reasons above, the assumptions used by Senergy/KBB combine to produce a working gas volume that is unduly pessimistic when compared to local knowledge and experience in Cheshire (the same salt body that extends to Preeall). Senergy/KBB do not purport to base their analysis on actual experience in developing underground salt caverns, let alone relevant local experience. Halite calculates the static working gas capacity of the Project as 324 Mcm and the dynamic working gas capacity as 3888 Mcm per annum based on a modest cycle time of 30 days; whereas the Senergy capacity is 203 Mcm for static working gas, which would give rise to 2434 Mcm per annum dynamic working gas capacity (using the Senergy Base Case).

4.17.1 Nevertheless, even Senergy’s capacity figures, for all the flaws described, represent a very substantial gas storage capacity indeed and by any measure large enough to
lead to the conclusion that the benefits of the Project far outweigh any adverse impacts identified. This is discussed in Section 5 below, where the planning context for these figures is considered.
5 PLANNING CONTEXT: ASSESSMENT OF THE PROJECT UNDER SECTION 104 OF THE PLANNING ACT 2008

5.1 Section 104 of the Planning Act 2008 requires an application for a DCO to be determined in accordance with the relevant NPS, unless the adverse impacts of the proposal would outweigh its benefits. It is therefore a central tenet of the NSIP planning regime that where a Project is in accordance with the relevant NPS, there is a presumption in favour of a development consent order being granted.

5.2 This Section of Halite’s response explains that the Project clearly accords with the relevant NPSs, having regard to the findings of the Senergy Report described in Sections 3 and 4 above. The importance of Senergy’s findings in this respect cannot be overstated. The Independent Geological Assessment commissioned by the Secretary of State demonstrates that the Preesall halite body is suitable for the type of gas storage proposed. Whereas the Secretary of State had previously found that the Project did not accord with NPS EN-4, there is now no basis for a conclusion other than that the Project does accord with NPS EN-4.

5.3 This section of Halite’s response then describes the considerable benefits of the Project, and its more limited adverse impacts (identified only as landscape and visual effects), and explains why those adverse impacts clearly do not outweigh the benefits.

5.4 Compliance with relevant National Policy Statements, including paragraph 2.8.9 of EN-4 (Suitability of the geology at the site for the type of underground gas storage proposed)

5.4.1 The only reason identified in the SoS Decision Letter for the refusal of the DCO application was that the Secretary of State had not been persuaded that Halite had complied with the requirements of paragraph 2.8.9 of EN-4 to demonstrate the suitability of the geology at the site for the type of underground gas proposed, and that need could not therefore be weighed against potential disbenefits of the Project.

5.4.2 However, in the SoS Decision Letter, the Secretary of State interpreted “suitability of the geology” as including proving a minimum capacity; an approach that was rejected by the High Court. Patterson J expressly considered this matter in the High Court decision of 17 January 2014, and concluded as follows:

“122. The natural meaning of the words in paragraph 2.8.9 is, in my judgement, clear. They are seeking a detailed geological appraisal to demonstrate the suitability of the site for the development proposed. It is no more than that. The ordinary meaning of “suitability” would not necessarily include capacity. The geological assessment is to show that the type of medium is appropriate or fit for the purpose for which it is proposed. The fact that the paragraph appears under the section entitled “factors influencing site selection” endorses that view. The paragraph is advising applicants to establish whether the site is geologically fit for the intended purpose. That is why the subsequent paragraph refers to safety as an additional factor to be considered when considering where to site gas storage facilities. If capacity was a necessary part of the geological assessment then I would have expected it to be mentioned expressly. It is not.”
5.4.3 Demonstration of the capacity of the Project is not therefore part of the consideration of whether the proposed facility is in accordance with NPS EN-4 (indeed, as set out in extracts from EN-1 and EN-4 at paragraphs 5.5.28 to 5.5.30, capacity appears to be considered to be a commercial matter). What is important for the purposes of compliance with EN-4 is whether the Preesall halite body itself is suitable for a gas storage project.

5.4.4 In the light of Senergy’s conclusions on data coverage, which accord with the position taken by Halite, there can now be no serious question that the totality of the geological data before the Secretary of State amounts to a “detailed geological assessment” for the purposes of paragraph 2.8.9 of National Policy Statement EN-4.

5.4.5 Furthermore, on the basis of Senergy’s assessment, there can now be no serious question that the geology within the Planning Polygons is “suitable” (in the context of paragraph 2.8.9) for the type of storage facility proposed, i.e. storage in salt cavities. Senergy and Halite’s geological consultants (the British Geological Survey, Mott MacDonald and Geostock) all agree that the Preesall Halite could accommodate up to 19 caverns and could be operated as a fast cycle underground gas storage facility (Sections 4.1.1 and 5.2 of the Senergy Report).

5.4.6 As such, the Project clearly complies with National Policy Statement EN-1 and EN-4 and, in particular, paragraph 2.8.9 of EN-4 which requires the suitability of the geology at the site for the type of underground gas storage to be demonstrated.

5.4.7 When the Secretary of State determined the application in April 2013 it was clearly on the premise that the Project did not comply with the NPS (see, for example, paragraph 26 of the SoS Decision Letter) and he therefore applied no presumption in favour of the development.

5.4.8 The Secretary of State’s own independent geological assessment means that the Project should now be considered as being in accordance with the requirements of EN-1 and EN-4. This should represent a major change to the Secretary of State’s approach to and consideration of the Project. Development consent should now be granted unless it is clear that the adverse environmental impacts of the Project outweigh its benefits.

5.5 Benefits of the Project

5.5.1 The next matter to be considered, therefore, is the nature and extent of the benefits of the Project, having regard to the NPSs and other matters, which must be balanced against the limited environmental impact of the Project that has been identified by the ExA and the SoS.

5.5.2 Section 6 of the Planning and Sustainability Statement (document reference 9.1.1) submitted with the DCO application provided an assessment of the Project against section 104 of the Planning Act 2008 and the balance that needed to be struck between the need for underground gas storage and the adverse impact it may have on the environment. The Planning and Sustainability Statement outlined a number of benefits, which are summarised below for convenience.

5.5.3 Taking the Senergy Base Case of 203 Mcm, and on the basis of Senergy’s conclusions on cycling, an effective annual capacity of 2434 Mcm, or 2.4 Bcm (billion cubic metres), can be achieved. The Project’s effective annual capacity would allow gas storage, over a 12 month period, at a similar volume overall to some of largest facilities in the country, many of which due to their nature cannot be operated to fast-cycle gas.
5.5.4 The benefits of the Project are therefore of three types: first, the Project has *policy benefits* in terms of meeting national need; secondly, the Project has considerable *capacity benefits* as one of the largest proposed facilities in the UK (even on Senergy’s figures); thirdly, there are a number of *locational benefits specific to the site itself* which further reinforce the need for this facility.

5.5.5 These benefits also mean that the Project would make a significant contribution towards addressing strategic concerns about UK energy supplies raised by DECC, OFGEM and the Commons Energy and Climate Change Select Committee.

**(1) Policy Benefits**

5.5.6 In terms of the policy benefits, the NPSs confirm that there is an acknowledged need for underground gas storage facilities in the UK.

5.5.7 Paragraph 2.1.2 of NPS EN-1 confirms that *“energy is vital to economic prosperity and social well-being and so it is important to ensure that the UK has secure and affordable energy. Producing the energy the UK requires and getting it to where it is needed necessitates a significant amount of infrastructure, both large and small scale”*. 

5.5.8 Part 3 of EN-1 deals with the need for new nationally significant energy infrastructure projects, in particular paragraph 3.1.1 confirms that *“the UK needs all the types of energy infrastructure covered by this NPS in order to achieve energy security at the same time as dramatically reducing greenhouse gas emissions”*. 

5.5.9 Paragraph 3.1.2 of EN-1 goes on to confirm that; *“it is for industry to propose new energy infrastructure projects within the strategic framework set by Government. The Government does not consider it appropriate for planning policy to set targets for or limits on different technologies”*. This is important in the consideration of whether it is appropriate to set any minimum capacity threshold for the Project.

5.5.10 EN-1 makes the point in paragraph 3.1.3 that the Secretary of State should “assess all applications for development consent for the types of infrastructure covered by the energy NPSs on the basis that the Government has demonstrated that there is a need for those types of infrastructure and that the scale and urgency of that need is as described for each of them in the NPS.” 

5.5.11 It cannot be overstated that paragraph 3.1.4 of NPS EN-1 continues that the Secretary of State “should give *substantial weight* to the contribution which projects would make towards satisfying this need when considering applications for development consent under the Planning Act 2008”. This is reinforced in paragraph 3.2.3 of NPS EN-1, which states as follows:

> “Government considers that, without significant amounts of new large-scale energy infrastructure, the objectives of its energy and climate change policy cannot be fulfilled. However, as noted in Section 1.7, *it will not be possible to develop the necessary amounts of such infrastructure without some significant residual adverse impacts*. This Part also shows why the Government considers that the need for such infrastructure will often be urgent. The [Secretary of State] should therefore give *substantial weight* to considerations of need. The weight which is attributed to considerations of need in any given case should be proportionate to the anticipated extent of a project’s actual contribution to satisfying the need for a particular type of infrastructure.”
Whether the Secretary of State adopts the capacity figures proposed by the British Geological Survey, Mott MacDonald and Geostock or by Senergy, the Project’s “actual contribution to satisfying the need” for underground gas storage is very substantial indeed (see paragraphs 5.5.31 to 5.5.50 below in respect of capacity) and therefore very substantial weight should be accorded to the consideration of need.

Section 3.6 of NPS EN-1 details the role of fossil fuel in electricity generation and explains at paragraph 3.6.2 that “gas will continue to play an important role in the electricity sector - providing vital flexibility to support an increasing amount of low-carbon generation and to maintain security of supply”.

Paragraph 3.6.2 of NPS EN-1 also confirms that “unlike some renewable energy sources such as wind power, fossil fuels may be stockpiled in anticipation of future energy demands”.

Paragraph 3.6.3 of NPS EN-1 goes on to confirm that in order to maintain security of supply and to provide flexible back-up for intermittent renewable energy from wind, some of the new conventional generating capacity needed is likely to come from fossil fuel.

NPS EN-1 makes the point that the UK is “highly dependent on natural gas” (paragraph 3.8.1) with domestic (household) demand for gas for heating purposes underpinning “strong seasonal variations in demand” (paragraph 3.8.3).

Paragraph 3.8.5 of NPS EN-1 confirms that Great Britain’s gas supply infrastructure must be sufficient to allow market participants access to gas storage (especially close-to-market storage) “to manage the large uncertainties around the evolution of Great Britain’s demand for gas”.

Paragraph 3.8.7 of EN-1 notes as follows:

“In the past, and in the winter of 2009/2010 as described above, so-called ‘swing supply’ to meet seasonal changes in demand has been provided by highly responsive gas fields in the North Sea and Eastern Irish Sea. However, as these fields age and become depleted, and even though they may still contain considerable gas reserves, they react more sluggishly, and cannot release gas at the rate they previously did. Great Britain needs a diverse mix of gas storage and supply infrastructure (including gas import pipelines and terminals) to respond effectively in future to the large daily and seasonal changes in demand, and to provide endurance capacity during a cold winter.”

The Project has been designed exactly to respond to “large daily and seasonal changes in demand”. Paragraph 3.8.12 of EN-1 makes the point that a range of gas infrastructure is required but that underground gas storage facilities have faster withdrawal and refill rates and can assist in responding to changing market conditions day to day and week to week.

The need for more gas infrastructure is detailed in paragraphs 3.8.8 – 3.8.13 of EN-1 and it is clarified that “further infrastructure – beyond that which exists or under construction at present - will be needed in future in order to reduce supply or price risks to consumers” (paragraph 3.8.8).

Paragraph 3.8.9 goes on to confirm that “increased gas storage capacity, whether for gaseous gas in underground storage facilities, or as LNG tanks above ground, is required to provide close-to-market ‘swing supply’ to help meet peak demand.”
Demand varies considerably throughout the day and it is necessary for some sources to be close to the market so that gas is quickly available. Gas supply infrastructure will also need to keep pace with any changes in regional demand for gas across the UK – which may change due to changes in location of population and/or commercial or industrial demand.

5.5.22 The advantages of close to market gas storage capacity that complement import capacity are highlighted in paragraph 3.8.12 of NPS EN-1:

“Close-to-market gas storage capacity has advantages complementary to import capacity. [...] "Medium range storage", typically gas stored in caverns in salt strata deep underground, has faster withdrawal and refill rates helping gas supply companies to respond to changing market conditions from day to day ("diurnal") and week to week. "Short-range storage", gas stored in small quantities as LNG very close to some main centres of demand, helps to respond to sudden peaks in demand. Gas travels slowly through pipelines, at around 40 kph, and LNG at the speed of the tanker. Close-to-market gas storage also provides a prompt supply capability, which is particularly valuable when there is a delay before gas imports can respond to a market signal for increased supplies.”

5.5.23 Paragraph 3.8.13 acknowledges that; "the appropriate portfolio of supply sources, and the implications for gas supply infrastructure, are quintessentially commercial decisions for the various gas market participants (and potentially a source of commercial advantage for them)".

5.5.24 NPS EN-4 is consistent with the approach set out in EN-1 above regarding the need for nationally significant infrastructure projects and clarifies that EN-4 and EN-1 should be considered together. Paragraph 2.1.2 states; “the [Secretary of State] should act on the basis that the need for the infrastructure covered by this NPS has been demonstrated”.

5.5.25 Paragraph 2.85 of EN-4 confirms that there are limitations as to where natural gas can be stored underground, due to natural geological constraints; “the subsurface geology influences the extent of the potential gas reservoir and the feasibility of using it for an underground storage facility”. Of particular relevance to the project is paragraph 2.87 of EN-4 which also confirms that; “in some areas, Britain has salt present in strata which are, or could be, suitable for gas storage. The most extensive areas, where suitability thick natural layers of salt are found, are in northern England and in smaller areas further south”.

5.5.26 The Secretary of State acknowledged in the SoS Decision Letter that the key points identified above apply to the Project. Paragraph 9 of the SoS Decision letter stated that it "would be consistent with energy Overarching National Policy Statement EN-1 ("EN-1") to grant [the Project] development consent (in the absence of any adverse impacts which made it unacceptable in planning terms), given the need for this type of Development and the contribution such projects can make to ensuring the UK’s security of supply (Parts 3.8.8 – 3.8.13 of E-N-1 refers)".

5.5.27 Paragraph 10 of the SoS Decision Letter further explained the Secretary of State’s reasoning for the Project’s compliance with EN-1, explaining that as United Kingdom Continental Shelf gas production declines, a range of infrastructure is likely to be required including increased gas storage capacity (quoting from paragraph 3.8.9 of EN-1, which is detailed above). Paragraph 10 also acknowledged the Project’s role in the advantages of close to market gas storage
capacity that complement import capacity, quoting extensively from paragraph 3.8.12 of EN-1 (again, detailed above).

5.5.28 It is appropriate to consider that no minimum thresholds for capacity are given in the relevant national policy statements – this is considered to be a matter of commercial risk. EN-1 states:

"3.1.1 The UK needs all the types of energy infrastructure covered by this NPS in order to achieve energy security at the same time as dramatically reducing greenhouse gas emissions.

