

Acorn CCS Project

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Document Title	Date Originally Issued	Document Title	Date Originally Issued
D02 Stakeholder Engagement and Communications Plan	31/08/2019	D12 Environmental Assessment (onshore)	
D24 Concept Options Report	08/11/2019	D13 Environmental Impact Assessment (offshore)	
D06 Permits & Consents Register	20/12/2019	D18 Risk Management Plan	
D11 Onshore Site Selection Report	28/02/2020	D21 Financing Plan	
D25 Concept Select Report	08/05/2020	D03 CO2 Capture Plant Design	
D10 Well Operating Guidelines	30/09/2020	D14 Economic Model & Report	
D08 Operations and Maintenance Philosophy	30/11/2020	D15 FEED Close-out Report	
D09 Well Design Report	30/11/2020	D16 FEED Lessons Learned Report	
D05 Storage Development Plan	31/03/2021	D17 Acorn CCS Development Plan & Budget	
D22 East Coast Deployment Report	31/03/2021	D19 Whole Chain Cost Estimate	
D04 Whole Chain BoD		D20 Project Schedule	
D07 Health, Safety and Environment Report		D23 Project Summary Report	



Signed by Storegga COO

Pale Blue Dot.



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1.0 Executive Summary

This report reviews the prospective locations for siting the onshore Phase 1 carbon capture, conditioning and compression facilities for the Acorn CCS project. It outlines the Acorn CCS Phase 1 project site requirements, including specifications for footprint, potential for build-out and the site location relative to emission sources and the tie-in to Goldeneye pipeline which will be used for CO₂ export. This has been an essential step within the Concept Select process and will provide a focused foundation for the ongoing commercial discussions and a more refined basis for the project to develop forward towards Concept Select.

A number of sites situated at St Fergus gas terminal complex were considered, on land currently owned and/or operated by SEGAL, NSMP or National Grid. A total of ten site options were considered:

- A. SEGAL Laydown Area
- B. SEGAL Unit 2600
- C. SEGAL South
- D. SEGAL Mothballed Goldeneye Plant
- E. Combined SEGAL sites
- F. NSMP North
- G. NSMP South
- H. Blackhill
- I. Split Site Option – SEGAL South + NSMP South
- J. Split Site Option – NSMP North + NSMP South

Based on the project value drivers, a set of nine assessment criteria were developed, against which each site was scored using a common scoring system.

Each site was scored out of ten for each criterion, with a red/amber/green traffic light system used to provide clear visual differentiation between each option.



Figure 1-1: Options shortlist; Options I and J (not shown) are combinations of Compression at NSMP South and capture at SEGAL South and NSMP North respectively



The top four options were as follows:-

- Option I (Split Site – SEGAL South Capture, NSMP South Compression)
- Option J (Split Site – NSMP North Capture, NSMP South Compression)
- Option G (NSMP South both Capture & Compression)
- Option F (NSMP North both Capture & Compression)

The work detailed within this report provides a strong basis upon which to continue to progress the commercial dialogue with the site owners for the four options that are considered technically preferable and allow a full commercial-technical assessment to be performed, to advance the project toward Concept Select phase.



2.0 Introduction

2.1 Project Summary

Acorn CCS project is a phased carbon capture and storage (CCS) project based in the north-east of Scotland as shown in Figure 2-1. Acorn CCS project is being designed to securely store captured CO₂ in the Acorn CO₂ Storage Site licenced area, as defined by the Oil and Gas Authority (OGA) Licence Agreement (OGA, 2018) and the Crown Estate Scotland (CES) Lease.

It is proposed that St Fergus gas terminal complex, located 64km north of Aberdeen, will be the onshore focus for Acorn CCS project and that existing, redundant, offshore gas pipelines will be re-purposed for transporting CO₂ to the Acorn CO₂ Storage Site licenced area.

This project will be led by the Acorn CCS delivery team managed by Pale Blue Dot Energy (PBDE). The project is being funded by the EU as a Project of Common Interest (PCI) and the UK Government, via the Department of Business, Energy and Industrial Strategy (BEIS) as part of the CCUS Innovation Fund and Industry.

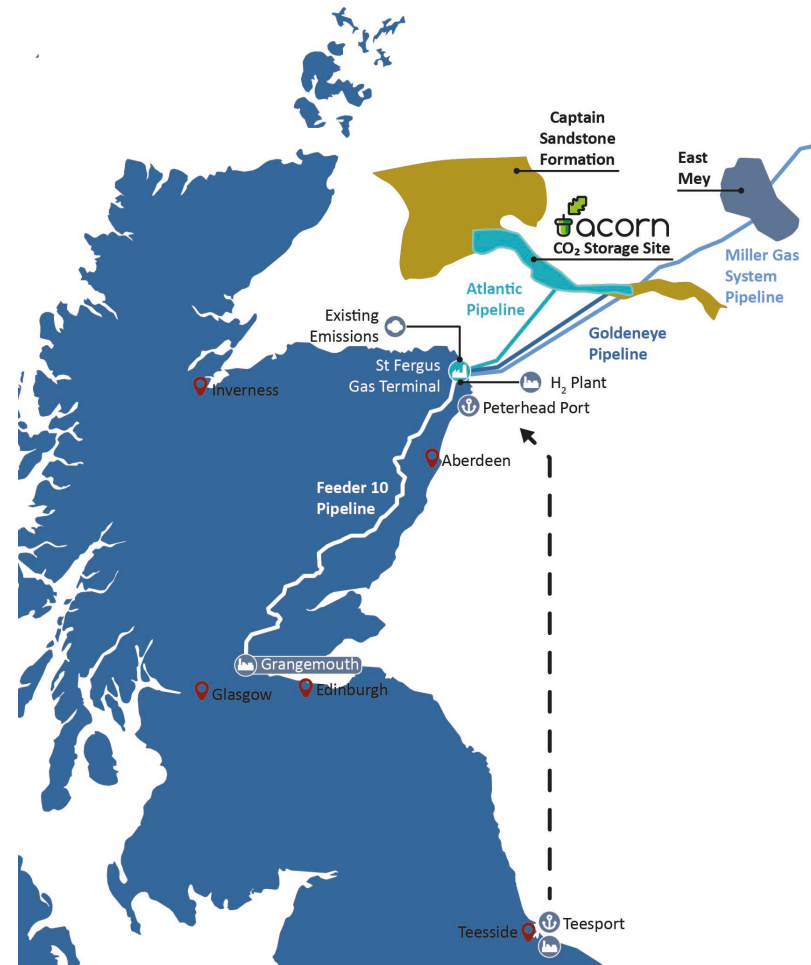


Figure 2-1: Acorn CCS project map



As shown in Figure 2-2 the Phase 1 elements of the Acorn CCS Project include:

1. Flue gas collection from one or more existing St Fergus gas terminal complex industrial emitters and transport of the flue gases to the CO₂ capture plant.
2. Pre-conditioning of flue gas, if required, prior to CO₂ capture plant. Preliminary work suggests it may be possible to eliminate the requirement for pre-conditioning.
3. CO₂ capture plant using a liquid solvent.
4. Transport of the CO₂ from the CO₂ capture plant to the low pressure (LP) compression plant, conditioning of the CO₂ to remove oxygen and water, high pressure (HP) compression and cooling to meet the pipeline specification.
5. Onshore tie-in to the offshore pipeline (including pigging tie-ins/facilities if required).
6. Offshore infrastructure, including the re-use of the existing 20" Goldeneye pipeline and connection to one or more wells.
7. Drilling and completion of one or more CO₂ injection wells, capable of injecting, as a minimum, the Phase 1 volumes of CO₂, complete with the subsea tree(s).