3.1.2 It is for industry to propose new energy infrastructure projects within the strategic framework set by Government. The Government does not consider it appropriate for planning policy to set targets for or limits on different technologies.

3.1.3 The IPC should therefore assess all applications for development consent for the types of infrastructure covered by the energy NPSs on the basis that the Government has demonstrated that there is a need for those types of infrastructure and that the scale and urgency of that need is as described for each of them in this Part.

3.1.4 The IPC should give substantial weight to the contribution which projects would make towards satisfying this need when considering applications for development consent under the Planning Act 2008."

5.5.29 However, EN-1 provides no such scale for gas storage facilities, considering that this is a commercial decision for promoters:

"3.8.13 There is no "right" way to balance the GB gas market – there are indigenous supplies, imports by pipe-line, imports by LNG, or storage (whether long, medium or short range). The appropriate portfolio of supply sources, and the implications for gas supply infrastructure, are quintessentially commercial decisions for the various gas market participants (and potentially a source of commercial advantage for them). A great strength of the British gas market is the way that separate commercial decisions, by a number of separate companies, contribute to the overall diversity of our gas supply, promoting secure supplies at competitive prices.

[...]

3.8.20 Decisions on gas supply infrastructure are initially a commercial matter for gas market participants (and subject to regulatory requirements). They will take into account the continuing central role for gas, during the transition to a low carbon economy and against that background their requirement for additional gas supply capacity. The nature of that capacity (as between indigenous production, imports and storage) and the technical specification of gas storage capacity that might be proposed (for example the "range" of a proposed storage facility), are all commercial matters. Market participants will also take into account the various risks summarised above. There is no one "right" answer. However, the strong expectation is that they will wish to bring forward proposals for additional gas supply infrastructure, i.e. import and storage capacity. Some market participants may judge that their requirement for additional gas supply capacity is urgent. The UK markets and consumers (in Northern Ireland as well as Great Britain) benefit from the diversity of sourcing strategies developed by gas supply companies, and the way that this translates into a diversity of instruments for balancing the market."
EN-4 is consistent with this approach, considering that need for nationally significant infrastructure projects, without specifying any scale greater than those prescribed in Planning Act 2008 has been demonstrated:

"2.1.2 The policies set out in this NPS are additional to those on generic impacts set out in EN-1 and do not replace them. The IPC should consider this NPS and EN-1 together. In particular, EN-1 sets out the Government’s conclusion that there is a significant need for new major energy infrastructure generally (see Part 3 of EN-1). EN-1 Part 3 includes assessments of the need for gas supply infrastructure and gas and oil pipelines. In the light of this and for the reasons given in Part 3 of EN-1, the IPC should act on the basis that the need for the infrastructure covered by this NPS has been demonstrated."

(2) Capacity benefits

The British Geological Survey, Mott MacDonald and Geostock have adopted the worst credible interpretation of the base salt (giving the thinnest probable salt thickness and hence lowest likely working gas volume) to produce an anticipated static working storage capacity for the Project of up to **324 Mcm** at standard temperature and pressure. When cycling of caverns is considered, the effective (12 month) operational working gas capacity is calculated to be **3888 Mcm** (based on a modest cycle time of 30 days that includes 10 days of standby time). On its static working capacity alone, the Project is very large indeed, but as a fast cycle facility, which Senergy accepts that it is, its effective annual capacity would allow storage of amounts of gas, over a 12 month period, at a similar volume overall to the largest facilities in the country, many of which due to their nature cannot be operated to fast-cycle gas. The Project would therefore be a very large underground gas storage facility on any reasonable basis.

In this context, the Project can make a significant contribution to national need and it is appropriate to consider that the benefits noted in EN-1 and EN-4 above apply to the Project by virtue of its scale. This is even true on the capacity figures arrived at in the Senergy Report.

Turning then to Senergy’s capacity figures, even though the British Geological Survey, Mott MacDonald and Geostock consider that these are unduly pessimistic, for the reasons set out at Section 4 above, the Senergy Report confirms that the Project is a Nationally Significant Infrastructure Project:

(a) in its base case calculation, Senergy estimates that the working gas volume would be 203 Mcm, being well above the 43 Mcm capacity required to be a NSIP as set out in paragraph 17(4) of the Planning Act 2008; and

(b) even Senergy’s Monte Carlo analysis indicates a 50% probability of achieving a working gas volume of 190 Mcm and a 90% probability of achieving 124 Mcm – both capacities being well over that required for the Project to be an NSIP.

By way of background, it should be noted that in its original GSR, Halite calculated the capacity of the facility on a single cycle basis as it was necessary to identify the largest volume of gas that could be stored in the caverns at any one time for the purposes of the Hazardous Substances Consent (i.e. up to 600 Mcm). The ExA did not ask Halite about the static or effective capacity of the Project if it were to be operated as a fast cycle facility. That has now become a matter on which the Secretary of State wishes to be informed and Senergy has perfectly properly assessed the Project as a fast cycle facility, as that is how it is intended to be operated; although for the purposes of the Hazardous Substances Consent, it is still...
necessary to know the maximum volume of the hazardous substance that could be
stored in the facility and Halite suggests that this be left at up to 600 Mcm and that
this also be the maximum capacity provided for in the Requirements to the DCO.

5.5.35 Nevertheless, it is of great significance that Senergy’s Base Case assessment of
capacity is based on the Project being a fast-cycle facility with a 10-12 day
withdrawal period. This is because whilst static working capacities are lower in a
fast cycle facility, the volume of gas stored over time becomes higher overall than
in single cycle facilities. Capacity is very much, therefore, a function of how a
facility is operated.

5.5.36 The Project, as proposed to be operated, has the ability to rapidly increase or
decrease injection and withdrawal rates in response to market conditions.
Accordingly, the base or static working gas capacity alone does not reflect the
Project’s capability in meeting UK gas demand needs but must be considered
alongside its ability to ‘cycle’. Halite expects the caverns to be ‘churned’ several
times in a year (paragraph 7.3 of document reference 9.1.3) with a consequential,
and substantial, increase in the total volume of gas that would be stored, annually,
in the Project.

5.5.37 It is a complex matter to demonstrate the dynamic capacity associated with fast
cycle facilities which may operate on in-day injection and withdrawal as well as
longer term cycles. However, it is important to do this because comparing facilities
based on static capacity alone is too simplistic.

5.5.38 Section 6.5 of the Updated GSR (document reference H30) explains Halite’s
approach (on the basis of the figures from the British Geological Survey, Mott
MacDonald and Geostock) to calculating an effective annual working capacity which
takes account of cycling. As described at paragraph 5.5.31 above, a static working
gas volume of 324 Mcm and an injection/withdrawal rate of 32.2 Mcm/day give a
total annual volume of 3888 Mcm when allowing for a conservative 10 days’
standby time for each cycle.

5.5.39 Senergy calculates a 203 Mcm Base Case working gas capacity, which could deliver
17 to 19.8 Mcm a day over a 10-12 day withdrawal period (Section 5.3 page 38 of
the Senergy Report). By way of comparison with Halite’s 3888 Mcm figure, in a
year, Halite calculates that this production rate of at least 12 cycles per annum
(based on a modest cycle time of 30 days that includes 10 days of standby time)
could amount to a total effective working gas storage volume of 2434 Mcm. That
still is a very large effective capacity which would make a significant contribution to
national need.

5.5.40 There is another useful way of illustrating dynamic capacity, as shown by the
Oxford Institute for Energy Studies which produced a report in January 2013
entitled “Gas Storage in Great Britain” by Chris Le Fevre (the “Le Fevre Report”),
a copy of which can be found on the project page for Preesall on the PINS website.

5.5.41 Table 7 of the Le Fevre Report provides a comparison of static working gas
capacities, delivery rates and number of cycles per annum for existing storage
facilities.

5.5.42 The Le Fevre Report calculated the cycle time based on the number of days for an
individual facility to inject the full working gas volume plus the days to withdraw it
divided by 350, which allows a uniform 15 day standby time for all facilities per
year. Whilst facilities can be operated in a much more sophisticated way than a
number of complete cycles, this approach allows both a demonstration of the static
capacity and, more importantly, the potential deliverability through a dynamic gas
capacity. It also allows a comparison to be made on a like-for-like basis across different projects.

5.5.43 Halite's approach to reporting the dynamic (effective) capacity in the Updated GSR (Section 6.5), described at paragraph 5.5.38 above, is more conservative than the Le Fevre approach: Halite allowed 10 standby days within each injection/withdrawal cycle, i.e. 120 standby days per year, whereas Le Fevre allows for 15 standby days per year.

5.5.44 However, when comparing the Project to other UK facilities using the le Fevre approach the dynamic capacity for Presall (using the Halite working gas capacity of 324Mcm) is 5670 Mcm per year and the equivalent figure using Senergy's Base Case figure is 3150 Mcm per year.

5.5.45 Table 1 below provides a comparison of the effective gas storage capacities of existing or under construction underground salt cavern gas storage facilities in the UK with that of Presall, using the le Fevre approach.

Table 1: Comparison of effective gas storage capacities of existing, or under construction, salt cavern underground gas storage projects in the UK

<table>
<thead>
<tr>
<th>Storage Facility</th>
<th>Facility Type</th>
<th>Status</th>
<th>Static Capacity (Mcm)</th>
<th>Cycles p.a.</th>
<th>Effective Capacity* (Mcm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldbrough - Phase 1</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>330</td>
<td>18.2</td>
<td>6000</td>
</tr>
<tr>
<td>Presall (Halite figures) *1</td>
<td>Salt Cavern</td>
<td>Planning</td>
<td>324</td>
<td>17.5</td>
<td>5670</td>
</tr>
<tr>
<td>Stublach</td>
<td>Salt Cavern</td>
<td>Construction, advanced stages</td>
<td>400</td>
<td>13.1</td>
<td>5250</td>
</tr>
<tr>
<td>Rough</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>3650</td>
<td>1.3</td>
<td>4705</td>
</tr>
<tr>
<td>Holford</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>160</td>
<td>24.1</td>
<td>3850</td>
</tr>
<tr>
<td>Presall (Senergy figures)</td>
<td>Salt Cavern</td>
<td>Planning</td>
<td>203</td>
<td>15.9</td>
<td>3228</td>
</tr>
<tr>
<td>Hill Top Farm</td>
<td>Salt Cavern</td>
<td>Construction, advanced stages</td>
<td>98</td>
<td>25.0</td>
<td>2454</td>
</tr>
<tr>
<td>Humby Grove</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>254</td>
<td>5.4</td>
<td>1375</td>
</tr>
<tr>
<td>Holford H165</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>3.83</td>
<td>350.0</td>
<td>1341</td>
</tr>
<tr>
<td>Hole House Farm</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>55</td>
<td>20.6</td>
<td>1133</td>
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<tr>
<td>Hatfield Moor</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>117</td>
<td>6.9</td>
<td>806</td>
</tr>
<tr>
<td>Horncsea/Atwick</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>325</td>
<td>1.9</td>
<td>630</td>
</tr>
</tbody>
</table>

* Effective Capacity = Static Gas Capacity x No. cycles per annum

*1 Value different from Updated GSR figure of 3888 Mcm, which is based on a typical monthly cycle

5.5.46 Note that sources for the data given in Table 1 above can be found beneath Tables 4.1 and 4.2 of Halite's Geological Technical Appendix at Appendix 2.

5.5.47 Table 1 above illustrates that the Project has the capability at its proposed delivery rate of 32 Mcm/day, in accordance with the assessment of the British Geological Survey, Mott MacDonald and Geostock, to provide 27.5% additional deliverability for all UK salt cavern storage, and an additional 20.6% for all UK storage deliverability.

5.5.48 If the delivery rate were as proposed by Senergy at 18 Mcm/day then these figures would still be 15.6% and 11.7% respectively (although, as described at paragraph 5.6.10 below, there is no reason whatsoever for Senergy having reduced the
delivery rate in proportion to its reduced static working gas capacity - because the
daily volume of 32.4 Mcm could still be delivered with that static capacity but, using
KBB’s “huff and puff” terminology, if the caverns were smaller, the injection and
withdrawal equipment would simply “huff and puff” more frequently to deliver the
same daily volumes).

5.5.49 The above table also shows that the Project is not dissimilar to many of the existing
or proposed cavern facilities in that it operates on multiple cycles. The Project,
however, does appear to have one of the fastest cycle rates even when compared
with fast cycle facilities that are operational or under construction, due to its
relatively shallow depth.

5.5.50 The fast-cycling potential of the Project is a central consideration in the Secretary
of State’s assessment of the benefits of the Project. It reinforces the already
overwhelming need case for the Project (even on Senergy’s base case
assessment), and properly reflects the commercial context in which the Project
would operate. On the figures given above, it will be seen that the Project’s
effective annual capacity would allow storage of amounts of gas, over a 12 month
period, at similar capacities to some of the largest underground gas storage
facilities in the UK, many of which cannot fast-cycle.

(3) Locational Benefits

5.5.51 In addition to the policy benefits of the Project described at paragraphs
5.5.6 to 5.5.30 above and the capacity benefits at paragraphs 5.5.31 to 5.5.50 above, the
Project has a number of site specific or locational benefits, which were described in
the DCO application documents, in particular the Halite “Preesall Need Case”
document reference 9.1.5) and which are summarised below. Where there is
further discussion in the Need Case than that presented here, further paragraph
references are given.

5.5.52 The relationship of gas storage, wind, combined cycle gas turbines (referred to as
CCGTs) and Preesall is an important one. In the Energy Act 2008, the UK
Government adopted a legally binding target to replace 15% of the fossil fuels used in
2020 with renewable energy. The UK Government is therefore supporting a
massive expansion in offshore wind generation which will be increasingly important
in the provision of electricity if the UK is to meet its climate change targets by
2020. However, wind generation is an intermittent power source that is naturally
subject to fluctuation and thus unpredictable – it cannot reliably just be turned on
or off by operators at the request of power grid operators. In order to
accommodate this type of renewable energy source in the Grid, standby generation
capacity needs to be maintained to fill the gap for unexpected supply problems. For
the most part, the standby capacity is provided by gas fired power stations,
combined cycle gas turbines, as they are the most responsive to changes in short
term supply. Gas from Preesall would enter the NTS at a location that is close to
five existing, and three planned, CCGT electricity generating stations (see
paragraph 4.3.2 of the Halite “Preesall Need Case” (document reference 9.1.5)).

5.5.53 There is also substantial offshore wind generation in the vicinity of the Preesall site.
The local CCGTs will therefore be expected to support electricity demand at short
notice. Preesall’s location is critical here because gas moves relatively slowly
through the NTS (around 40 kph) and hence the changes in demand for gas
caused by the wind-CCGT interaction cannot easily be met by pipelines moving gas
over long distances from other gas storage facilities (and it would not matter to the
CCGTs whether the capacities of other facilities were larger, or indeed smaller, than
Preesall as the gas from other facilities might not reach it in time to make up for
the shortage in supply). So Preesall’s location is fundamental to its contribution to need as well as capacity alone.