8. Subsurface work for the Acorn South CO₂ Storage Site and scoping work for the build-out.
9. Well control

The scope of the Acorn CCS project study also includes:

1. Integration of the collection, capture and compression facilities with the relevant St Fergus host facilities, including:
 - (a) civils
 - (b) constructability
 - (c) control room and control integration
 - (d) utilities
2. Metering of CO₂ at the change of ownership points and for reservoir monitoring purposes.
3. Onshore health, safety and environment (HSE) aspects to deliver a consentable, compliant design for Acorn Phase 1.
4. Offshore HSE aspects to deliver a consentable, compliant design for the Acorn South development and well control infrastructure (umbilical).



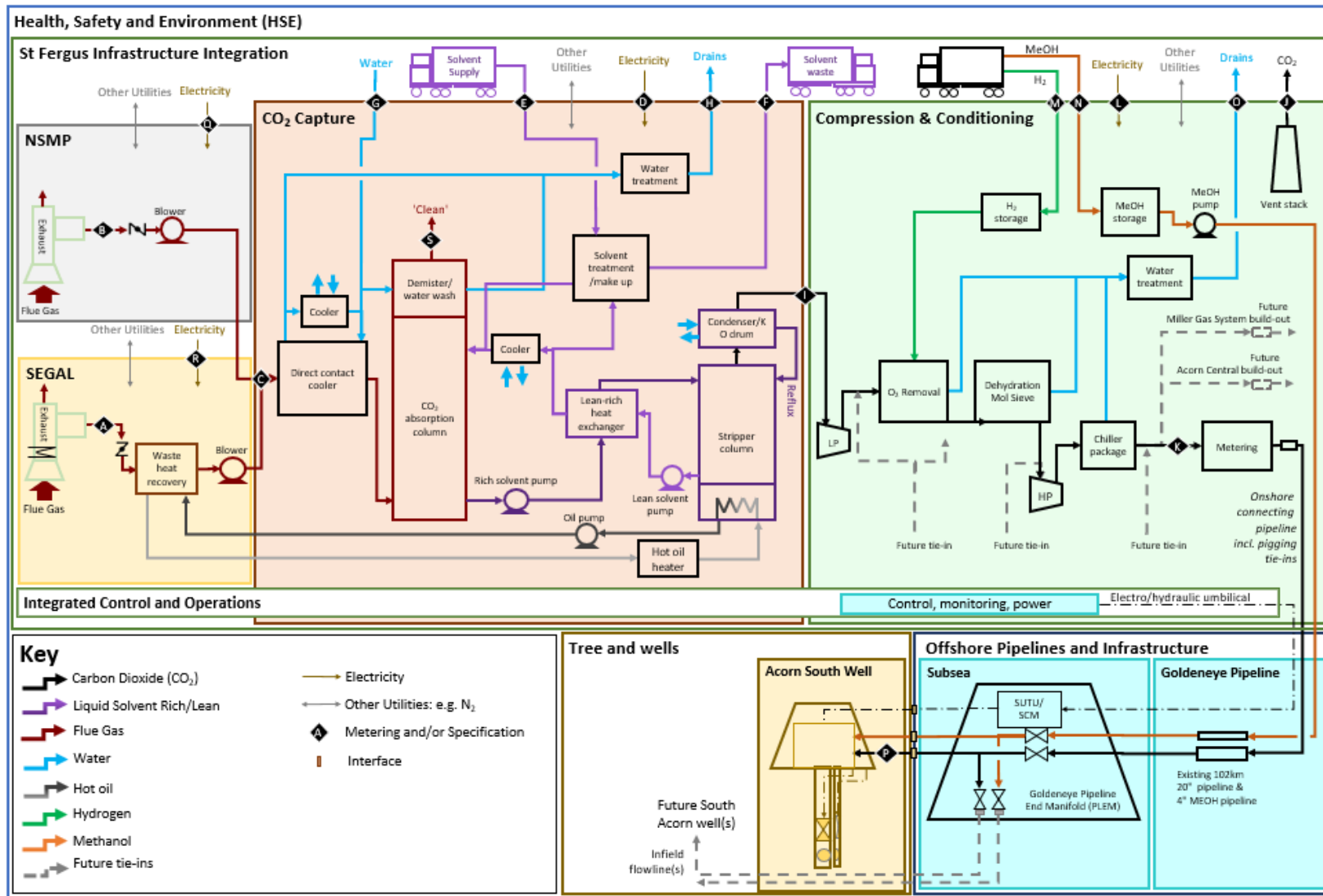


Figure 2-2: Preliminary Acorn CCS Phase 1 Block Diagram



Once the Phase 1 infrastructure has been established, Acorn CCS project could then be built-out via a number of potential Phase 2 options. These Phase 2 build-out options could include:

1. Carbon capture from a new hydrogen plant (reforming natural gas) at St Fergus and onwards transport of the CO₂ to the Acorn CO₂ Storage Site licenced area
2. Re-purposing of the National Grid Gas (NGG) Feeder 10 pipeline and infrastructure to transport CO₂ from the industrial centres around Grangemouth to St Fergus and onwards to the Acorn CO₂ Storage Site licenced area
3. Re-using the existing Peterhead Port infrastructure (where feasible) and installation of new infrastructure to support import of CO₂ to the St Fergus Acorn facility and onwards transport to the Acorn CO₂ Storage Site licenced area
4. Using the Peterhead shipping infrastructure to support the export of CO₂
5. Drilling and completion of additional well(s) capable of injecting, nominally 2MtCO₂/yr within Acorn South
6. Offshore infrastructure, including new in-field flowline to one or more Acorn South well(s)
7. Drilling and completion of further wells capable of injecting, nominally 2MtCO₂/yr each, at Acorn Central. The areas that represent Acorn South and Acorn Central are shown in Figure 2-3.
8. Offshore infrastructure, including the re-purposing of the existing Atlantic pipeline, new in-field pipelines and manifold capable of expansion to further wells at Acorn Central

9. An international interconnection utilising the Miller Gas System pipeline

Development of the offshore infrastructure and drilling and completion of additional wells will be as and when needed (subject to looking at efficiencies of campaign mobilisation/demobilisation costs and weather windows) to match the timing of new sources of CO₂ becoming available.

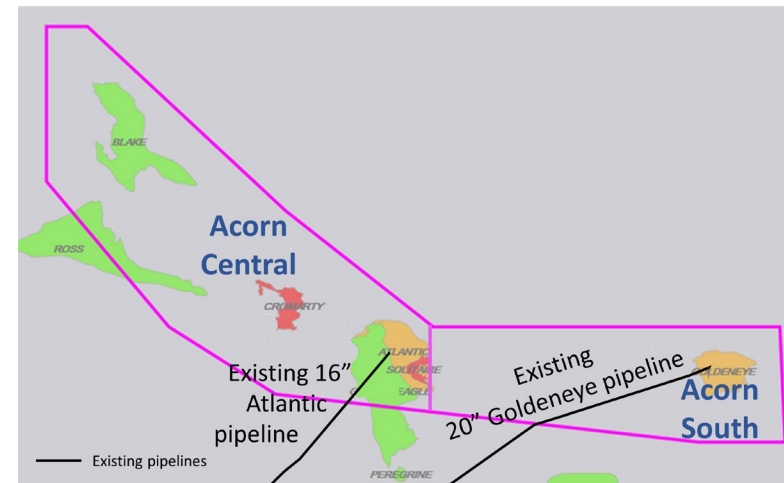


Figure 2-3: Acorn Central and Acorn South Map



2.2 Scope

This report discusses the different sites available at St Fergus gas terminal complex where the Acorn CCS Phase 1 facilities could potentially be located. The requirements for Acorn Phase 1 facilities are stated and each of the available sites are introduced. Each prospective site has then been compared against a common set of decision criteria which have been developed from the project value drivers set out in the Concept Options Report (Pale Blue Dot Energy, 2019). Based on the ranking of each site relative to the criteria, several technically viable options have been identified.