5.5.54 NTS line-pack may be able to provide some short term flexibility, but this is limited in volume and duration (see paragraph 4.3.3 of the Halite “Preesall Need Case” (document reference 9.1.5)). Preesall’s location can provide more of the necessary flexibility due to its proximity to CCGTs. The map below shows the NTS and the location of the offshore wind turbines and the existing and proposed CCGTs within a 100 mile radius of Preesall. The fast reaction time and its location make the Project particularly suited to provide the flexibility needed to supply the intermittent gas needs of the local CCGTs.

**NTS, CCGTs and Offshore Windfarms Within 100 Miles of Preesall**

5.5.55 This interrelationship is acknowledged in EN-1, which states as follows:

>“3.3.11 An increase in renewable electricity is essential to enable the UK to meet its commitments under the EU Renewable Energy Directive. [...] However, some renewable sources (such as wind, solar and tidal) are intermittent and cannot be adjusted to meet demand. As a result, the more renewable generating capacity we have the more generation capacity we will require overall, to provide back-up at times when the availability of intermittent renewable sources is low. [...]
3.3.12 There are a number of other technologies which can be used to compensate for the intermittency of renewable generation, such as electricity storage, interconnection and demand-side response, without building additional generation capacity. Although Government believes these technologies will play important roles in a low carbon electricity system, the development and deployment of these technologies at the necessary scale has yet to be achieved."

5.5.56 The Project would be acting as one of these “other technologies” in this sense, as its gas could be used to fuel the CCGTs making up for the intermittency of the offshore windfarms (see paragraph 2.2.6 of the Halite “Preesall Need Case” (document reference 9.1.5)). The Project’s ability to deliver gas speedily at appropriate pressures for the NTS, at the right point in the NTS, (see further below) makes it highly suited to this supportive role for CCGTs. Further, underground gas storage facilities in shallow salt bodies, such as the Preesall site, are better suited to supporting CCGTs because of the much lower carbon footprint associated with the smaller pressure range required for gas cycling: less compression energy is required to fill the store, and less heat energy is required to counteract Joule-Thompson effect cooling (the lowering of gas temperature when a substance is converted from a gas to a liquid) when the gas is withdrawn from the store.

5.5.57 The Project is physically located at the midpoint of the Gas Natural Transmission System (NTS) by a relatively short connecting pipeline. This allows gas to be easily injected into and withdrawn from the NTS. As pipelines are essentially pressure maintenance systems it is ideal that gas enters the NTS at the midpoint and the midpoint connection is especially good for system pressure maintenance during periods of high system demand or terminal interruption.

5.5.58 The NTS pipe system near Preesall was designed to handle the variable swing production from Morecambe Bay (discussed in more detail in sub-paragraph 5.5.67 below but see also paragraph 4.3.5 of the Halite “Preesall Need Case” (document reference 9.1.5)) and is, therefore, extremely robust and ideally suited to supply and receive gas from Preesall.

5.5.59 The Project proposes to create caverns in a relatively shallow body of rocksalt. It will operate in a very different way when compared to some of the operational UK UGS facilities, which are used in the main as single turn, one cycle storage facilities. Those facilities are developed principally in depleted gas reservoirs but include a few salt cavern facilities, and are used primarily to store gas during the temperate months and to deliver gas to the NTS during the winter months. The design and operating regime of this type of facility, particularly its low injection and withdrawal capabilities, limits its ability to react quickly. The Project is different as its relatively shallow depth means it offers a number of benefits. It will operate at pressures close to that of the NTS, meaning storage operations require less compression on filling, or pressure reduction on withdrawal, thereby increasing its operational efficiency. This permits the Project to be designed in such a way as to provide very fast reaction times and, additionally, change the direction of gas flow very quickly (see paragraph 5.5.51). The Project would provide hourly balancing, pressure maintenance, short-term storage services and gas system needs at speeds, scale and efficiency, which other deep storage facilities simply cannot match. The relatively shallow depth of the Project in comparison with some other schemes is therefore a significant advantage in terms of a practical contribution to national energy need.

5.5.60 The Project would be an energy efficient gas storage project as the gas is stored virtually at the same pressure as the NTS, which means that it requires far less
energy to store and return the gas to the NTS than is used in storage schemes operating at greater depth and pressure. The Project is, therefore, a more sustainable form of underground gas storage project than most other such projects. This is also, again, important in supporting a flexible gas supply market in the UK. See further discussion at paragraphs 4.4.1 to 4.4.4 of the Halite “Preesall Need Case” (document reference 9.1.5).

5.5.61 As the Project has been designed to operate in the same pressure range as the NTS (again, possible because of its relatively shallow depth) it is able to provide high injection and withdrawal rates as less time is spent pressurising the gas before it enters the caverns or de-pressurising it before it is returned to the NTS compared with what would be necessary for a deeper underground gas storage facility. The NTS system near Preesall also has a very large capacity and can supply and receive large amounts of gas to and from the Project. The high injection rates mean that when gas is available in the system for storage, the Project can absorb it quickly. The Project’s high rates of withdrawal also mean that when gas is required by the system, the Project can supply a significant proportion of the UK’s daily gas requirements, particularly in high demand winter days.

5.5.62 The UK system is susceptible to large-scale interruption if supplies are curtailed during periods of high demand. The Project would represent an important source of stored gas for short-term gas system requirements. The high injection and withdrawal rates are also useful for the NTS operations. Diurnal pressure swings on the NTS can be mitigated very efficiently by the Project and National Grid Gas would benefit from better system efficiency and operating costs.

5.5.63 The Project would have winter refill capability. Whilst gas may be available during the winter for injection it is typically only available on an intermittent basis. The combination of high injection rates and fast reaction time allows the Project to absorb gas when it is available.

5.5.64 Because the Project has multiple caverns, manifolds, pipeline and electrical connections it would have very high levels of reliability. Maintenance or the outage of some caverns would not affect the ability of the Project to store gas in those that are operational. It is also the case that many of the UK’s existing terminals and associated gas infrastructure are ageing. Whilst the Health and Safety Executive (HSE) ensures continued safety of all gas storage and transmission infrastructure, ageing equipment inevitably means greater risk of outage, with a predictable decline in reliability. The Project would be new, modern, on shore and would add to the overall reliability of the UK gas system.

5.5.65 The Project would also be relatively low cost and thus more deliverable than many projects, as the caverns are not as deep as on other schemes.

5.5.66 The Project is flexible and could be operated in a number of ways. The physical capabilities of the Project would create a storage facility that would be able to provide a portfolio of storage services. Although it is intended to be operated as a fast cycle facility, it could also be operated to provide medium-term storage. It would also provide balancing, pressure maintenance and physical back-up to the NTS. These capabilities would also create new storage products currently limited or unavailable in the UK and boost the options for gas users to use energy reserves efficiently and cost effectively.

5.5.67 The Project would assist in replacing Morecambe Bay’s capabilities. The Morecambe Bay Gas Field was developed by British Gas as a super peaking gas supply. With the privatisation of British Gas, Morecambe Bay was used as a low load, high swing field that acted as a very large backstop to the capacity of the terminals.
Morecambe Bay is now in decline and can no longer provide the swing it once could. The Project would have the ability to increase the swing capacity to make up part of that which is being lost from Morecambe Bay and, indeed, provide that capacity in the same part of the NTS.

5.5.68 The Project would also assist in replacing some of the capacity lost from the West coast terminals. The western leg of the Gas NTS has three main sources of supply, Fergus in Scotland, Barrow from Morecambe Bay and Burton Point from Liverpool Bay. These terminals are in decline and will continue to supply less gas each year to the UK. The Project would therefore add capacity to the western leg of the NTS and assist the replacement of some of the lost terminal capacity. Indeed, for the same reason, the Project is an efficient and sustainable use of existing gas transmission infrastructure.

5.5.69 These locational and site specific factors give the Project specific advantages of scale, speed, reliability and costs in assisting security of gas supply in the UK.

**Addressing government concerns about future UK gas supply**

5.5.70 When the Project is operational, the benefits described above would make a major contribution towards alleviating four particular strategic concerns about future UK gas supply identified by DECC, Ofgem and the House of Commons Energy & Climate Change Select Committee:

(1) Supply Disruption

5.5.71 The 2012 DECC & Ofgem report on 'Gas Security of Supply' noted (at paragraph 3.45) that: "our increased exposure to international gas markets has also increased the range and likelihood of possible sources of disruption, including certain shocks that could have profound impacts on GB security of supply ... [such as] the potential impact of the closure of critical LNG shipping lanes; an unexpected curtailment of Russian supplies ...".

5.5.72 As discussed above, the Project would supply "within system" deliverability of gas as insurance against major import disruptions.

(2) Intermittency

5.5.73 The 2012 DECC & Ofgem report on 'Gas Security of Supply' also stated (paragraph 2.16): "...Looking forward, there is likely to be an increase in the need for flexibility from our gas supplies ... to meet larger and faster swings in demand from gas-fired electricity generators as ... renewable generation increases."

5.5.74 As also discussed above, the Project would provide reliable, and rapid response, flexibility to support intermittency of electricity supply from renewable sources.

(3) Investment need

5.5.75 The House of Commons Energy & Climate Change Select Committee report: UK Energy Supply; Security or Independence?” 2011 recommended (in its Recommendation 13) that: “the UK needs more gas storage capacity capable of delivering gas at a high rate ... It should aim to double the UK’s current gas storage from current levels by 2020 in order to avoid exposure to gas supply interruptions and price spikes”

5.5.76 The Project would make a significant contribution towards gas storage capacity, and in particular storage capacity which can deliver gas at a high rate. The working
capacity of the Project could be cycled multiple times in a year, enhancing its contribution to system deliverability.

(4) Investment risk

5.5.77 The Commons Energy and Climate Change Select Committee Report UK Energy Supply; Security or Independence? (2011) also recommended (Recommendation 15): "The UK needs to significantly increase its gas storage capacity. The Government must develop a strategy for achieving this. Doing nothing—or continuing to give inconsistent signals to the market about which approach it will choose—could result in no storage being built. This would diminish energy security."

5.5.78 Granting consent for the Preesall Project would send a critically important message to the market that the government continues to give a high level of support to investment in UK gas storage and supply infrastructure.

5.5.79 The extensive benefits described above (the policy benefits described at paragraphs 5.5.6 to 5.5.30, the capacity benefits described at paragraphs 5.5.31 to 5.5.50 and the locational and site specific factors described at paragraphs 5.5.51 to 5.5.69 above) thus fall to be considered against the limited adverse visual impacts of the Project now summarised below.

5.6 The adverse environmental impacts of the Project

5.6.1 The Secretary of State agreed in the SoS Decision Letter with the findings of the ExA Report concerning flooding and surface water drainage; pipelines; brine discharges to the Irish Sea; noise; Habitats Regulation assesssment and ecology; disposal of insoluble wastes in brine well 123; access; rights of way; built heritage; archaeology and socio-economic impacts (paragraphs 11 and 12 of the SoS Decision letter).

5.6.2 The only material adverse impact identified by the ExA Report and referred to in the SoS Decision Letter related to landscape and visual impact. For the purposes of considering whether the Project’s adverse impacts outweigh its benefits, the scale of that landscape and visual impact, and its relationship with need and benefits (as described in Section 5.5 above), must be considered, and this is done below.

Concern about the visual effect of the gas compressor compound

5.6.3 The ExA Report’s concern about landscape and visual impact related primarily to the Gas Compressor Compound (the "GCC"):

"7.13 Turning to the impact of the development on the landscape, there are few issues relating to the western side of the Estuary, where apart from the seawater pump station in the Fleetwood Fish dock, there is little surface development in any event. The main impacts on the eastern side of the Estuary are in the largely rural landscape, the scene of the historic brinewells. Whilst nearly all evidence of the plant associated with the former salt extraction industry has disappeared, this is a locality which has seen substantial industrial activity in the past. Most of the surface infrastructure proposed for this application i.e. the booster and seawater pump stations, pipelines and access tracks, can be accommodated without too much difficulty, though we consider the landscaping treatment to the proposed wellhead compounds could be improved within the powers of Requirement 4(3)."
7.14 **The main landscape issue in our minds is the GCC.** We accept that the location ultimately chosen is required to properly service the wellhead compounds and that substantial attempts have been made to fit it into the landscape, and further mitigate views particularly from the Wyre Way and from the south. Nonetheless, this is a complex array of industrial plant much of which would be sited externally and in our view would create an intrusion in the local landscape however well screened it is. This is one of the principal reasons that we suggest the verification of the geology to enable the UGS [Underground Gas Storage] caverns to be constructed, in order to fully justify the size and scale of the surface infrastructure as proposed. If that is achieved, with the safeguards provided by the requirements in terms of future landscaping details, and particularly the continuing refinement of the LEMSP, we are satisfied that the landscape and design disbenefits of the proposal do not outweigh the presumption of need."

Relevance of the 300 Mcm identified in the ExA Report, and the actual relationship between visual impacts and the size of above ground infrastructure

5.6.4 The ExA recommended that the figure of 300 Mcm for the minimum working capacity be inserted into the Requirements because, principally, it considered that if materially less capacity could be achieved than that applied for it was likely that some of the surface infrastructure would be oversized (paragraph 9.28 of the ExA Report). In particular, the ExA was “of the view that the GCC could be reduced in scale if it was only needed to handle a much smaller quantity of gas, and arguably its impact on the landscape would be reduced commensurately.” (paragraph 9.29 of the ExA Report).

5.6.5 The ExA Report conceded at paragraph 7.10, however, that the ExA had had “no direct evidence about the relationship of the facilities required at the GCC and the volume of gas stored” (as none had been requested and capacity had not been understood to be a matter in respect of which evidence was required) and the ExA accepted that the 300 Mcm figure was “to some extent arbitrary” at paragraph 9.30 of the ExA Report. Notably, in his Decision Letter the Secretary of State appeared to accept the point that the 300 Mcm was “arbitrary” (see paragraph 25 of the SoS Decision Letter).

5.6.6 The ExA’s reliance on the 300 Mcm figure is also arbitrary for a further, important reason. As explained at paragraph 5.5.34 above the capacity of a underground gas storage facility is determined by how it is operated, and not just how much gas is stored there at any one time i.e. for the same cavern volume the amount of gas that is stored in a facility will be lower if it is operated as a fast cycle rather than a single cycle facility. Depending on the number of times caverns are ‘churned’ the effective capacity of a fast cycle facility can be substantial; as shown at paragraph 5.5.39 above, even on Senergy’s base case calculation, the effective capacity of the Project (again on the basis of the Senergy approach) would be 2434 Mcm.

5.6.7 In fact the scale of above ground infrastructure of the Project relates very little to its static capacity and this could have been explained to the ExA if it had raised the issue during the Examination.