This report provides the outcome of a technical review of site selection options for Acorn CCS project. The information provided within this report will support a full technical-commercial assessment of the options, before a final site selection decision is made prior to the project progressing into the Define phase. This has been an essential step within the Concept Select process. This provides a focused foundation for the ongoing commercial discussions and a solid basis for the project to develop forward towards Concept Select phase.



3.0 Site Requirements and Influencing Factors

This section provides an overview of the key site requirements for the Acorn CCS project. In order to understand the ability of the sites to support these requirements a formal Request for Services (RfS) process has been undertaken. This process is discussed in more detail in Section 3.6.

3.1 Footprint

3.1.1 Acorn CCS (Phase 1)

A single site or a combination of sites should have sufficient space to accommodate all of the Acorn CCS Phase 1 facilities. The Phase 1 facilities consist of a CO₂ capture, compression and conditioning plant, to be located on land at St Fergus.

The capture plant footprint is based on a reference case capture plant layout provided by the vendor Carbon Clean Solutions Limited (CCSL), for a CO₂ output of 0.34MtCO₂/yr. The space requirement calculated during the feasibility phase of the project for the CO₂ capture plant was estimated as 2,500m². An indicative layout is shown in Figure 3-1.

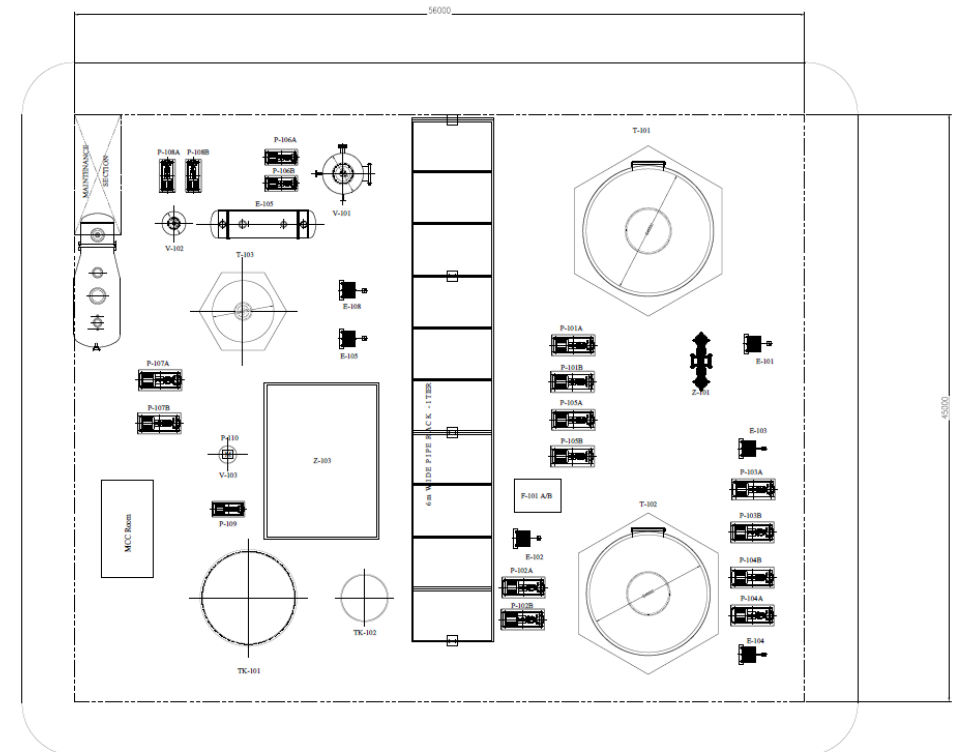


Figure 3-1: Indicative Layout for Acorn Carbon Capture Plant (CCSL, 2019)

The footprint requirement for the compression and conditioning plant is based on the Plant Design Management System (PDMS) 3D modelling software used to produce a site layout during the Acorn PCI SAPLING Feasibility project (Genesis, 2019), as shown in Figure 3-2.



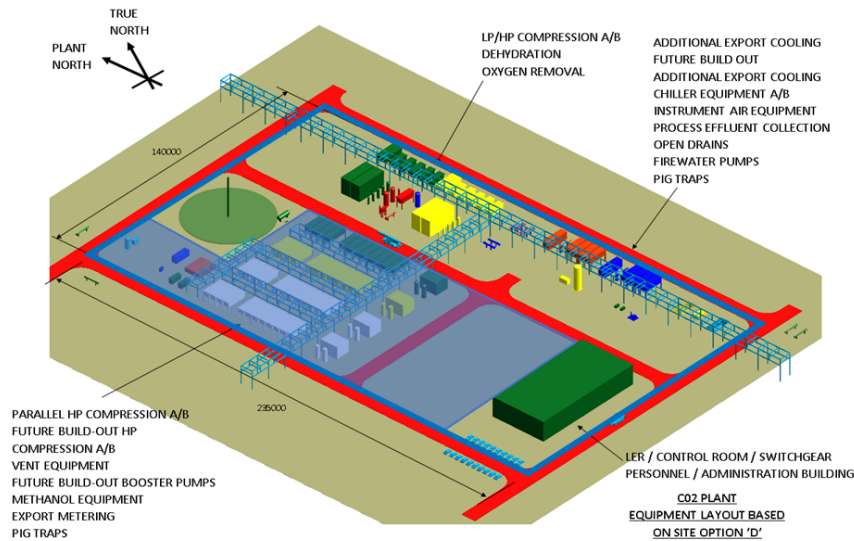


Figure 3-2: Acorn PCI Sapling compression and conditioning proposed layout (build-out only facilities shaded out) (Genesis, 2019)

Using the footprint from the full build-out layout from the Acorn PCI SAPLING Feasibility project an estimate of 9,535m² for the Phase 1 only (local St Fergus CO₂ capture) footprint and layout was produced. This was completed in three steps:

1. The footprint of each individual Phase 1 item in the equipment list was summed to give a total equipment footprint. (Genesis, 2019) (Note 1)
2. A 50% allowance was added onto this total, to account for utility systems which were excluded from the equipment list (e.g. emergency power generation, uninterruptible power supply (UPS)).(Note 2)

3. A 100% allowance was added onto this total, to account for equipment layout (space between equipment items, road access) (Note 3)

Notes:

1 The compression module equipment list was based on a CO₂ throughput of 0.55MtCO₂/yr, whilst conditioning was based on 0.77MtCO₂/yr. This is greater than the Phase 1 flowrate of 0.34MtCO₂/yr, and includes 2x100% compression trains hence, this can be considered conservative.

2 A 50% allowance was included conservatively, as most utilities are already included in the equipment list with only a few minor utilities such as emergency power excluded. A new local equipment room (LER), switchroom and local control room building is included within the equipment list and is incorporated in the footprint.

3 A 100% allowance was selected based on the layout of the Phase 1 facilities shown in Figure 3-2 (north east corner), which shows a significant proportion of empty space in addition to the equipment.

Initial CO₂ vent sizing and dispersion modelling was completed as part of the Acorn PCI SAPLING project using the software PHAST (Genesis, 2019). This concluded that a 20m high vent stack with a 20m sterile radius would be sufficient for venting. This corresponds to a footprint of 1,257m². Note that vent sizing and stack elevation has still to be finalised – this footprint has been used as as an estimate.

Table 3-1 presents the total footprint requirements for the Acorn CCS Phase 1 capture, compression and conditioning plant. Using the layout modelled in PDMS, this shows a footprint estimate of 9,535m² for Phase 1 CO₂ export of



0.34MtCO₂/yr, versus a footprint of 32,900m² for a build-out CO₂ export of 7.15MtCO₂/yr. Therefore, the footprint estimate used for the Phase 1 facilities is considered conservative.

Plant	Footprint
Capture Plant	2,500m ²
Compression & Conditioning Plant	9,535m ²
Vent Stack	1,257m ²
Total	13,292m²

Table 3-1: Acorn CCS Phase 1 Footprint Requirements

3.1.2 Build-out

The Acorn CCS project site should ideally have space to accommodate the compression or onsite plant requirements for exporting of CO₂ offshore from other sources. This could include Feeder 10 CO₂ compression and/or compression of CO₂ from the production of hydrogen at St Fergus and the reception facilities for CO₂ from Peterhead Port. Footprint estimates for this plant were produced as part of the Acorn PCI SAPLING project (Genesis, 2019).

This work provided a footprint and layout for the Acorn full build-out case consisting of compression of:

- Local St Fergus CO₂ capture (Phase 1) and CO₂ from hydrogen production (assumed total 0.55MtCO₂/yr).
- CO₂ from Feeder 10 CO₂ and that imported from Peterhead Port (assumed total 6.6MtCO₂/yr).

This layout was modelled in PDMS as 235m by 140m, or 32,900m², based on a total CO₂ throughput of 7.15 MtCO₂/yr.

The footprint estimates for build-out phases are shown in Table 3-2.

Plant	Footprint (m ²)
Feeder 10 CO₂ Compression + Hydrogen Plant CO₂ Compression + Peterhead CO₂ Import	32,900m²

Table 3-2: Acorn Build-out Footprint Requirements

The ability to accommodate these aspects of build-out was considered important for site selection for the following reasons:

- Locating the CCS infrastructure (Phase 1 and build-out) on a single location at St Fergus concentrates the developments which handle CO₂ and the associated hazards, contributing to an inherently safer solution.
- Acorn CCS Phase 1 final investment decision (FID) is considered likely be made with consideration to future project phases, when increased CO₂ volumes could be transported through the transport and storage infrastructure commissioned during Phase 1.
- Locating the Phase 1 plant on land with build-out potential provides an opportunity for future phases of the project to integrate into Phase 1 infrastructure e.g. control and safety systems, utilities. Although not quantified at this stage, this may increase the capex of Phase 1 but may also present an opportunity to the reduce opex for Phase 1 infrastructure as additional volumes are transported through the system.



3.2 Request for Services (RfS) Process

To inform the site selection decision, a formal and consistent “Request For Services” process was followed with each of the plant Operators at St Fergus.

The owners/operators of the various St Fergus sites that were contacted are:

- Southern Area Gas Evacuation (SAGE) is owned by Ancala and the Brae Group; operated by Wood
- Shell-Esso Gas and Liquids (SEGAL) owned by Shell-Esso; operated by Shell
- Frigg UK Association (FUKA) owned by North Sea Midstream Partners (NSMP) and Gassled; operated by PX Limited. This site is referred to in this document as NSMP
- National Transmission System (NTS) owned and operated by National Grid Gas (NGG). This takes gas from all three gas receiving facilities, however only gas from the NSMP gas receiving facility is compressed in the NTS facility

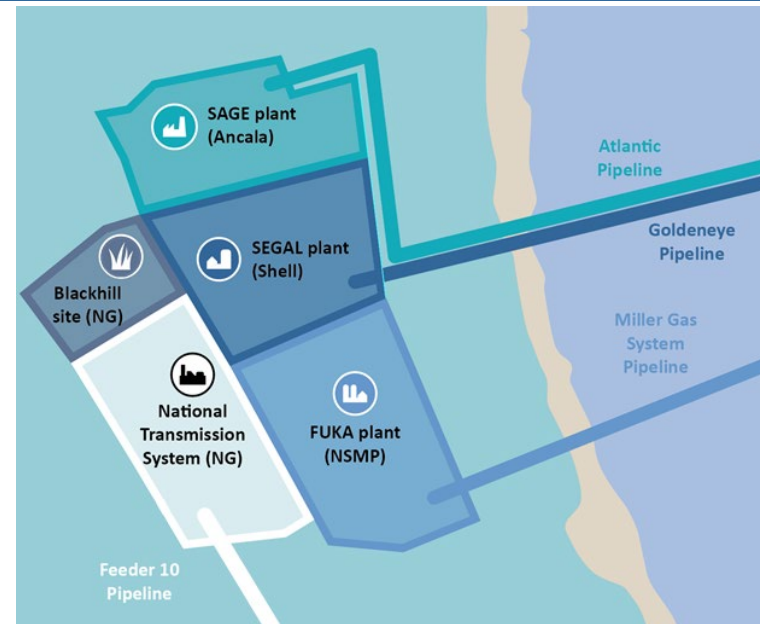


Figure 3-3: St Fergus Gas Terminal Owners (FUKA plant owned by NSMP and Gassled)

This process required site operators, to provide details (within a fixed format spreadsheet) of currently available site services such as available land, services and manpower at each site. The operator of each site was also asked to formally express their interest (and that of their partners) in participating in the Acorn CCS project.

This process included face-to-face meetings with each site Operator and where positive responses were received site tours were also held where possible (e.g. SEGAL and NSMP sites). Along with informing the site selection decision, the information gained will also inform the wider Acorn Concept Select decision and



is providing the basis for the ongoing commercial engagement with the relevant parties.

3.3 Tie-In's

3.3.1 Flue gas

Flue gas is required as a feedstock to the CO₂ capture plant. The emission sources selected for Acorn CCS Phase 1 are the two SEGAL gas turbines (GTs), two NSMP hot oil furnaces and two NSMP glycol furnaces, as shown in Figure 5-1. These sources of emissions were selected through a decision review process and agreement for the decision has been sought with TDSA partners. (Pale Blue Dot Energy, 2020).

The key reasons why these sources were selected are:

- Interest from site operator – Shell and NSMP have both expressed interest in having their CO₂ emissions from these sources captured by the Acorn CCS project.
- Ease of capture – The SEGAL and NSMP emissions derive from a small number of point sources, with cumulative CO₂ captured greater than 300,000 tCO₂/yr, meeting the project value driver of delivering significant emission reductions.
- Availability – The SEGAL GTs and NSMP hot oil furnaces have a high availability, providing a consistent source of CO₂ to the Acorn plant. The NSMP glycol furnaces are more variable, although output is predicted to increase in the future.
- Proximity of emission sources to prospective sites – All six emission sources are located in close proximity (<1km) to several of the prospective sites.