5.6.8 The ExA accepted that “there are elements of the infrastructure which are not in a linear relationship as the sizes are based on flow rates rather than stored gas volumes” (paragraph 9.29 of the ExA Report) but did not understand (because it did not ask) that the GCC itself is one of those elements.
5.6.9 Senergy has confirmed that the Project could provide up to 19 caverns and it is important to understand, in this context, that the surface infrastructure is required to construct and operate 19 caverns as set out in the application drawings. Senergy has also confirmed that the Project could be operated as a fast cycle facility generating significant flows of gas. The gas compressor equipment for the GCC will be commissioned and designed to accommodate (1) these fast cycling flow rates and (2) the number of caverns that need to be serviced — the static working capacity of the caverns does not have a material bearing on these flow rates because even if the caverns were smaller the gas compressors would simply withdraw and inject gas into and out of those smaller caverns more frequently to meet the same overall volumes of gas needed by users (i.e. to use KBB's "huff and puff" terminology, if the caverns were smaller, the same equipment would simply "huff and puff" more frequently rather than needing to be downsized).

5.6.10 It is useful at this juncture to note that the Senergy assessment of deliverability at Section 5.2 of the Senergy Report proposes a reduced withdrawal rate compared to that proposed in Halite's Updated GSR (document reference H30). The British Geological Survey and Mott MacDonald consider that this appears to be a straightforward misunderstanding of the correct approach:

(a) The Senergy Base Case, static working gas capacity, is stated as 203 Mcm but the dynamic capacity was not stated.

(b) In Appendix 1 of the Senergy report, KBB noted that Geostock's proposed injection rate of 32.4 Mcm/day was "modest", i.e. the injection rate could actually be faster.

(c) Senergy, however, in Section 5.2 erroneously implied a maximum daily delivery rate of less, 17-19.8 Mcm/day (0.6-0.7bcf/d), arrived at by reducing the delivery rate in proportion to its reduced static working gas capacity to keep the same withdrawal time at 10-12 days.

(d) This assessment by Senergy was a wrong application of the approach as the delivery rate of 32.4 Mcm/day will not change even if Senergy's unduly pessimistic static working gas capacity of 203 Mcm is adopted.

(e) If the static working gas capacity became less, and there were less gas in the caverns, it would simply take less time to empty and refill the caverns (the so-called "w" time) - the volume that could be delivered each day would not become less. That is a function of the specification of the injection and withdrawal equipment in the GCC. The daily volume of 32.4 Mcm could still be delivered but, again using KBB's "huff and puff" terminology, if the caverns were smaller, the injection and withdrawal equipment would simply "huff and puff" more frequently to deliver the same daily volumes.

(f) In any event, paragraph 3.8.20 of EN-1 acknowledges that the "technical specification of gas storage capacity that might be proposed" is "a commercial matter". The proposed flow rate of the Project is exactly such a technical specification and thus entirely a matter for Halite. It is therefore not appropriate for the Senergy Report to amend the Project by assuming, even erroneously, a reduction in the proposed flow rate.

5.6.11 It is thus also worth considering what buildings, structures and equipment the GCC contains (as set out in the "Construction Report" (document reference 9.1.6; paragraph 2.45) and why:
• Pig Launchers and Receivers;
• Slug Catchers;
• Large diameter above ground high pressure pipelines;
• Glycol Contactors to dry the gas;
• Glycol Regeneration system;
• Gas Compressors;
• Compressor Knock Out Separators;
• Compressor Aftercoolers;
• Gas filters;
• Gas Heaters;
• Various utility systems, plant drainage and power supply;
• Emergency/maintenance vent stack;
• Electrical/instrument and Utilities buildings; and
• Vent Stack provided within the centre of a new pond.

5.6.12 The pig launchers/receivers, slug catchers, above ground high pressure pipelines, utility systems, emergency vent stack and utilities buildings are all required because it remains necessary for the GCC to service the 19 caverns that comprise the Project (and which Senergy agrees can be achieved).

5.6.13 The most important elements of the GCC are actually the 2 gas compressors along with the gas heating and gas drying equipment. As set out in the Project Overview (document reference 9.1.3) submitted with the application, the gas compressors “would be used to inject and withdraw natural gas into and out of the storage caverns” (paragraph 7.6) and the GCC “essentially comprises gas compression, gas heating and gas drying. Gas compression would be provided by 2 compressors, whose capacity varies with speed [i.e. not by the cavern’s working gas capacity] and by operating in series or parallel configuration. This would allow the flexibility of operation that can control the temperature of the caverns within permissible parameters” (paragraph 7.10).

5.6.14 The Project Overview also explains how the compressors assist flows from the caverns to the NTS: “as the cavern pressure approached the NTS pressure, the compressors would be needed to export gas to the NTS. Depending on the flow rate required, one compressor can be dedicated to export of the gas to the NTS and the second to recycling gas to the caverns to control the temperature. If larger flows are required that require both compressors in parallel to export to the NTS, then the duration for which this flow can be sustained would be short as the temperature fall in the cavern approached permissible limits” (paragraph 7.17). Furthermore, “as the cavern pressures fall towards the minimum cavern operating pressure, export to the NTS would require both compressors to be operating in series” (paragraph 7.18).
Accordingly, the 300 Mcm threshold figure adopted by the ExA in its Report to the Secretary of State, of which much has subsequently been made, is of very little, if any, relevance for the purposes of redetermination of the DCO application: it was based on the incorrect assumption (not put to Halite) that at below 300 Mcm capacity the above ground structures for the Project would be smaller, and that therefore at below 300 Mcm capacity the benefits of the Project would not outweigh the impacts of (what were wrongly assumed to be outsized) above ground structures proposed. That assumption is simply incorrect. As can be seen from the points made above, the scale and size of the gas compressors, heaters and driers do not materially relate to the overall static capacity of the Project; all are needed for the Project to operate as a flexible, fast cycle facility and are thus integral to the type of contribution which the Project would make to national need, as described in Section 5.5 above.

The approach to visual impacts in EN-4, and in relation to the Project

In terms of the weight to be given to landscape and visual impact, NPS EN-1 acknowledges that “virtually all nationally significant energy infrastructure projects will have effects on landscape” (paragraph 5.9.7 of EN-1) and that “all proposed energy infrastructure is likely to have visual effects for many receptors around proposed sites” (paragraph 5.9.18 of EN-1). NPS EN-1 advises that “local landscape designations should not be used in themselves to refuse consent as this may unduly restrict acceptable development” (paragraph 5.9.14 of EN-1).

The landscape at Preesall is not designated as being of national, regional or even local importance and no part of the Project falls within an area of landscape quality as set out in a local development plan. Furthermore, the NPS and planning policy recognise that minerals can only be worked where they are found. Policy acknowledges that there are only a limited number of opportunities in the UK where the geology is able to support underground gas storage and Preesall is one of these locations. Paragraph 1.7.4 of NPS EN-4, for example, confirms that as gas supply infrastructure will be clustered in certain locations as a result of specific development requirements: “For example underground storage of gas in salt caverns will be in Wessex, West Lancashire, Cheshire and the Yorkshire North Sea Coast […]. This could result in a concentration of effects in the cluster areas, potentially elevating the effects from local to regional significance. Since in practice, the geographical constraints on underground storage […] will dictate their location, and it is not clear that a more centrally planned approach to gas and oil pipeline development would be advantageous, the approach set out in EN-4 is preferred”.

Moreover, industrial activity is not new to this location. The ExA Report noted that “Whilst nearly all evidence of the plant associated with the former salt extraction industry has disappeared, this is a locality which has seen substantial industrial activity in the past” (paragraph 7.13)

Put shortly, the landscape and visual impacts are modest, at their highest, compared to the importance of addressing the urgent national need for gas storage capacity. It would, therefore, be perverse to refuse the DCO on the basis of the impact of the GCC on the landscape given the significant contribution that the Project could make to gas storage in the UK. Moreover, refusal would send out a very alarming signal to any potential promoter of, or investor in, infrastructure projects in the UK, and would beg the question as to how any promoter of infrastructure could secure a DCO where the only adverse impact is limited landscape and visual effects upon an undesignated landscape.
6  **CONCLUSION: THE PLANNING BALANCE**

6.1  The Senergy Report confirms Halite’s geological analysis, including in particular:

(a)  the suitability of the halite body for the type of gas storage proposed, and therefore the Project’s compliance with NPS EN-4; and

(b)  the ability of the halite body to accommodate 19 gas storage caverns.

6.2  Because the Project satisfies NPS EN-4, and in particular paragraph 2.8.9 of that document, the presumption in section 104 of the Planning Act 2008 applies. The DCO should be granted unless the adverse impact of the proposed development would outweigh its benefits.

6.3  The Senergy Report confirms that the Project is likely to be developed with a minimum static capacity well above the threshold for an NSIP. Even using the figures proposed by Senergy, the Project would be one of the largest schemes of comparable type that have been built to date.

6.4  On the basis of the capacity figures given by Senergy, which are unduly pessimistic, the effective capacity of the Project, when the ability of the caverns to be cycled at least 12 times per annum is taken into account, is much greater at up to 2434 Mcm. It would be a major gas storage facility of huge significance, nationally.

6.5  The impacts on an undesignated landscape, which the ExA Report conceded has seen “substantial industrial activity in the past”, are modest and, in the light of the policy framework set out in the NPSs, clearly cannot be said to outweigh the benefits of this very large capacity scheme.

6.6  The critical issues for the Secretary of State are:

6.6.1  whether the Project is compliant with the national policy statement; and

6.6.2  whether the benefits of the project are outweighed by its adverse impacts.

6.7  In relation to the first of the issues above, the Senergy Report has removed any doubt that the geology at Preesall is ‘suitable’ for the type of underground gas storage proposed and, indeed, the Senergy report confirms that the geology is sufficient to accommodate 19 caverns. On this basis the Project is in accordance with the NPSs and the presumption in section 104(3) applies.

6.8  In relation the second of the issues above, the policy benefits, the capacity benefits and the locational benefits of the Project hugely outweigh the limited visual impacts of the Project on an undesignated landscape.

6.9  In the context of section 104 of the Planning Act 2008, therefore, development consent should be granted for the Project.
Appendix 1
Glossary

"Appendices to the Updated BGS Report" Appendices to report with British Geological Survey reference "CR/13/122" entitled "Results of an interpretation of newly acquired seismic lines over the Preesall Saltfield, NW Lancashire: their relevance to proposed areas for salt cavern gas storage development ('planning polygons')" prepared by the British Geological Survey dated 9 May 2014 and given DCO application reference "H27B"

"Bcm" million cubic metres

"BGS" British Geological Survey

"CCGT" Combined Cycle Gas Turbine

"COMAH" The Control of Major Accident Hazards (COMAH) Regulations

"DCO" development consent order

"EN-1" Overarching National Policy Statement for Energy (EN-1) dated July 2011

"EN-4" National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4) dated July 2011

"ExA Report" the ExA's 'Report of Findings and Conclusions and Recommendation to the Secretary of State' published in January 2013

"GCC" gas compressor compound

"Geostock Cavern Field Layout Report" Report with Geostock reference GKF/0/J/0002 entitled Halite Energy Gas Storage; Preesall Gas Storage Project; Revision of Cavern Field Layout prepared by Geostock dated 9 May 2014 and given DCO application reference "H28"


"Halite" Halite Energy Group Limited

"Halite's Geological Technical Appendix" see Appendix 2 of this document

"Halite's Response to the SoS Statement of Matters" Halite's Response to the Statement of Matters Raised by the Secretary of State pursuant to Rule 20(2) of the Infrastructure Planning (Examination Procedure) Rules 2010 prepared by Barton Willmore dated 8 May 2014 and given reference "H26"

"KBB" KBB Underground Technologies, appointed as technical experts in cavern design to complement the Senergy technical team

"LCC" Lancashire County Council

"Le Fevre Report" The Oxford Institute for Energy Studies report of January 2013 entitled "Gas Storage in Great Britain" by Chris Le Fevre, a copy of which can be found on the project page for Preesall on the PINS website
“LPA” Local Planning Authority

“Mcm” million cubic metres

“NPS” National Policy Statement

“NTS” National Transmission System

“OFGEM” The Office of Gas and Electricity Markets

“Planning Polygons” the proposed areas of cavern development identified within the DCO application

“Project” underground gas storage scheme subject of the DCO Application

“Senergy” Senergy (GB) Limited

“Senergy Report” the Independent Geological Assessment dated July 2014 produced by Senergy (GB) Limited for the Secretary of State in the course of her redetermination of Halite’s application for a Development Consent Order

“SoS Decision Letter” the Secretary of State’s decision letter of 9 April 2013

“Updated BGS Report” Report with reference “CR/13/122” entitled “Results of an interpretation of newly acquired seismic lines over the Preenall Saltfield, NW Lancashire: their relevance to proposed areas for salt cavern gas storage development (‘planning polygons’)” prepared by the British Geological Survey dated 9 May and given reference “H27A”

“Updated GSR” Updated Geological Summary Report prepared by Mott MacDonald dated 9 May 2014 and given reference “H30”

“WBC” Wyre Borough Council
Appendix 2
Halite’s Geological Technical Appendix
Halite Responses to The Independent Geological Assessment

Geological Technical Appendix

September 2014

Halite Energy Group
Halite Responses to The Independent Geological Assessment

Geological Technical Appendix

September 2014

Halite Energy Group

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1 Introduction

Halite Energy Group Ltd’s (Halite) team of geological advisors undertook a review of the Independent Geological Assessment prepared by Senergy (GB) Ltd (Senergy) and commissioned by DECC ("the Senergy Report"). The Senergy Report is referenced as A14DEC085A and was released to DECC on 25th July 2014. This report presents a summary of the findings of Halite’s review of the Senergy Report.

The Halite geological team comprises Geostock (GK) for the cavern development plan and rock mechanics assessment, and Dr D Evans of the British Geological Survey and Dr Everett Rutherford II (international oil and gas geological and geophysical expert) as geological advisors. Mott MacDonald Ltd (MML) has co-ordinated responses, and provided infrastructure planning and geological support.

This report is divided into sections that deal with the following:

- Section 2 summarises the key findings of the Senergy Report, from which it can be concluded that the geology at the Project site is suitable for development of an underground gas storage facility and that the key requirements of paragraph 2.8.9 of NPS EN-4 are met.

- Section 3 discusses technical differences between Senergy and Halite’s detailed assessment of working gas volumes, concentrating on two main points:
  - Senergy’s base salt interpretation;
  - How Senergy has considered uncertainty in its assessment of working gas volumes.

In this section, an explanation is given as to why Senergy’s volumetric assessment is unduly pessimistic. The British Geological Survey considers that Senergy’s alternative, shallower base pick is wrongly identified and appears to contradict borehole data. The implications of Senergy factoring the wrongly identified alternative base pick into its Monte Carlo analysis are explained.

This section also explains why changes made by Senergy to various assumptions and parameters (cavern sizes, shape factor, insoluble content and other factors), in both its assessment of base case, and in its Monte Carlo analysis, are considered to be less robust than Halite’s approach, which is based on direct experience within the laterally equivalent strata in Cheshire where underground storage caverns are already in operation.

- Section 4 discusses the relationship between static storage capacity, operating gas pressures and the importance of cycling to the assessment of the dynamic capacity of the Project.

- Section 5 contains a summary.
2 Key Findings of the Senergy Report

2.1 Key Findings with Respect to NPS EN-4 Requirements

Introduction

2.1.1 With respect to data coverage Senergy states (Section 2.3 page 9) “Overall however, there is good data coverage across the region; most of the planned cavern locations sit within approximately 200m of a seismic dip line...”.