- Equipment requirement – CO₂ from all six emission sources can be captured using solvent absorption technology, without a requirement for additional stages of pre-treatment.

The ducting from the SEGAL GTs is expected to have a cross-sectional area between 2m² and 3m², whilst the NSMP flue gas ducting is expected to be 1.5m². This constitutes a significant capital cost for the project; hence, the Acorn CCS project site should ideally be located in close proximity to the emission sources for Acorn Phase 1, primarily to minimise ductwork costs.

A comparison of the ductwork costs between the NSMP South only option and a split site using SEGAL South and NSMP South, demonstrates that a capex saving of approximately £5million can be achieved by siting the capture plant close to the SEGAL emissions. This excludes the cost savings associated with shorter lengths of hot oil pipework (from Waste Heat Recovery Units (WHRU) to capture plant) and smaller blowers for the SEGAL flue gas, which will result in further capex and opex savings.

3.3.2 Goldeneye Tie-In

The site should ideally be located in close proximity to the Goldeneye pipeline tie-in point, for transport of CO₂ to the offshore Acorn storage licence area. Minimising the length of dense phase CO₂ pipework to the tie-in point will reduce the inventory of CO₂, presenting a smaller potential hazard to personnel and minimise capital cost.

3.4 Utilities

The Acorn CCS plant will require a range of utility supplies, including power, air, nitrogen and demineralised water. Exact quantities have still to be defined, however, a good estimate of the demand for key utilities (e.g. power) has been



developed to allow the project team to evaluate if there will be sufficient capacity at any of the facilities to influence site selection. Existing utility systems on site could be used to supply some of Acorn's requirements. The preliminary availability of utilities has been provided by site operators as part of the RfS process.

3.4.1 Power

Power is required as a utility to the Acorn CCS plant. Based on discussion with site operators through the RfS process, none of the existing sites at St Fergus gas terminal complex have sufficient spare power capacity to supply Acorn CCS project requirements. Therefore, the working base case assumption is that Acorn CCS project will require a new connection to the power grid. As this is common to all sites, this is not considered a differentiator between site options.

3.4.2 Heating/Cooling

Heat is required primarily to regenerate the solvent used during CO₂ absorption. A small heat demand is also required to regenerate the molecular sieves used to dehydrate the CO₂. The RfS process has not identified an availability of heat and/or heating medium at any of the sites other than SEGAL.

The SEGAL flue gas is emitted at an elevated temperature of ≈500°C. Heat can be recovered from the SEGAL flue gas using a WHRU. There are existing WHRUs already in situ which could be utilised, although initial engineering analysis suggests that the existing WHRU will require modification or a new WHRU will need to be installed to achieve the heat loading required for solvent regeneration. The recovered heat from the existing WHRU currently supports a hot oil system which is occasionally utilised for molecular sieve regeneration at the SEGAL terminal. Hot oil is the common heating medium used at the St

Fergus terminal complex and is therefore the current preferred medium within the CCS concept (although steam could still be used if there are overriding benefits identified).

By siting the CO₂ capture plant closer to the SEGAL flue gas, it will minimise the length of insulated heating medium pipework (resulting in lower capex for the project). This aspect has been considered as part of the decision criteria 'Proximity to Emission Sources'.

There are no existing cooling systems located on any of the prospective sites for Acorn CCS project. New cooling system(s) will need to be provided for the project regardless of location. Hence, cooling was not considered a differentiator between site options.

3.4.3 Waste

The CCS plant will produce several waste streams, including waste water from the Direct Contact Cooler (DCC) and hazardous waste from the solvent treatment system.

Initial work has shown that some form of pre-treatment of the DCC waste water (e.g. pH control) is likely to be required prior to discharge into an existing onsite waste water systems. Both SEGAL and NSMP have waste water treatment systems and subject to detailed engineering, these could be utilised by the project. The potential site at Blackhill has no existing utilities, so a new waste water treatment system would be required, although tie-in to SEGAL would remain an option.

Due to the relatively low volumes of hazardous waste from the solvent treatment system (circa 12-13tpa), this waste stream would be diluted and exported from site for treatment by a licenced third party.



Based on the above, waste treatment is considered to be common to all site options and is not considered a significant differentiator for site selection.

3.4.4 Other Utilities

Preliminary utility availability for services such as nitrogen, towns water, demineralised water and instrument air has been provided by the site operators as part of the RfS process and is shown in Table 3-3. These were not considered significant differentiators for site selection and have been included for information only.

Utility	NSMP	SEGAL	National Grid ²
Power	X	X	X
Heating ⁴	X	✓	X
Cooling ⁴	X	✓	X
Hydrogen	X	X	X
Nitrogen	✓	TBC	X
Instrument Air	✓	✓	X
Demineralised Water	X	X	X
Towns Water	✓	✓	X
Methanol ⁶	✓	✓	X
Hydraulic Fluid	X	X	X
Firewater (Pumps)	X	X	X
Firewater (Pond) ⁵	✓	X	X
Open Drains ³	✓	✓	X
Closed Drains ¹	X	X	X
Fuel Gas	X	X	X

Table 3-3: Availability of Key Utilities for Acorn



Notes

1 Based on initial discussion with site operators, it will not be feasible to drain amine filled vessels from the solvent regeneration system to existing closed drains systems.

2 No existing utility systems exist on Blackhill, with National Grid stating they would prefer not to provide utilities to Acorn CCS Phase 1. It may be possible for some utilities to be supplied from SEGAL.

3 Decommissioned Miller open drains pond available adjacent to NSMP South which could potentially be re-used by Acorn.

4 Heating and cooling from SEGAL could be provided by cooling of the flue gas via a WHRU, with the absorbed heat used to regenerate solvent in the capture plant.

5 Decommissioned Miller firewater pond available adjacent to NSMP South, which could potentially be re-used by Acorn. SEGAL has a firewater pond, but have indicated no available capacity. Existing firewater pumps on both sites have insufficient capacity to supply Acorn's requirements.

6 SEGAL MEG facilities could be repurposed for methanol storage and injection.

3.5 Constructability

The prospective Acorn facilities and site must provide a constructible, maintainable and operable facility. Assessment of these elements is an ongoing process that will evolve during the project, but an initial high-level constructability review was conducted, to allow the constructability differentials to be taken into account when evaluating the different sites. Generic constructability aspects that are consistent between sites have not been considered.

The constructability review covers the following aspects:

3.5.1 Construction Village

Provision of a construction village (offices, welfare, workshop, stores, construction laydown) will be required for the construction phase of the project. The ability for each prospective site to either provide these facilities, or provide space for them, was considered as part of site selection.

3.5.2 Security

The St Fergus gas terminal complex is of national significance and therefore has a high security requirement. Security measures are necessary for both the construction and operation phases, including the requirement for fencing, monitoring and access. A review of the impact on security has been undertaken for each site.

3.5.3 Transport and Lifting

The Acorn CCS project will involve the construction of large items (such as 9m wide x 30m high columns and potentially long distances of large cross-sectional ducting).

Understanding the transportation and lifting differentials between sites could have an impact on project cost and schedule. This includes "lifting over live plant" and movement of packages from fabrication facility to site, and from the site laydown yard to the point of construction. This aspect has been considered under this criteria when assessing the site.