2.1.2 The above statement acknowledges the good data coverage and that the proposed caverns are all within 200m of a seismic dip line (east-west orientation). When all of the seismic lines are considered, including the north-south Line HEG13-08, no cavern is more than 100m from a seismic survey line. The Project has four site-specific salt exploration boreholes with comprehensive down hole geophysical log suites and, in two of the boreholes, in-situ pressure tests. There is now some 35km of seismic reflection survey lines within and adjacent to the planning polygons (the polygons identified as areas suitable for cavern development), together with a large number of brine wells and ICI exploration boreholes. All of this data represents a substantial body of information defining the salt body within and around the planning polygons, which has now been acknowledged by Senergy.

2.1.3 Paragraph 2.8.9 of EN4 states:

“Applicants should undertake, and supply to the IPC, a detailed geological assessment to demonstrate the suitability of the geology of the site for the type of underground gas storage proposed. When considering storage in a salt cavity, the geological assessment should include depth below surface, salt thickness, salt purity and presence of shale bands which could affect cavern design. In addition, a study of the geological integrity of the overlying strata and potential for collapse, taking account of the proposed minimum and maximum working pressures, will need to be undertaken.”

2.1.4 The following sections summarise relevant comments from the Senergy report in the context of meeting and satisfying a number of requirements of EN-4 and Section 17 of The Planning Act 2008.

Top Salt

2.1.5 Section 3.2.1 of the Senergy Report acknowledges the data quality down to the Top Salt. Section 3.2.3 states: “The Top Salt interpretation in time domain is considered of good quality with little or no uncertainty.”

2.1.6 The newly acquired seismic sections show that the top salt forms a shallow syncline bounded by graben faults to the west (Burn Naze) and to the east (Preesall), with no significant faulting affecting the top salt between them in the planning polygons and immediately adjacent areas.
2.1.7 It is noted that no uncertainty factor is used in either the Senergy volumetric Base Case or within the varied parameters used in the Monte Carlo simulation, presumably because of Senergy’s positive conclusions on this aspect.

**Base salt**

2.1.8 Senergy identifies the Base Salt interpretation as a key risk to the current development plan in the penultimate paragraph of Section 3.7. They believe that there is uncertainty with the depth conversion to the Base Salt and its position within the seismic sections as detailed within Sections 3.2.3 and 3.2.4. It is not clear from the Senergy report how it has applied the uncertainty introduced within Section 3.2.4 but it is noted here, and within Table 5.2 Line 1 Column 5, that the error on the Base Salt is considered by Senergy to be zero at the margins of the syncline and up to +/-12% at the centre.

2.1.9 The Senergy approach therefore indicates that there is no substantial uncertainty in the shallow base salt areas. The magnitude of uncertainty for the deeper base salt described by Senergy is confusing and disputed, as described in Section 3 of this report.

**Salt Thickness**

2.1.10 The approach adopted by Halite in the depth conversion of the seismic interpretations from two-way-time was two staged. Firstly, for the top salt, a variable velocity with depth within the overburden mudstones was applied. This was based upon borehole data and known seismic times to the well constrained top salt reflection.

2.1.11 Secondly, a constant velocity was then applied to the salt time interval (top to base salt picks) in order to determine the salt thickness, which was then added to the depth to top salt to provide a depth to base salt. The Senergy report states at Section 3.2.4 that "This depth conversion procedure is considered to be appropriate."

2.1.12 However, Senergy - whilst considering the procedure appropriate - comments on the velocity for the salt adopted and introduced its own uncertainty assessment for the base salt which introduces a zero error for shallow salt and up to 171.6m variation in the deeper salt. No explanation is provided to support the uncertainty range proposed. This is discussed further in Section 3.

**Insoluble Content**

2.1.13 The Senergy report at Section 3.4 addresses the interpretation of the insoluble mudstone rocks within the Preeasill Hallite. Paragraph 3.4.1 recognises the British Geological Survey approach by stating that "Correlation of the six distinct mudstone units by the British Geological Survey suggests a level of regional correlation across the planning area, and possibly over a much greater area.....but, given the environment of deposition it is not unreasonable to assume continuity of the thickest mudstones across the immediate area away from the borehole control."
Section 3.4.1 goes on to state: "The approach taken to extend the mudstones across the planning area is appropriate and would generate a geologically reasonable map of the intra-salt mudstones." Also it states that (second paragraph, Page 21): "Qualitative comparisons of the Arm Hill #1 borehole gamma ray log with those from the Burrows Marsh and The Heads boreholes suggest that the Arm Hill #1 borehole can be considered representative of the intra-salt character across this southern part of the basin."

The Senergy report also highlights the relevance of the insoluble content and its impact on the volumetric assessment which is further addressed in Section 5.2 of its report. In the Base Case it appears that Senergy has used a set 8% of total salt thickness for the amount of insoluble mudstone and in the Monte Carlo simulation has used a variable insoluble content from 4% to 12%. The Halite analysis used a 27m average thickness of mudstone within a proposed salt interval which represented between 8% and 30% of the salt interval. The Halite approach has therefore introduced greater conservatism than the Senergy approach.

The Senergy Report notes in 3.4.2, final sentence, that the "final cavern design will have to take site-specific data into account and this may impact final capacity." It is axiomatic that this is the case and is part of the normal process of developing a scheme from an outline to a detailed design prior to submission to the COMAH Competent Authority for consent to construct caverns.

**Integrity of Overlying Strata**

The integrity of the overlying strata relates in particular to Geomechanical behaviour of the cavern roof and considerations relating to possible subsidence. Senergy states in Section 4.1.2 that: "The overall methodology (procedure) for the conceptual design can be considered as 'state of the art' and therefore appropriate."

The Senergy review of the subsidence calculation methodology concluded at Section 4.5 (page 30) that "The general procedure for subsidence modelling follows state of the art concepts. A rough check with data from other locations shows that the assumed values for convergence rates are within the range of experience."

Further qualifications were made by Senergy that "assumed model parameters have to be compared to measurements and observations". This is of course the case with any project and part of the normal design, operational and COMAH requirements.

Points of detailed disagreement raised by Senergy are discussed in Section 3 below.

**Capacity**

Section 5 of the Senergy report deals with volumetric calculation. Senergy estimated the working gas volume as stated within Section 5.2 which records: "...Senergy has produced a more substantial revision of the volumetric calculation and the associated uncertainty. This is based on Senergy's own evaluation of the interpreted seismic, borehole logs and the geological model, together with
consideration of KBB UT’s comments and recommendations on the Geostock reports.”

2.1.22 Senergy concluded in Section 5.3 that: “Senergy’s probabilistic calculations provides a range of Total, Cushion and Working gas volumes which we feel represents a more realistic view of the uncertainties in relation to the volumetrics inherent in this project.”

2.1.23 The assessment by Senergy for its Base Case (based on the British Geological Survey base salt pick) provided a static working gas volume of 202.8 million cubic metres (mcm). The working gas volume from its Monte Carlo simulation produced a 100% probability of achieving 82.1 mcm.

2.1.24 Appendix 1 of the Senergy report notes that the pressure change rates are modest. Section 5.2 also confirms that a withdrawal period of 10-12 days is considered attainable, which relies on the flow rate of 32.4 Mcm/day.

2.1.25 Section 17 of The Planning Act 2008 and NPS EN-4 paragraph 2.8.2 states that “Nationally significant underground natural gas storage facilities will hold 43 million standard cubic metres (Mcm) of gas or higher, or will have a predicted flow rate capacity equivalent to 4.5 million standard cubic metres a day or higher.” On both of these standards the Senergy report verifies that the Halite project meets the requirements of both documents.

2.2 Other Key Findings of the Senergy Report

Faulting

2.2.1 Faulting is assessed in Section 3.3 of the Senergy report. Section 3.3.1.1 notes: “The newly acquired HEG-13 lines have successfully delineated the position of the Burn Naze Fault Zone showing it to lie further to the west than previously mapped and is currently well to the west of the southern polygon.”

Gas Tightness

2.2.2 Section 3.5 reports on gas tightness and concludes: “The test site selection covers the key risk elements (with regard to gas migration) of the gas storage sites: multiple tests were taken in both boreholes within the overburden mudstones, the clean Presale halite, and two of the regionally mapped mudstones. The results indicate that the permeability and fracture pressure of both the salt, intra-salt mudstones and the overburden mudstones within the operating pressure range are sufficiently low to reduce the risk of gas migration through capillary migration.” The maximum operating pressures of the proposed caverns have been designed to be sufficiently lower than the fracture pressure of the surrounding rocks.
Wet Rockhead and Wild Brine Runs

2.2.3 Section 3.6 of the Senergy report notes that: “The cavern design rules proposed by the Applicant site new caverns at least 4 Radii (R) from mapped wet rockhead areas and 5R from former brine caverns of unknown shape and any brine run that may be connected to it (REP207, paragraph 5.47). This approach was accepted by the Panel Authority for the 2009 application and if applied as stated should not impact the cavern design.”

Cavern Development Plan

2.2.4 The general conclusion of the Senergy report on the cavern development plan as represented in Geostock documents (refs H28 and H29) was: “it can be stated that, in general, the methodology applied by Geostock in the Conceptual Design Study is appropriate” (paragraph 4.3)

Safety

2.2.5 The Senergy report, Section 4, has accepted that the rock mechanical assessment procedures for the outline cavern design are state of the art. As noted within 2.2.3 above, no issues with gas tightness have been raised. On this basis no concerns over the safety of the scheme have been identified or raised.

Fast Cycle Capability

2.2.6 Senergy considers “The overall methodology (procedure) for the conceptual design can be considered as ‘state of the art’ and therefore appropriate.” However, the Senergy report also notes potential constraints regarding a number of rock mechanical issues which are more usually the domain of more detailed design rather than planning. Notwithstanding the issues raised, in its volumetric assessment in Section 4.1.1 Senergy accepts the withdrawal rate of 10-12 days, but notes in Section 5.2 that as it has calculated a reduced static working gas capacity, the daily delivery rate will necessarily also be reduced. This is considered to be an incorrect deduction, and is discussed in Section 3 below. Senergy calculates, in Section 5.2, that the daily deliverable rate will be 0.6 to 0.7 bcf/d (billion of cubic feet/day). This equates to 19 to 19.8 mcm/day. Even adopting a pessimistic 10-12 day withdrawal period, at least 12 cycles per annum would be possible, delivering a dynamic working gas capacity of up to 2434 mcm per annum. The dynamic capacity is discussed further in Section 4.

2.2.7 The EN4 requirement is for a static capacity of 43 mcm OR a deliverability of 4.5 mcm/d. Senergy has calculated that there is a 100% probability of exceeding the figure of 43 mcm and also far exceeding the 4.5 mcm/d delivery rate.

2.3 Summary of Key Findings

2.3.1 In general Senergy accepts the geological model but identify that the Base Salt interpretations represents a key risk to the project. The rock mechanics analytical
methodology is accepted as state of the art but additional constraints were introduced. The Senergy static Base Case working gas capacity of 202.8mcm included reductions to allow for changes in cavern placement and other design factors.

2.3.2 The injection rate of 32.4mcm/d giving a 10-12 day withdrawal period was accepted by Senergy.

2.3.3 Senergy provides its probabilistic assessment of the potential variation due to a range of eight factors which they “feel represents a more realistic view of the uncertainties…”. Halite does not agree that the assessment represents a realistic view as Senergy appears to have made errors and unduly pessimistic design changes.

2.3.4 What Senergy describes as its more “realistic” assessment is an unduly pessimistic view. In reaching that conclusion Halite relies on the advice of its expert advisors and their experience in developing gas storage caverns in Cheshire, in laterally equivalent strata and, indeed, on other international expert opinion. These errors and examples of Senergy’s unduly pessimistic approach are discussed in the following section.
3 Discussion of differences between the Halite and Senergy Assessments

3.1 General Statement

3.1.1 Senergy has presented its review of the geology and the KBB UT (“KBB”) review of the rock mechanics. Senergy has then generated its own volumetric calculations.

3.1.2 The Senergy report makes negative comments about the late arrival of data and states that Senergy experienced initial difficulty with the formats in which data was received. Halite was, however, given no advance warning that such data would need to be provided for a third party review. Provision of such extensive raw geological data is unusual and, indeed, is understood to be unprecedented at the planning stage. The request was also poorly defined which made it difficult to understand how to present the data. Notwithstanding this, Halite produced a large volume of data, amounting to some 90 files, within 14 days of the request being made. Ultimately, Senergy was able to access and load the relevant files, which were in industry standard format.

3.1.3 The difficulties with using some of the data, as noted within the Senergy report, appear in part due to the resources available to Senergy. Halite offered to provide any assistance it could with the data provided, but this was only taken up to a limited extent. Following several email exchanges and telephone conversations with the Senergy Project Manager, the British Geological Survey provided a series of PowerPoint slides to explain the relatively simple process of geographical referencing and loading data to the PETREL seismic interpretation software package (the requested software format). The emails indicated that this process had not been understood until the slides were provided, after which Halite was informed the problem had been resolved.

3.1.4 Despite the general agreement between Senergy and Halite on many of the principles of the analysis and interpretations, there are differences of detail on aspects of the geological interpretation and capacity calculations. Some of these differences have little effect on the overall assessment of the storage capacity of the Project, others have a larger effect. Rather than review each point of difference separately, this response is focussed on 2 key issues:
   - base Salt interpretation; and
   - treatment of uncertainty

3.2 Base Salt Interpretation

3.2.1 There are two fundamental questions to be addressed when interpreting the base of the salt from the seismic survey, these being:
1. which reflection to pick within the two-way-time domain sections; and
2. how to convert the two-way-time pick to a depth.
3.2.2 Considerable effort was applied by Halite to analysing the seismic sections. Indeed this basic analysis was undertaken by three separate geological teams: the British Geological Survey, Dr Everett Rutherford and Geostock. All three have national and international experience of seismic interpretation in the oil and gas industry. The collective experience of the international experts amounted to more than 100 years. Synthetic seismograms, generated from the downhole geophysical logs in four modern, site specific salt exploration boreholes provide calibration of these seismic lines and predict a broad negative reflection arising from the base salt. It is acknowledged that not everywhere is such a reflection developed, with some uncertainty of the base salt reflection in some areas.

3.2.3 A number of interpretations of the base salt were considered, by Halite’s geological team, and models produced, which ranged from a cautious assessment that took into account concerns from previous representations, through to optimistic interpretations. It was considered too confusing to show this range of interpretations in Halite’s Updated GSR (H30) and so, in keeping with the cautious approach adopted by Halite, the shallowest of the plausible interpretations was adopted. Some indication for an alternative deeper pick for the Base Salt was given within the British Geological Survey report (H26A and H27A, Sections 5.3.2.6 to 5.3.2.8).

3.2.4 The reasoning behind Halite’s shallowest plausible base salt pick was provided within the British Geological Survey report and summarised in the Updated GSR (H30). Extensive correlation of the pick was undertaken across sections and tied to boreholes. It was expected that the base salt would be less well defined than the top salt for sedimentological reasons and these were taken into account in the variations of the base salt picks considered.

3.2.5 The interpretation of the thinning of the salt around Borehole E1 is an example of the cautious approach taken by Halite. Some of the interpretations included considering that the mudstone within which Borehole E1 terminated represents a thick mudstone interbed which would correlate more readily with adjacent boreholes. However, the interpretation adopted and presented in the 3D geological model was what Halite’s geological advisors believe to be the worst credible, by assuming it terminated in the older underlying Thornton Mudstones and that there was a natural westwards thinning of the salt in this particular area.

3.2.6 It is noted that the Senegy report adopts the British Geological Survey Base Salt pick for its Base Case volumetric assessment and as the mid-point within its Monte Carlo simulation. The apparent justification for the latter case was the proposed alternative base pick at a much higher level (shallower depth). This alternative pick is said to be shown on Figures 3.3 to 3.6 but in fact is only shown as a partial pick and only on Figures 3.3, 3.4 and 3.6. A full Petrel project containing either the model, or the interpretation of the independent geological evaluation, has not been made available to Halite. However, analysis of this alternative pick by the British Geological Survey within its Petrel interpretation shows that, when it is tied back to boreholes, the pick chosen by Senegy correlates to an interval of muddier salts and
series of interbedded (intrasalt of Senergy) mudstones, and does not therefore represent a plausible or credible interpretation of a higher Base Salt level.

3.2.7 Figures 3.1 and 3.2 below show the comparison of the Senergy and British Geological Survey “picks” and why it is considered that the Senergy “base salt pick” is an interbedded mudstone.
3.2.8 The energy report acknowledges that the top salt interpretation in the line domain is considered of good quality with little or no uncertainty (Section 3.2.1) and that the depth conversion procedure for obtaining the base salt is considered appropriate (Section 3.2.4). However, the Energy report then makes much of the problems in the depth conversion of both top and base halite seismic picks, commenting on assumed associations in picking and velocities.

3.2.9 The energy states that it did not have access to vertical seismic profile (VSP) data in order to substantiate and make assessment of possible errors in overburden and halite velocities used during depth conversion. However, this was not necessary as the critical and relevant time-depth velocity data taken from the well surveys, and verified by site-specific downhole borehole logs, were summarised in Tables 12 of the British Geological Survey report (H26A & H27A).
3.2.10 The report tables clearly demonstrate the relevant depth and time values and with them the associated velocities of the main intervals. The value of 4290 m/s obtained for the Preesall Halite is thus from site specific borehole data and importantly, lies at the slower end of velocities measured for halite beds around the world. Very clean salts give rise to velocities of 4600-4800 m/s and, rarely, even faster at up to 5000 m/s (e.g. Sun et al.; Sun, 1994). From experimental work, the velocity of damaged halite maybe as low as 3200 m/s, but soon recovers to highs of around 4600 m/s (e.g. Chen et al., 2013). Laboratory experiments also reveal that little change in velocity occurs with increasing pressure, temperature and even insolubles content (Sun, 1994; Sun et al).

3.2.11 The current Preesall site characterisation has, therefore, honed site-specific velocity data and followed the constant theme of the work in taking a cautious approach. The application of the faster velocities obtained from salts elsewhere in the world would imply deeper and thicker halite at Preesall, but would have less credibility at this stage.

3.2.12 In terms of the overburden velocities, Senergy took issue with the fact that they did not have the background data and derivation of the polynomial equation used to depth convert the top halite seismic pick. The actual derivation of the equation was not included in the British Geological Survey report for reasons of practicality, brevity and to reduce to a minimum the complexity of an already technical report. Had Senergy requested this information an explanation could have been provided; however, the following paragraphs explain the depth conversion process in more detail.

3.2.13 Initial attempts at depth conversion to top-salt found that use of stacking velocities alone did not provide a sufficiently robust solution for resolving depths to top of salt. Records for all eight seismic lines represent four seconds of two-way travel time ("twt"), with much of the stacking velocity data pertaining to deeper parts of the section. These areas are well below the zones of interest for the purposes of investigating the proposed natural gas storage zones within the Preesall Halite and in particular, that lying beneath the two planning polygons.

3.2.14 For this reason, a polynomial equation was derived for the overburden mudstones using a time-depth relationship to Top Halite. This was obtained using well ties from sonic logs, synthetic seismograms and ties to the top salt pick (known twt value) from the new seismic lines at wells for which no well log data are available. The four site specific salt exploration boreholes provided velocity and density data with which to establish well-to-seismic ties, and for building a framework for incorporating and tying older ICI wells in the area of interest to the velocity structure. This permitted the full volume of well data available to Halite to be incorporated into the time-depth model. After time-depth relationships were established on a well-by-well basis, a curve was fitted to the data and an equation was derived to allow any 2-way time to top-salt within the seismic data set to be converted to a depth in meters below sea-level.
A “best-fit” was obtained using a second-order polynomial equation:

\[ y = 0.0016x^2 + 2.3414x - 152.84 \quad R^2 = 0.9836 \]

that is valid over a depth range of ~80 to ~400 meters, which encompasses the depth maximum and minimum depth ranges within the total area of the new seismic data (Figure 3.3). Although the depth datum for the seismic data is MSL, a “0-0” intercept was not used for a variety of reasons. Firstly, use of zero-intercept results in a greater mismatch to observed well-to-seismic ties. Secondly, a uniform replacement velocity of 2000m/s was used from surface to sea level during processing and it was felt that introducing shallow velocity relationships into the curve would induce the risk of error propagation down-section.

The final time-depth model for Preesall provides a close match to well data and to the small volume of shallow-level stacking velocity data, thus providing confidence for the deeper parts of the basin. The resulting time-depth equation used for depth conversion is shown in Figures 3.3 and 3.4. The process to produce the maps for top and base salt has been detailed in the British Geological Survey report (H26A and H27A) and the Updated GSR (H30) and is not repeated here. In summary, the methodology adopted by Halite for depth conversion is generally accepted by Senergy as being appropriate, although there is a query over depth conversion of the top salt pick. Using a single velocity for the overburden mudstones in the depth conversion of the top salt would result in unrealistic results. Instead, a polynomial equation was derived by combining time data from the new seismic data set with the existing (and acknowledged extensive) borehole database. This establishes a time-depth relationship for the overburden mudstones that more accurately reflects lateral variations in the velocities of the overburden mudstones arising from e.g. variations in the density mudstone due to changes in depth and also salt content in the form of thin salt beds or salt veins. This approach represents a more realistic methodology, providing a greater degree of accuracy and thus confidence in depth conversion of the top salt.
Figure 3.3: Derived Time-Depth Relationship to Top-Halite using well ties from sonic logs, synthetic seismograms and ties to the top salt pick from the new seismic lines for wells from which no well log data are available.

Top-Salt Time-Depth Curve
(from well-to-seismic ties)

\[ y = -0.0016x^2 + 2.3414x - 152.84 \]
\[ R^2 = 0.9836 \]

Source: Everett Rutherford
Figure 3.4: Stacking velocity data extracted for the depth range pertinent to the top of salt are shown in this graph as small blue open circles. For this depth interval, stacking velocities are generally in good agreement with well data and provide an independent validation on the time-depth relationship to top of salt.

Top-Salt Time-Depth Curve
(from well-to-seismic ties)

Although stacking velocities fall mostly on the time-depth curve, they were found to yield a less accurate match to known top-salt depths than the curve generated by well to seismic correlation method.

Source: Everett Rutherford

3.2.17 Senergy states (p.15 and in Table 5.2) that it believes the error at base salt levels may vary from zero in the shallowest areas (around 418m – p.15), to up to +/-12% at depths of circa 715m in the deepest parts of the basin. No explanation or methodology is provided to show how the error was estimated at 12%. Senergy then extends these figures to an estimated error of salt volume from zero to +/- 25%, with an average of +/-15%. Doubt is then cast over exactly what average error in salt thickness is calculated/applied as in Table 5.2 (along with the incorrect reference to sand), it is quoted as 13%.

There are a number of inconsistencies and flaws/errors in the Senergy approach. Discussion of these inconsistencies and errors also explains why the British Geological Survey base salt pick is the shallowest credible pick:

1. In the currently deepest mapped part of the basin the base salt is known with certainty, having been proved by the site specific salt exploration Burrows Marsh Borehole. At these points there cannot be any doubt regarding depth, and the application by Senergy of an error is therefore wrong. Other questions over the application of an error also arise:
a. Senergy has not provided detailed explanations of its methodology for applying its uncertainty factor to the base salt at each cavern position. It is not clear, therefore, whether a sliding error has been applied between the shallowest and deepest parts of the basin, or whether an overall average error has been applied. If the latter is the case, this conflicts with Senergy’s conclusion that there is zero error in the shallower parts of the basin.

b. Senergy may have applied uncertainty factors to the base salt interpretations at cavern locations that are adjacent to boreholes, or along seismic lines that (away from the cavern locations) tie to boreholes and where the base salt has been proven. If so then boreholes have been ignored and the volume of salt grossly underestimated in the Senergy review.

2. The nature and depth/thickness of the Preesall Halite is proved elsewhere by three other site-specific salt exploration boreholes:
   a. in land immediately adjacent to both planning polygons (Arm Hill, Hay Nook); and
   b. in land to the south of the southern planning polygon (The Heads)

3. Legacy ICI boreholes also provide important controls on the depth to base salt in land:
   a. between the two planning polygons (B6);
   b. to the east and south of the planning polygons in the shallower parts of the worked saltfield (e.g. BW’s 110-130, BW’s 32, 33, 43, 56, 61, 77, 79, 81 & 82); and
to the north of the northern planning polygon (e.g. P1 and E1). The E1 Borehole reached terminal depth (TD) in a thick mudstone, which ICI interpreted as the underlying Thornton Mudstones. Again, in producing the revised 3D geological model the British Geological Survey has taken the most pessimistic interpretation of the salt thickness at that point in the basin. Halite has other interpretations and models that interpret the borehole reaching TD in a thick interbedded mudstone within the salt and that further salt is present beneath this. An indication of a deeper, alternative base Salt pick, is presented in Figs. 19-21 of the British Geological Survey report (H26A & H27). The 3D geological model maintains a conservative base salt pick away from the borehole and honours facts known about the salt body from the many borehole ties established in Petrel, including synthetic seismograms generated from the site-specific salt exploration boreholes, which establish the seismic character of the Preesall Halite. Despite the thinner salt hereabouts and conservative pick in general, the 3D model still provides Geostock with sufficient salt to permit development of 19 caverns and at least 324 mcm working gas volume.

4. Senergy correctly recognises that the Arm Hill Borehole, (drilled in 2004, and which proved what was at the time the deepest and thickest known salt in the Preesall Saltfield), did not prove the base Preesall Halite. However, Senergy portrays this as a negative, and suggests that doubt exists over the base of salt, which could perhaps be thinner, it suggests. Whilst the British Geological Survey
believes the borehole almost reached the base of the halite beds and that the base lies just below the terminal depth (TD) of the borehole, the actual base of the halite beds can only be below the base of the borehole. This can only be a positive, because a greater thickness of halite is in fact possible in the Arm Hill area rather than the value assumed by the British Geological Survey. This is an example of the conservative approach which Halite has taken to determining the depth to base salt in the planning polygon areas.

**Summary Comments on Base Salt Interpretation**

3.2.18 The base salt interpretation proposed by Halite has taken the most cautious interpretations of three international geologists with wide experience in salt basins. The depth conversion adopted by Halite has used site specific data pertaining to velocity of the mudstone and salt. The depth conversion of the salt beds has used conservative salt velocities across the project area and which are derived from salt exploration borehole geophysical logs. In the final assessment the calculated depths have been ‘sense-checked’ against base salt depths proved in boreholes. A complete model for the base salt has been built across both polygons which ties between seismic lines and honours data from numerous boreholes.

3.2.19 By contrast, the Senergy report has been unduly pessimistic, used generalised and unsupported assumptions, failed to recognise the importance of considerable borehole data, and in our opinion wrongly identified the base of salt pick.

**Treatment of Uncertainty**

3.3.1 The reappraisal of geology and generation of capacity calculations presented by Senergy (Section 5.2) is based on its own evaluation of the interpreted seismic lines, borehole logs and the geological model together with consideration of the implications of KBB. Two volumetric calculations have been generated by Senergy: 1) its Base Case; and 2) a Monte Carlo simulation. These are discussed separately below.

**Senergy Base Case**

3.3.2 The Senergy Base Case is described in its report, Section 5. This uses the British Geological Survey Base Salt interpretation, but makes changes to the cavern diameters and cavern heights because Senergy applies different rules on cavern separation and top salt to top cavern and base salt to base cavern separation distances.

3.3.3 The general methodology of volumetric calculations employed by Halite is considered by Senergy to be appropriate. The Senergy Base Case uses the same top and base salt interpretations as the British Geological Survey at all cavern locations, but Senergy has introduced changes which impact on the volumetric calculation. These comprise:

3.3.4 One-off Impacts on the physical cavern size:
Cavern separation (which impacts the diameter of 13 caverns);  
Distance between cavern roof and the top salt surface; and  
Distance between cavern base and the base salt surface.

3.3.5 Impacts on the useable cavern capacity
- Shape factor;
- Amount of insoluble mudstone;
- Insoluble bulking factor;
- Remaining brine after first fill;
- Insoluble content of salt layers; and
- Insoluble content of interbedded mudstone layers.

3.3.6 Miscellaneous factors:
- Minimum pressure gradient; and
- Cementation of final casing string.

3.3.7 The difference made by the three types of factor are as follows:

One-off Impacts on Physical Cavern Size

3.3.8 The separation distance between caverns defines the pillar width (P). The minimum pillar thickness relative to cavern diameter (D) gives the ratio (P/D) between two adjacent caverns which was set by Halite to between 1.4 and 1.9R. These figures have been calculated from numerical analysis using site specific data and by the Geostock design experience of P/D ratios of the Holford caverns (Cheshire) which are in the stratigraphically equivalent strata. The numerical analysis shows that the mean deviatoric stress at pillar centre is relative to depth; hence shallower caverns can have a reduced separation distance without increasing the stress within the pillar. Thus from analogy with the Holford site, referring to the same bearing stress at pillars centre, the P/D ratio at the mean cavern depth in Preesall project has been optimized to a minimum of 1.4R.

3.3.9 Senergy has changed this minimum separation distance to 1.5R. The impact of increasing the pillar width to a minimum of 1.5R is to reduce the diameters of 13 caverns by up to 5m.

3.3.10 The minimum distance between the cavern top and top salt as well as the distance between the cavern bottom and the salt base have been set by Halite to one cavern radius and to 20% of a cavern radius, respectively, as recommended by cavern design expert Professor Rokahr. Senergy has arbitrarily increased these to 1.25R and 0.5R, respectively. This has reduced the height of every cavern by up to 27.3m.