3.5.4 Safe System of Work

The opportunity exists to relieve responsibility and additional work from the different site operators for isolated work fronts which could be completed within a “ring-fenced” area, using a standalone control of work system compliant with Construction, Design & Management Regulations 2015 (CDM). This would be dependent on level of risk posed by the activity, potential hazard consequence and the site operators view of this approach. The ability to realise this opportunity will be influenced by the extent to which sites are integrated within current site operations and this has been considered under this criteria.

3.5.5 Material Laydown & Pre-Assembly Area

Area(s) that can be utilised onsite for preassembly and storage, within the perimeter of the security fencing, but outside of hazardous areas, will benefit the the constructability of the project.

3.6 Health, Safety and Environment

The Acorn CCS plant should be sited such that risks are minimised to as low as reasonably practicable (ALARP). In practice, this means that the plant should be sited such that exposure to the potential impacts of existing fire/explosion hazards from St Fergus are minimised. Acorn CCS plant should also be sited such that the potential impact of CO₂ hazards on existing St Fergus plant and personnel are minimised.

Consenting risks should also be considered when selecting the Acorn CCS project site. To provide the project with the best chance of success, these risks should be minimised as far as possible.

During Concept Select, an HSE review (ERM, 2019), Hazard Identification workshop (HAZID) and Environmental Impact Identification workshop (ENVID) (ERM, 2020) were completed to assess the differences between the respective sites. The output from these activities have been considered as part of Acorn CCS project site selection.

3.6.1 Existing Site Hazards

The existing plants located at the St Fergus gas terminal complex present their own hazards to any new plant constructed in the vicinity.

- Ignition sources design of the Acorn CCS project facilities must prevent the introduction of sources of ignition, and the potential for fire and explosion hazards, by complying with existing hazardous area classification where applicable (eg by selection of ATEX equipment). Specifically, considerations should be made to avoid construction on live plant or in the vicinity of existing flares.
- Equipment layout: the impact of major accident hazards from existing plants, such as fires or explosions, may be escalated by new equipment sited adjacent or within hazardous areas, e.g. by release of CO₂ or flammable inventories.

3.6.2 Introduction of New Site Hazards

Construction and operation of Acorn CCS plant will introduce new site hazards. The impact of these hazards on the personnel onsite and at nearby facilities, as well as the potential environmental implications, have been considered as part of site selection. Certain hazards are unique to the CCS operations, such as the risk of asphyxiation due to CO₂ release. Some of the hazards are present to



differing extents for each site option and this has been considered in the site selection process.

The following key differential hazards between the sites were identified:

- Asphyxiation: processing of high concentration CO₂ streams carries risks of asphyxiation in the event of loss of containment or due to deliberate venting. CO₂ is denser than air and is likely to accumulate in low lying areas.
- Dense phase CO₂: after the final compression stage plant and within the export pipeline CO₂ will be present at high pressure in its dense phase. On loss of containment, due to Joule Thomson cooling, very cold temperatures will result posing an additional hazard. Escalation may result from embrittling of adjacent equipment and the release of additional CO₂ or other hazardous inventories.
- Solvent inventories: the amines used in the base case scenario for separation technology are hazardous.
- Existing safety processes: the impact of Acorn CCS project facilities on existing muster areas, escape routes and buildings should be minimised.

3.6.3 Environmental Considerations

All sites have been considered in an Environmental Impact Assessment Screening Opinion obtained from Aberdeenshire Council (Aberdeenshire

Council, 2020). This screening option states “that the proposed development, on any one of the proposed sites, is not likely to have significant effects on the environment to the extent that a detailed study through EIA would be necessary to.” Therefore, the consideration of environmental impact and consenting risk is a relative exercise to reduce risks as low as reasonably practicable. The following key environmental factors were highlighted by the ENVID workshop, for differentiating between sites.

- Flood risk: locating the plant on land at risk of flooding will have implications on construction requirements and potential need for enhanced mitigation and assessment to gain consent.
- Soil: distinction exists between the constructability on brownfield sites and greenfield sites with uncertainties regarding historic contamination and the requirement to manage this.
- CO₂ leaks: loss of containment of dense phase CO₂ may result in damage to local habitats and asphyxiate fauna depending on proximity to habitats of value.
- Visual impacts: visual implications to neighbouring properties will vary depending on the site selected).



4.0 Assessment Criteria

4.1 Project Value Drivers

Table 4-1 presents the value drivers for the Acorn project.

Item	Value Driver
A	Capex: Lowest capex for Phase 1
B	Schedule: Phase 1 project delivered by mid 2020s
C	HSE: Risk of planning, permitting, environmental, regulatory, public or other stakeholder objections minimised and HSE performance (construction and operational) maximised (a consentable design is a go/no go decision)
D	£/tonne: Lowest £/tonne (capex, opex throughput) for Phase 1
E	GHG Reduction: Net GHG reduction for Phase 1
F	Future Build Out: Flexibility for subsequent phases of development (Low regret cost)
G	Operability: Low risk to lifetime operability and availability for Phase 1
H	Market Stimulation: Offers greatest potential for CO ₂ transport storage market and knowledge transfer to build the market

Table 4-1: Acorn Project Value Drivers

Based on these value drivers and the site requirements outlined in the previous section, a set of assessment criteria was developed. A scoring system was also developed for each criteria, against which each site option was considered:

Green – The option performs well relative to the criteria (Score: 8-10)

Amber – The option performs well relative to the criteria although there are some negative aspects (Score: 4-7)

Red – The option performs unsatisfactorily relative to the criteria, this option will not be considered further (Score: 0-3)

Grey – Ruled out by previous criteria

4.2 Site Availability and Size Initial Screening

Each site was initially screened on the basis of site size, using the following three criteria. The criteria is listed in order of significance:

4.2.1 Availability of Land

The identified site(s) should be identified as commercially available for use by the Acorn CCS project, otherwise, this is not viable as an option. The RfS process has provided an indication of which sites are available.

This criteria links to the schedule value driver. If the land is not commercially available then it could take longer to negotiate an agreement with the owner (if at all feasible). This presents a risk to the project schedule.



4.2.2 Available Space

The prospective site(s) must have sufficient space to fit the Acorn CCS Phase 1 infrastructure (CO₂ capture, compression, conditioning and utilities). As discussed in section 3.1, 13,292m² of space is considered a suitable provision for Phase 1.

This criteria links to both capex, £/tonne and operability. Sufficient space must be provided for Phase 1, otherwise, the infrastructure may be constrained by a smaller space, potentially entailing a more complex design, higher cost and/or lower availability and operability.

4.2.3 Potential for Build-out

The prospective site or site arrangement should have flexibility to support subsequent phases of the Acorn CCS project (Feeder 10 CO₂ Compression, Hydrogen Production). Footprint requirements for build-out are discussed in Section 3.1.2.

This criteria links to the future build out and market stimulation value drivers.

4.3 Site Options Detailed Screening

Each of the screened sites was then compared with an additional six criteria to provide a total score:

4.3.1 Proximity to Emission Sources

The identified site should be located in close proximity to the emission sources on SEGAL and NSMP (<1 km). This will minimise capex associated with ducting to route the flue gas to the capture plant and reduce the size of the required blower. This will also reduce capex and opex associated with transfer of hot oil/steam from the SEGAL WHRU to the capture plant. As SEGAL emissions are

the main feed to the CCS plant, the scoring was weighted in favour of this source, relative to NSMP emissions.

This criteria links to both capex and £/tonne value drivers.

4.3.2 Proximity to Goldeneye Tie-In

The identified site should be located in close proximity to the Goldeneye pipeline tie-in (<1 km). This will minimise the dense phase CO₂ inventory and present a smaller hazard to plant and personnel.

This criteria links to the HSE value driver. This criteria is also relevant to capex, as minimising the length of dense phase pipework will result in lower capex for the project.

4.3.3 Constructability

This criterion considers four separate points:

1. Does the site have space local to it for a temporary construction village (office facilities, laydown, stores, workshop)?
2. Will the site require a Control of Work (CoW) system compliant with a live hydrocarbon plant?
3. Does the site have access for construction vehicles?
4. Is there existing plant on site which would require destructed prior to Acorn use?

This criteria links to several of the value drivers, including capex and schedule. The points above will impact the productivity of the project team, manifesting in the form of project cost and project schedule.



4.3.4 Existing Site Hazards

This criteria considers whether the proposed site at St Fergus is impacted by existing hazards from the St Fergus plants. Fire and explosion hazards are presented by the existing St Fergus plant and introduce risk to personnel. Siting the Acorn facilities in a location where such hazards are minimised presents the lowest risk to personnel and plant.

This criteria links to the HSE value driver.

4.3.5 Introduction of New Site Hazards

This criteria considers whether the proposed site introduces new hazards onto the existing plant at St Fergus. CO₂ presents an asphyxiation hazard, hence, the ALARP solution minimises personnel exposure to this hazard. Amine solvent is also a substance hazardous to human health.

This criteria links to the HSE value driver.

4.3.6 Environmental Impact and Consenting

This criteria considers whether the proposed site presents any specific environmental impact and consenting challenges relative to other site options.

This criteria links to the HSE value driver.



5.0 Site Options

Table 5-1 presents the site options which were considered for the Acorn CCS Phase 1 facilities.

Options	Description	Dimensions (m)	Footprint (m ²)
A	SEGAL Laydown Area	120x35, 85x20	6,000
B	SEGAL Unit 2600	90x80	7,200
C	SEGAL South	195x35	6,800
D	SEGAL Mothballed Goldeneye Plant	85x60	5,100
E	Combined SEGAL sites	See above	25,100
F	NSMP North	230x235, 135x145	73,625
G	NSMP South ¹	290x150	43,500
H	Blackhill	351x250	88,000
I	Split Site – SEGAL South (Capture plant) and NSMP South (Compression and conditioning plant) ¹	See above	50,300
J	Split Site – NSMP North(Capture plant) and NSMP South (Compression and conditioning plant)	See above	117,125

Table 5-1: Potential Site Options for Acorn Phase 1

Notes

1 This footprint encompasses the area to the east of the burn which runs across the NSMP South site (see Figure 5-1). Additional land is available to the west of the burn, which is approximately the same size as the area to the east of the burn. NSMP owned land is also available south of the existing St Fergus fence line.

Ancala land was not considered available.

An alternate site split option is to locate the CO₂ absorber local to the emission source, whilst locating the solvent regeneration plant on another site. This option offers the advantage of removing CO₂ from the flue gas local to the emission source, minimising the distance which the flue gas must be transported. CO₂ rich solvent would then be pumped from the absorber to the regeneration system. This option was not considered in detail for the following reasons:

- Introduction of amine hazard across multiple sites at St Fergus.
- Increased capex and opex associated with transporting amine from absorber to the solvent regeneration system.
- Sufficient space is available local to the SEGAL emission sources to site the full capture plant enabling Options I and J to provide the same benefit without the above drawbacks.

Figure 5-1 shows the location of each of the prospective sites at St Fergus gas terminal complex.





Figure 5-1: Potential Site Options for Acorn at St Fergus

5.1 Option A – Laydown Area

The SEGAL Laydown Area is a brownfield site located at the north of the SEGAL site. SEGAL have indicated that part of the land is available for use by the Acorn CCS project. The available area has a footprint of approximately 6,000m², as shown in Figure 5-2.

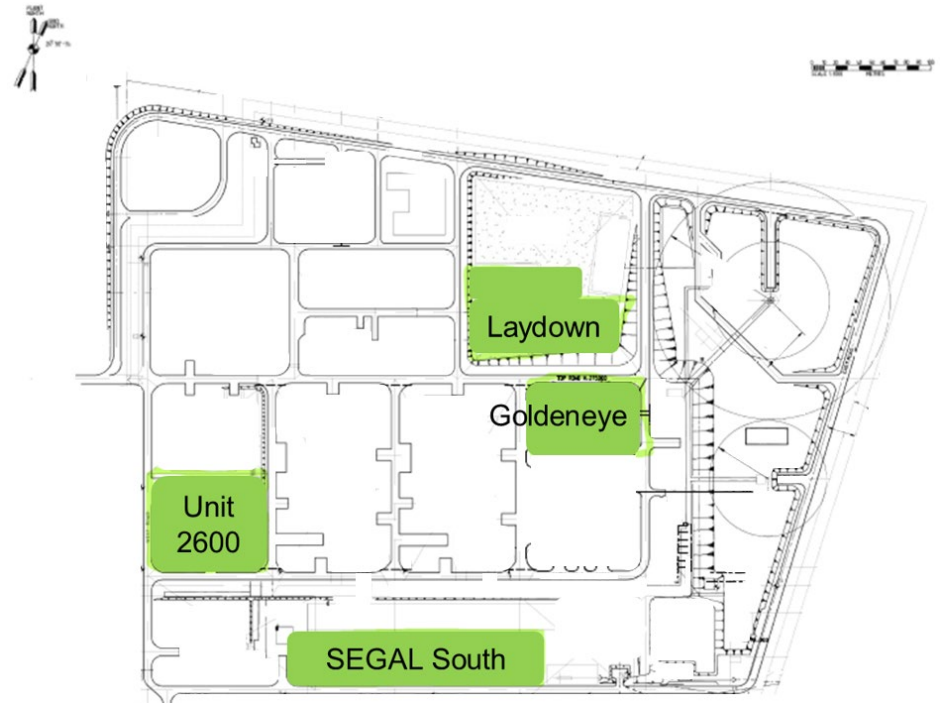


Figure 5-2: Response from SEGAL showing potential locations



5.2 Option B – SEGAL Unit 2600

Unit 2600 is a brownfield site located on the west side of the SEGAL site. Unit 2600 is a redundant section of plant which was previously used to process high H₂S content gas. Shell are currently considering options to decommission the equipment. The available area has a footprint of 7,200m², as shown in Figure 5-2. The redundant process plant is still located on the site and would need to be fully decommissioned and destroyed prior to use by Acorn CCS project.

5.3 Option C – SEGAL South

SEGAL South is a brownfield site located south of the SEGAL slug catcher and has a footprint of approximately 6,800m², as shown in Figure 5-2. The land is currently unoccupied and available for use.

5.4 Option D – SEGAL Mothballed Goldeneye Plant

The mothballed Goldeneye plant is a brownfield site located to the east of the SEGAL Module 2 facilities. The site has a footprint of 5,100m², as shown in Figure 5-2. The mothballed Goldeneye facilities are still located on site and would need to be removed prior to use by Acorn.