3.3.11 The changes introduced by Senergy appear to be on the basis that KBB considered the Halite assessment to be optimistic. No justification has been provided for this assumption, nor for the proposed ranges given for each parameter. The combined effect of these changes is to reduce the geometrical cavern volume by 21%.
Shape and Insoluble Factor Impacts on Cavern Size

3.3.12 The cavern shape factor takes account of the leached shape relative to the perfect geometrical shape. The value used by Geostock was based on its experience in Cheshire cavern construction in stratigraphically equivalent strata. Geostock has been involved in many salt cavern projects in the UK and particularly in laterally equivalent salt beds in Cheshire (Holfort, Stubbach, Hilltop, British salt, Hole-House, etc.). In addition, the evidence from the correlation of borehole geophysical logs shows the Preesall halite to contain no more interbedded mudstones, and to be cleaner, than the laterally equivalent beds in Cheshire (e.g. Evans & Holloway, 2009). The leaching experience at the Holfort project allowed calibrating more realistic figures for cavern shape factor at Preesall.

3.3.13 Senergy has reduced the cavern shape factor value of 85% used by Halite (Geostock) to 75%, apparently based on comments from KBB that the Halite assumption was optimistic.

3.3.14 The insoluble content within the salt body over the potential cavern height impacts the usable cavern volume because, if this insoluble material is not washed out of the cavern to the surface, it falls to the bottom of the cavern and thereby reduces the volume available to store gas. As the leached insoluble material sinks to the cavern sump it increases in volume (bulking factor). The insoluble factors used by Halite were based on site specific data from the geophysical logs of site specific salt exploration boreholes, as well as rock properties determined by well test data in the Hay Nock #1 borehole (Geo-Mesy and Golder Associates tests). The values adopted by Halite are site specific data, as opposed to the general assumptions used by KBB and Senergy.

3.3.15 The Senergy factors appear to be based on KBB’s opinion that the Halite figures are optimistic, and propose alternative values which have not been justified. The combined effect of the Senergy assumptions is to reduce the usable volume by 39%.
## Table 3.1: Halite/Senergy Cavern Comparison

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Miscellaneous Factors

3.3.16 The other factors identified by Senergy which are different from the Halite calculation and the Senergy Base Case calculation are, firstly, changes of the minimum pressure gradient for some caverns and, secondly, a reduction factor against the probability of successfully implementing any cavern.

3.3.17 The impact of these factors on cavern volumes will be negative; however, no specific details have been presented as to how these miscellaneous factors have been applied by Senergy. As a result the magnitude of the impact of these factors on cavern volume or static working gas volume cannot be assessed.

3.3.18 The minimum pressure gradient was set at 0.06bar/m for all caverns based on the geotechnical study performed by Geostock. This study concluded that the minimum pressure ranges from 0.06 to 0.08bar/m as follows:

- for the cavern geometry Type I (large cavern with a volume >750,000m3 and an aspect ratio H/D >3) a minimum pressure gradient of 0.08bar/m can be applied.
- for the cavern geometry Type III (small cavern with a volume <380,000m3 and an aspect ratio H/D of <0.8) a minimum pressure gradient of 0.7bar/m can be applied.
- for medium sized caverns, Type II (between Type I and Type III) a minimum pressure gradient of 0.06bar/m can be applied.

3.3.19 Within the revised cavern layout produced by Geostock for Halite all the projected caverns have been classified as Type II with a minimum pressure gradient of 0.06bar/m. Senergy has applied a 0.07bar/m pressure gradient which may be due to a misunderstanding of the cavern type definition.

Discussion of Base Case Uncertainties

3.3.20 A comparison of the Halite proposal, and the impact of the uncertainty factors proposed by Senergy, is shown in Table 3.1, and for the example of cavern 9 is shown pictorially in Figure 3.5.
Figure 3.5: Cavern Layout Comparison

Source: Mott MacDonald
3.3.21 The changes made by Senergy to the cavern sizes, shape factor, the insoluble content and miscellaneous factors are not explained and are almost all negative. The combined effect of deviations from the Halite figures is to reduce by 37.5% the static working gas volume calculated by Halite. The Halite factors were based on site specific factual data, site specific numerical analysis, and specific experience of cavern design, construction and operation within the laterally equivalent strata in Cheshire, as well as international expert opinion.

**Senergy Monte Carlo Simulation**

3.3.22 Having established a base case that utilised the British Geological Survey Base Salt interpretation, and then applied different shape, insoluble and miscellaneous factors as described above, Senergy sought to analyse what they considered to be further data uncertainties through a Monte Carlo simulation. In a Monte Carlo simulation a range of possible values is given for each of the uncertain parameters, instead of taking a single value as was the case in, for example, the Base Case calculation. The calculation of capacity is then run thousands of times, randomly selecting a single value from within the range specified for each of the factors. In this way a probabilistic assessment of the worst, average and best cases can be calculated.

3.3.23 Senergy undertook the Monte Carlo simulation applying parameter ranges for the following factors:
- Base salt pick
- Shape factor
- Amount of insoluble mudstone
- Insoluble material bulking factor
- Insoluble content of salt layers
- Insoluble content of interbedded mudstone layers
- Maximum pressure gradient at casing shoe
- Possibility of successfully implementing any cavern.

**Base Salt Pick**

3.3.24 The uncertainty range applied by Senergy appears to be based on the adoption of the British Geological Survey worst credible case as a median point, and then allowing for the base salt, in Senergy’s worst case, to be shallower than the British Geological Survey Base Salt pick. For the reasons discussed in Section 3.2.2 to 3.2.20 above, the Senergy alternative pick is not considered to be plausible. If that pick is adopted it will result in an unduly pessimistic assessment. The actual range of uncertainty applied by Senergy is not described clearly. Table 5.2, Column 5, Line 1 describes the range applied to the base salt. The text within the table describes the uncertainty as zero at the shallowest salt up to +/- 12% at the deepest salt. The effect of this error is said to introduce a variation in “sand” thickness of +/- 25% with an average of +/- 13%. The text within Section 3.2.4 (page 15) appears to be the source explanation for the Table 5.2 comments. The uncertainty is described as zero to 25% with an average of 15%. No further explanation of how the figures have been incorporated within the calculations has been provided, so no further comment on their application can be made.

3.3.25 The Senergy report at Section 3.3.2 refers to various scenarios for the Base Salt interpretation being illustrated within Figures 3.2 to 3.6; however, only figures 3.3, 3.4 and 3.6 appear to
show any alternative illustrations. The illustrations provided within these two figures amount to some 2km of alternative interpretation out of the total of 19km for the HEG 13 seismic survey. No further detail of these alternative models has been provided to show how the shallower alternative base salt pick might tie to other seismic sections or boreholes.

3.3.26 Analysis undertaken by the British Geological Survey, which has many years of experience of the geology of Preesall, and who prepared a comprehensive model from the seismic lines, interprets the alternative higher pick by Senergy for the base salt as a reflection arising from a series of muddier salts and interbedded mudstones. This pick, by Senergy, would be an error, as shown in Figures 3.5 and 3.6.

3.3.27 The British Geological Survey interpretation is part of a basin-wide model that is tied to boreholes. In particular the Burrows Marsh borehole penetrates the base salt in the deepest part of the basin which proved the base salt at 754m depth. The three deepest caverns, Caverns 16, 17 and 18, are some 200m from the location where the base salt is penetrated. An interbedded mudstone is indicated some 83m vertically above the base salt within the Burrows Marsh borehole which is very similar to the 86m (-12%) uncertainty proposed by Senergy at the deepest part of the basin, i.e. adjacent to the Burrows Marsh borehole.

Shape Factor

3.3.28 The shape factor adopted by Halite was based on the international experience of its experts in general, and in the equivalent strata in Cheshire in particular. It also took advantage of the analysis of existing sonar surveys of brine caverns within the Preesall brinefield and their comparison with sonar survey results from gas storage caverns in Cheshire.

3.3.29 The value of 60% for the lower bound value, used by Senergy, is considered to be unduly pessimistic and outwith the range of experience of caverns within similar strata.

Amount of Insoluble Mudstone

3.3.30 Halite assumed that the vertical thickness of mudstone that would occur within any cavern would be 27m. This was a conservative assumption that is corroborated by Senergy, which uses less onerous values.

Insoluble Material Bulking Factor

3.3.31 This represents the amount that the mudstone will increase in volume, from the in situ value, due to dissolution and then settling out of the leaching brine. It assumes that none of the insoluble material is washed from the cavern during construction, i.e. the worst credible case. A value of 1.5 was used by Halite based on the experience of its experts in the stratigraphically equivalent strata in Cheshire. The Senergy range of 1.4 to 2.4 appears unduly pessimistic. No details have been provided on how this factor has been applied in the calculation so further comment cannot be made at this stage.

Insoluble Content of Salt and Mudstone Layers

3.3.32 These factors are either not materially different from those adopted by Halite, or do not significantly impact the static working gas volume.
3.3.33 Maximum Pressure at the Casing Shoe

The Senergy Base Case used the same figure for determining the pressure at the casing shoe as Halite. Senergy’s Monte Carlo simulation introduced a range around this value of +3% and -7%. The lower end of the range at -7% represents an unduly pessimistically low value. The value adopted by Halite was based on site specific borehole log density data and laboratory test data which does not indicate that such a pessimistic range of pressures is appropriate.

3.3.34 Possibility of successfully implementing any cavern

Senergy report Table 5.2 refers to a range of 90% to 95% possibility of successfully implementing any cavern. We are not aware of how this factor has been applied to the analysis and how it impacts the static working gas volume so further comment cannot be made at this stage.

3.3.35 Discussion of Monte Carlo Simulation Uncertainty

The range for the individual parameters used by Senergy appears to be based on the KBB recommendations but has not been explained in any detail. The Halite values are based on the results of site-specific data and numerical analysis as well as experience from stratigraphically equivalent strata in Cheshire.

The assumptions used by Senergy/KBB in their Base Case assessment are considered to be pessimistic. The range of values used in the Monte Carlo analysis is considered to be unduly pessimistic and not to represent a reasonable assessment of the data. The Senergy assumptions also contain errors. The combination of these assumptions and values produces a working gas volume that is unduly pessimistic when compared to the large body of data available for the Preesall site and experience in Cheshire. In other words the Senergy assessment represents the Halite worst case at best as an average, and seeks to apply unduly pessimistic values, to provide a lower bound range.

3.3.36 A diagrammatic comparison of the Halite proposals, and the application of the Senergy assumptions, is shown in Figure 3.6 to demonstrate the impact of applying Senergy’s worst case in the Monte Carlo simulation.
The application of uncertainty as proposed by Senery provides an unduly pessimistic analysis. The base salt uncertainty introduced for the deepest part of the basin is adjacent to the Burrows Marsh borehole which proved the actual depth to the mudstone; consequently, the application of a +/- 12% uncertainty at this location is not justified. Further the alternative base salt pick identified by Senery, which would be about 86m (12% of 715m) above the level proposed by Halite, coincides with the level of the first mudstone interbed above the base salt, proved in the Burrows marsh borehole as some 83m above the Halite base salt pick.
3.3.40 In summary, the Senergy alternative base salt pick is limited in the extent shown and appears to contradict borehole data. The range of uncertainty introduced in shape and insoluble factors do not accord with expert experience in laterally equivalent strata in Cheshire. Senergy has not provided adequate explanation of how all the factors have been applied to their calculations. The arbitrary reduction in cavern sizes, the doubt as to their alternative base salt pick, and the unexplained application of uncertainty factors combines to produce an unduly pessimistic assessment of capacity.
4 Discussion of Outcomes on Capacity

4.1.1 The static working gas capacity of a cavern facility is a function of the useable cavern volume after leaching and its operating gas pressure range. The operating pressures vary between a maximum that gives the total gas that can be accommodated within a given volume, and a minimum value which gives the cushion gas volume.

4.1.2 The maximum pressure is dictated by the weight of rock above the cavern, in that the cavern gas pressure must be less than the overlying weight of rock. The minimum pressure is controlled by the need to keep the cavern stable and this dictates the volume of the cushion gas that is never removed during operation. The working gas is simply the difference between the maximum volume and the cushion gas volume.

4.1.3 The maximum and minimum pressures are also affected by the rate at which the working gas is injected or withdrawn; hence operational conditions of the facility are important as well as the physical volume. This is because when gas is pumped in to a cavern it heats up, in a similar manner to pumping up a bicycle tyre. Conversely, when gas is let out, it cools. The heating and cooling can affect the stresses in the cavern walls, so the speed at which the gas is injected or withdrawn has to be controlled and engineered into the design parameters. Consequently the working gas volume of any given cavern can change depending on whether it is operated as a fast cycle (faster injection and withdrawal) or slow cycle (slower injection and withdrawal) facility, even though the physical size of the cavern has not changed.

4.1.4 For risk assessment purposes, and for the purposes of Hazardous Substances Consent, it is the maximum and minimum amounts of gas that can be stored at a facility at any one time that are important. These are referred to as the static total (maximum) and cushion gas (minimum) capacities.

4.1.5 For the purposes of assessing the effective capacity of a facility, and its ability to meet market demands, however, the deliverability of the gas into and out of the facility is the critical factor.

4.1.6 The plant that is required at the surface and the size of the pipes to conduct the gas to the National Transmission System depend on, amongst other things, the rate at which gas is injected and withdrawn rather than the volume of the working gas. The greater the working gas volume, and the slower it is injected or withdrawn, the longer the cycle time will be.

4.1.7 The static working gas capacity calculated by Halite was calculated as 324mcm.

4.1.8 A comparison of the static working gas capacity for the proposed Preesall project and other facilities within the UK is shown in Table 4.1 below:
Table 4.1: UK Gas Storage Facilities – Working Gas Capacity

<table>
<thead>
<tr>
<th>Storage Facility</th>
<th>Facility Type</th>
<th>Status</th>
<th>Working Gas (static) Capacity (Mcm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>3650</td>
</tr>
<tr>
<td>Stublach&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Salt Cavern</td>
<td>Construction, advanced stages</td>
<td>400</td>
</tr>
<tr>
<td>Aldbrough - Phase 1&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>330</td>
</tr>
<tr>
<td>Hornsea/Atwick&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>325</td>
</tr>
<tr>
<td>Præsall (Halite figures)</td>
<td>Salt Cavern</td>
<td>Planning</td>
<td>324</td>
</tr>
<tr>
<td>Hambly Grove&lt;sup&gt;5&lt;/sup&gt;</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>254</td>
</tr>
<tr>
<td>Præsall (Senergy figures)</td>
<td>Salt Cavern</td>
<td>Planning</td>
<td>203</td>
</tr>
<tr>
<td>Holford&lt;sup&gt;6&lt;/sup&gt;</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>160</td>
</tr>
<tr>
<td>Hatfield Moor&lt;sup&gt;7&lt;/sup&gt;</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>117</td>
</tr>
<tr>
<td>Hill Top Farm&lt;sup&gt;8&lt;/sup&gt;</td>
<td>Salt Cavern</td>
<td>Construction, advanced stages</td>
<td>98</td>
</tr>
<tr>
<td>Hole House Farm&lt;sup&gt;9&lt;/sup&gt;</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>55</td>
</tr>
<tr>
<td>Holford H165&lt;sup&gt;10&lt;/sup&gt;</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>3.83</td>
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*<sup>1</sup> figures from Centrica Storage ‘Rough Gas Storage Facility’ Version 1.1 March 2014
*<sup>2</sup> figures from Storenergy literature (Leray, 2012) & assumes same cycle rate as adjacent Holford gas storage facility
*<sup>3</sup> figures from SSE literature (Alastair-Cleland 2012. Delivering increasing flexibility through SSE Hornsea growing the Global Gas Village SSE pres Manchester GS Meeting)
*<sup>4</sup> figures from SSE literature (hornsea_SSE_storage_2004)
*<sup>5</sup> figures from 2014 GSE literature (http://www.gse.eu/index.php/maps-data/gse-storage-map)
*<sup>6</sup> figures from EoN literature (Vizor, 2012 and https://www.eonenergy.com/About-eon/our-company/gas-storage/holford) and injection/withdrawal rates quoted as between 16 & 22 mcm/
*<sup>7</sup> Figures taken from 2011 Competition Commission report on Centrica and converted from GWh and GWh/d to mcm and also cycle rate taken from 2011 Commission report as 2 days, taking 350 day ‘uptime’ figure
*<sup>8</sup> figures from EDF literature (McCusker, 2010) and stated as fast cycle gas trading
*<sup>9</sup> GSE (Gas Storage Europe) 2014 report/map
*<sup>10</sup> figures from Ineos (pers comm, 2014) and stated as diurnal cycling being currently leased to, and operated by, National Grid on a diurnal cycle at NTS pressures (Robin Craig, pers comm., March 2013)

4.1.9 Table 4.1 shows figures of static working gas capacity for both depleted reservoir and salt cavern facilities. In order to represent the scale of the proposed Præsall facility against other similar salt cavern facilities the graph in Figure 4.1 shows only salt cavern storage facilities.
4.1.10 The Oxford Institute for Energy Studies produced a report in January 2013 "Gas Storage in Great Britain" by Chris Le Fevre. This report was published after the close of the Examining Authority’s Examination, however, was referred to in the decision letter from DECC dated 9 April 2013. Section 6.3 of the Le Fevre report identifies two key requirements driving the need for storage as:

- the need for growing flexibility as a result of increased variability of demand caused by the intermittency of renewable energy;
- and to underpin supply security.

4.1.11 Deliverability is therefore a key factor in meeting UK demand variability due to renewable intermittency and supply security. The Presell Project has been designed to be fast cycle to meet such supply requirements. Table 4.2 below shows the Presell Project deliverability compared to other existing UK gas storage schemes.
<table>
<thead>
<tr>
<th>Storage Facility</th>
<th>Facility Type</th>
<th>Status</th>
<th>Injection Rate (Mcm/day)</th>
<th>Delivery Rate (Mcm/day)</th>
<th>Cycles p.a.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough</td>
<td>Field</td>
<td>Built, operational</td>
<td>20</td>
<td>41</td>
<td>1.3</td>
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<tr>
<td>Aldbrough - Phase 1</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>30</td>
<td>40</td>
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<tr>
<td>Preesall (Halite figures)</td>
<td>Salt Cavern</td>
<td>Planning</td>
<td>32.4</td>
<td>32.4</td>
<td>17.5</td>
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<tr>
<td>Stublach</td>
<td>Salt Cavern</td>
<td>Construction, advanced stages</td>
<td>30</td>
<td>30</td>
<td>13.1</td>
</tr>
<tr>
<td>Holford</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>22</td>
<td>22</td>
<td>24.1</td>
</tr>
<tr>
<td>Preesall (Senergy figures)</td>
<td>Salt Cavern</td>
<td>Planning</td>
<td>18.4</td>
<td>18.4</td>
<td>15.9</td>
</tr>
<tr>
<td>Hornsea/Atwick</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>2</td>
<td>18</td>
<td>1.9</td>
</tr>
<tr>
<td>Hill Top Farm</td>
<td>Salt Cavern</td>
<td>Construction, advanced stages</td>
<td>16.3</td>
<td>12.3</td>
<td>25.0</td>
</tr>
<tr>
<td>Holford H165</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>7.66</td>
<td>7.66</td>
<td>350.0</td>
</tr>
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<td>Humbly Grove</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>8.5</td>
<td>7.3</td>
<td>5.4</td>
</tr>
<tr>
<td>Hole House Farm</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>8.1</td>
<td>5.4</td>
<td>20.6</td>
</tr>
<tr>
<td>Hatfield Moor</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>4.2</td>
<td>5.1</td>
<td>6.9</td>
</tr>
</tbody>
</table>

* Calculated on the basis of days to inject full working volume plus days to withdraw divided into 350 (after Le Fevre 2013)

1 figures from Centrica Storage ‘Rough Gas Storage Facility’ Version 1.1 March 2014
2 figures from SSE literature (Alastair-Cieland_2012_Delivering increasing flexibility through SSE Hornsea growing the Global Gas Village_SSE pres Manchester GS Meeting)
3 figures from Storenergy literature (2012) & assumes same cycle rate as adjacent Holford gas storage facility
4 figures from EoN literature (Vizon, 2012 and https://www.eonenergy.com/About-eon/our-company/gas-storage/holford) and injection/withdrawal rates quoted as between 16 & 22 mcm/
5 figures from SSE literature (hornsea_SSE_storage_2004)
6 figures from EDF literature (McCusker, 2010) and stated as fast cycle gas trading
7 figures from Ineos (pres comm, 2014) and stated as diurnal cycling being currently leased to, and operated by, National Grid on a diurnal cycle at NTS pressures (Robin Craig, pres comm., March 2013)
8 figures from 2014 GSE literature (http://www.gie.eu/index.php/maps-data/gse-storage-map)
9 GSE (Gas Storage Europe) 2014 report/map
10 figures from 2011 Competition Commission report

4.1.12 The comparison of delivery rates, reflected in the number of annual cycles, shows that the Preesall Project would be second only to Aldbrough for cavern storage and when depleted reservoir storage is included it is third behind Rough and Aldbrough. The delivery rate values (mcm/day) for both depleted reservoirs and salt caverns are shown in Figure 4.2 below. The figures shows that the delivery rate for the Preesall project, whether based on the Halite or Senergy data, are well above the threshold of 4.5mcm/day defined in EN4 and Section 17 of the Planning Act 2008.
4.1.13 It is a complex matter to portray the differences between single cycle, static working gas capacity and that of dynamic (effective) working gas capacity associated with fast cycle facilities. Comparing facilities based on static capacity alone is too simplistic as fast cycle facilities may operate on in-day injection and withdrawal as well as longer-term cycles. Figure 4.3 below illustrates the difference in static working gas capacity versus an example of dynamic working gas capacity for salt cavern storage, represented by a number of simple cycles per annum, which gives an annual dynamic capacity.

4.1.14 Put simply, the graph illustrates the one off, static capacity (green line), which shows initial rapid fill but then remains constant for the remainder of the period. Against this single fill operation is shown the multi cycle cavern fill (red solid line). There is no difference between the two operational modes on first fill, but thereafter the differences in working gas volume offered by multi-cycle operation are very clear. The dashed red line shows the cycling dynamic (effective) working gas capacity as the cavern is repeatedly filled and emptied a number of times. In this way the effective capacity of the storage facility rises with each fill cycle with the cumulative cycle-on-cycle increase in effective capacity represented by the solid red line. So, over time, whilst static capacity may reach 300 mcm in a year, the effective capacity of the fast cycle facility has doubled after the second cycle and reaches around 1300 mcm after four cycles.

4.1.15 Table 7 of the Lo Fevre (2013) report provides a comparison of static working gas capacities, delivery rates and number of cycles per annum for existing storage facilities. It is more appropriate to consider the combination of the number of cycles per annum with the static
working gas capacity which gives an annual dynamic (effective) capacity. The difference in static and dynamic (effective) capacity is shown in Figure 4.3 below.

Figure 4.3: Preasall Fast Cycle vs Single Cycle Capacity Comparison over a 12 month period

Source: Mott MacDonald

4.1.16 Le Fevre (2013) calculated the cycle time based on the number of days for an individual facility to inject the full working gas volume plus the days to withdraw it, divided into 350, which allowed a uniform 15 day standby time for all facilities (i.e. 365-15). Whilst facilities can be operated in a much more sophisticated way than a number of complete cycles, this approach allows both a demonstration of the static capacity and, more importantly, the potential deliverability through a dynamic (effective) working gas capacity.

4.1.17 The dynamic working gas capacity of the Halite Project, based on a modest cycle time of 30 days that included 10 days of standby time within each cycle (Geostock H29), was reported within the Updated GSR (H30) as 3888 Mcm/yr.

4.1.18 The Senergy Base Case static working gas capacity is stated as 203mcm but the dynamic capacity was not stated. In Appendix 1 of the Senergy report KBB noted that the proposed injection rate of 32.4mcm/day was modest. Senergy in Section 5.2 erroneously implied a maximum daily delivery rate of 17-19.8mcm/day (0.6-0.7bbl/d) based on a reduced static working gas capacity. This assessment by Senergy was a wrong application of the approach as the delivery rate of 32.4mcm/day itself will not change. If the static working gas capacity is reduced it is the cycle time - the time taken to empty and refill the caverns - that will be reduced, not the daily volume delivered, which will not change.

4.1.19 The Le Fevre (2013) report provided an independent method to demonstrate the dynamic capacity based on the number of potential full annual cycles. This has been adopted to allow
comparison of the Preesall project with other existing UK schemes. Table 4.3 below provides dynamic (effective) capacities for the exiting UK schemes.

Table 4.3: UK Gas Storage Facilities – Effective Capacity

<table>
<thead>
<tr>
<th>Storage Facility</th>
<th>Facility Type</th>
<th>Status</th>
<th>Static Capacity (Mcm)</th>
<th>Cycles p.a.</th>
<th>Effective Capacity* (Mcm)</th>
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</thead>
<tbody>
<tr>
<td>Aldbrough - Phase 1</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>330</td>
<td>18.2</td>
<td>6000</td>
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<td>Preesall (Halite figures)*1</td>
<td>Salt Cavern</td>
<td>Planning</td>
<td>324</td>
<td>17.5</td>
<td>5670</td>
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<td>Stublach</td>
<td>Salt Cavern</td>
<td>Construction, advanced stages</td>
<td>400</td>
<td>13.1</td>
<td>5250</td>
</tr>
<tr>
<td>Rough</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>3850</td>
<td>1.3</td>
<td>4705</td>
</tr>
<tr>
<td>Holford</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>160</td>
<td>24.1</td>
<td>3850</td>
</tr>
<tr>
<td>Preesall (Senergy figures)</td>
<td>Salt Cavern</td>
<td>Planning</td>
<td>203</td>
<td>15.9</td>
<td>3228</td>
</tr>
<tr>
<td>Hill Top Farm</td>
<td>Salt Cavern</td>
<td>Construction, advanced stages</td>
<td>98</td>
<td>25.0</td>
<td>2454</td>
</tr>
<tr>
<td>Humbly Grove</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>254</td>
<td>5.4</td>
<td>1375</td>
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<td>Holford H165</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>3.83</td>
<td>350.0</td>
<td>1341</td>
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<td>Hole House Farm</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>55</td>
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<td>Hatfield Moor</td>
<td>Depleted Field</td>
<td>Built, operational</td>
<td>117</td>
<td>6.9</td>
<td>806</td>
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<tr>
<td>Hornsea/Atwick</td>
<td>Salt Cavern</td>
<td>Built, operational</td>
<td>325</td>
<td>1.9</td>
<td>630</td>
</tr>
</tbody>
</table>

* Effective Capacity = Static Gas Capacity x No. cycles per annum
*1 Value different from UGSR figure of 3888 Mcm which is based on a typical monthly cycle

4.1.20 The dynamic (effective) capacities for UK schemes are also shown for comparison in graphical form in Figure 4.4, which illustrates that the Preesall Project would be second to Aldbrough.
Figure 4.4: Dynamic Working Gas Capacities of UK Facilities

Source: Mott MacDonald
5 Summary

The Halite proposal was prepared by international experts in geology, oil & gas geophysical exploration and cavern design, construction and operation. This expertise and experience includes decades working within the local area and within stratigraphically equivalent salt strata in Cheshire.

The development proposal prepared by Halite acknowledged uncertainty by adopting a cautious, worst-credible approach to the interpretation of the geology. The parameters selected for cavern design were based on site specific data, site specific numerical analyses and experience in the stratigraphically equivalent strata.

The Senergy assessment appears to include errors and to be unduly pessimistic.

The Halite proposal has been designed as a fast cycle facility. The different static and dynamic capacities have been calculated and compared to other existing UK schemes from which it can be seen that the Preesall Project offers a significant contribution to deliverability.

The Senergy report contains much that supports the development of an underground gas storage scheme at Preesall and, even using unduly pessimistic figures, the Senergy report provides strong evidence that the proposed scheme meets the capacity threshold for underground gas storage NSIP as set out at section 17 of the Planning Act 2008. The Senergy report also supports the conclusion that the geology at the proposed site at Preesall is ‘suitable’ to support 19 gas storage caverns.

Whilst the conclusions of the Senergy report on the capacity of the proposed facility are unduly pessimistic, even on that unduly pessimistic basis, the identified capacity of the proposed facility would be one of the largest in the UK in terms of static capacity, effective capacity and flow rates.
Halite Responses to The Independent Geological Assessment

Geological Technical Appendix - Enlarged Figures
September 2014

Halite Energy Group
# Issue and revision record

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Note: Figures within this document are larger format versions of the same figures included within the document 'Halite Responses to The Independent Geological Assessment - Geological Technical Appendix'

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Figure 3.3: Time – Depth Relationship

Top-Salt Time-Depth Curve (from well-to-seismicities)

\[
y = -0.0016x^2 + 2.3414x - 152.84 \\
R^2 = 0.9836
\]

Second-order Polynomial Curve fit to well tops

Source: Everett Rutherford
Figure 3.4: Stacking Velocities

Top-Salt Time-Depth Curve
(from well-to-seismic ties)

\[ y = -0.0016x^2 + 2.3414x - 152.84 \]
\[ R^2 = 0.9836 \]

Mismatch between depths derived from stacking velocities and depths associated with direct ties to well data at shallow depths.

Although stacking velocities fall mostly on the time-depth curve, they were found to yield a less accurate match to known top-salt depths than the curve generated by well to seismic correlation method.

Source: Everett Rutherford
Figure 3.5: Cavern Layout Comparison

Source: Mott MacDonald
Figure 3.6: Summary Worst Case Cavern Layout

Source: Mott MacDonald
Figure 4.1: UK Salt Cavern Gas Storage Facilities – Static Working Capacities (Mcm) Showing EN-4/Section 17 Planning Act 2008 Threshold for Nationally Significant Infrastructure Project

UK Salt Cavern Gas Storage Facilities - Static Working Capacities (Mcm)

Source: Mott MacDonald
Figure 4.2: UK Salt Cavern Gas Storage Facilities – Deliverability (Mcm/Day) - Showing EN-4/Section 17 Planning Act 2008 Threshold for Nationally Significant Infrastructure Project

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Figure 4.3: Preesall Fast Cycle vs Single Cycle Capacity Comparison over a 12 month period

Fast Cycle vs Single Cycle Capacity Comparison

- Capacity (Fast Cycle)
- Working Gas Volume
- Capacity (Single Cycle)

Source: Mott MacDonal
Figure 4.4: Dynamic Working Gas Capacities of UK Facilities

Static - Effective Capacity Comparison

Source: Mott MacDonald