5.5 Option E – Combined SEGAL Sites

This option combines all footprints of available land on the SEGAL site, upon which the capture, compression and conditioning plant could be sited.

5.6 Options F – NSMP North

NSMP North is a currently undeveloped brownfield site located on the north of the NSMP site. This area of land is jointly owned by NSMP and Gassco. The

footprint of this site is approximately 73,000m². Figure 5-3 shows the site locations identified by NSMP as potentially being available for the Acorn CCS project.

5.7 Option G – NSMP South

NSMP South is a greenfield location within the St Fergus fence line located at the south of the NSMP site and is owned by NSMP. The land has a footprint of 43,500 m², east of the burn. Approximately the same area is available west of the burn, totalling 87,000m². Figure 5-4 shows the preliminary routing of ductwork and CO₂ pipework for this location.



Figure 5-3: RfS response from NSMP showing potential locations



5.8 Option H – Blackhill

Blackhill is a greenfield site outside the current St Fergus fencelines, located to the north of the National Grid site and is owned by National Grid. The site has a footprint of approximately 88,000m². Figure 5-5 shows the preliminary ductwork and pipeline routing for Blackhill.

5.9 Option I – Split Site

A split site option was considered, whereby the CO₂ capture plant is located at a separate location from the CO₂ compression and conditioning plant. The capture plant was assumed to be located on SEGAL South, whilst the compression and conditioning plant was located on NSMP South.

SEGAL South was considered for the capture plant as it is closest to the SEGAL emission sources and is currently unoccupied land. NSMP South was considered for the compression and conditioning plant as it is located separate from the existing plant, minimising CO₂ hazards to existing plant and personnel. It is also well located for build-out, with CO₂ from Feeder 10 and Peterhead Port arriving from the south.



Figure 5-4: Preliminary Ductwork and Pipeline Routing for NSMP South





Figure 5-5: Preliminary Ductwork and Pipeline Routing for Blackhill

5.10 Option J – Split Site

A split site option was considered, whereby the CO₂ capture plant is located at a separate location from the CO₂ compression and conditioning plant. The capture plant was assumed to be located on NSMP North, whilst the compression and conditioning plant was located on NSMP South.

NSMP North offers the benefit of being located close to the main emission source for the capture plant (SEGAL GTs).



6.0 Assessment of Site Options

6.1 Site Size Initial Screening

Firstly, an initial screening on the basis of site size was completed, as shown in Table 6-1.

Site Option	Availability of Land	Available Space	Potential for Build-out	Total
A	8	0	0	8/30
B	8	0	0	8/30
C	8	0	0	8/30
D	8	0	0	8/30
E	8	10	0	18/30
F	8	10	10	28/30
G	9	10	9	28/30
H	5	10	10	25/30
I	8	10	10	28/30
J	8	10	10	28/30

Table 6-1: Site Option Initial Screening

6.1.1 Availability of Land

The responses by the site operators are as listed below. Further commercial terms are yet to be discussed and will form the basis of future engagement.

6.1.1.1 [SEGAL \(Option A – E\)](#)

All SEGAL sites have been initially identified as available for use by the Acorn CCS project during the RfS process.

6.1.1.2 [NSMP \(Option F & G\)](#)

All NSMP sites have been initially identified as available for use by the Acorn CCS project. Within Option G, the area to the east is already the subject of commercial options agreement between PBDE and NSMP.

6.1.1.3 [National Grid \(Option H\)](#)

National Grid have yet to provide a firm commitment that Option H is available for use by the Acorn project, hence, there is still some uncertainty on the land availability and Option H was classed as orange.

6.1.1.4 [Split Sites \(Option I and J\)](#)

All sites are available for use by Acorn.

6.1.2 Available Space

6.1.2.1 [SEGAL \(Option A – E\)](#)

None of the SEGAL sites individually have enough space to accommodate the Phase 1 CCS infrastructure and were scored red. A combined SEGAL site (Option E) would have sufficient space, although the compression plant would need to be split up across multiple SEGAL sites.



6.1.2.2 [NSMP \(Option F & G\)](#)

Both NSMP North and NSMP South have sufficient space to accommodate the Phase 1 infrastructure and scored green.

6.1.2.3 [National Grid \(Option H\)](#)

Blackhill has sufficient space to accommodate the Phase 1 infrastructure and scored green.

6.1.2.4 [Split Sites \(Option I and J\)](#)

Both split site options can accommodate the Phase 1 infrastructure.

6.1.3 Potential for Build-out

6.1.3.1 [SEGAL \(Option A – E\)](#)

The SEGAL sites have insufficient space to accommodate the Acorn build-out phases, hence, performed poorly relative to the criteria.

6.1.3.2 [NSMP \(Option F & G\)](#)

The NSMP sites have space available to accommodate Acorn build-out and scored green. NSMP south (option G) would require to utilise land across the burn to achieve the full build-out footprint being assessed.

6.1.3.3 [National Grid \(Option H\)](#)

Blackhill has sufficient space available to accommodate Acorn build-out and scored green.

6.1.3.4 [Split Sites \(Option I and J\)](#)

Both split site options have available space for Acorn build-out.

6.1.4 Conclusion

On the basis of insufficient space for Phase 1 infrastructure, Options A, B, C and D were ruled out as individual options.

Option E was also ruled out primarily on the basis of insufficient space for build-out, however, there are several additional reasons why Option E was ruled out:

- Requirement to split the compression and conditioning plant onto two separate sites upon SEGAL, increasing the complexity of the design.
- Introduction of CO₂ asphyxiation hazards onto the existing SEGAL plant
- Exposure of the Acorn plant to existing fire/explosion hazards from the SEGAL plant
- Challenges associated with constructing on multiple areas in close proximity to live hydrocarbon plant

However, SEGAL South (Option C) was re-introduced as part of split site Option I.



6.2 Site Option Detailed Comparison

The prospective sites were compared against the remaining criteria outlined in Section 4.0 and scored. The results are shown in Table 6-2

Site Option	Proximity to Emission Sources	Proximity to Goldeneye Tie-In	Constructability	Existing Site Hazards	Introduction of New Hazards on Site	Environmental Impact & Consenting	Combined Total
A	7	10	8	7	4	8	52/90
B	9	10	4	5	4	8	48/90
C	10	10	5	5	4	8	50/90
D	7	10	4	5	4	8	46/90
E	7	10	3	5	4	8	55/90
F	10	9	6	5	4	8	70/90
G	4	5	10	9	9	6	71/90
H	8	6	9	9	6	5	68/90
I	10	5	7	7	8	7	72/90
J	9	5	8	7	8	7	72/90

Table 6-2: Site Option Scoring



The following section presents a discussion of each site relative to the criteria

6.2.1 Proximity to Emission Sources

The proximity to emission sources is based on site surveys completed through January/February 2020 and the site assessment report produced by Costain. (Costain, 2020)

6.2.1.1 SEGAL (Option A – E)

SEGAL sites are all located less than 1km from the SEGAL emission sources, hence all scored highly. Option A and D are over 1km from the NSMP emission sources, hence, were marked down slightly. Option E will most likely utilise the SEGAL Laydown Area, hence, was also marked down.

6.2.1.2 NSMP (Option F & G)

NSMP North is located less than 1km from both the SEGAL and NSMP emission sources, hence scored highly.

NSMP South is located 1.6km from the SEGAL gas turbines, hence, scored poorly. The layout is shown in Figure 6-1

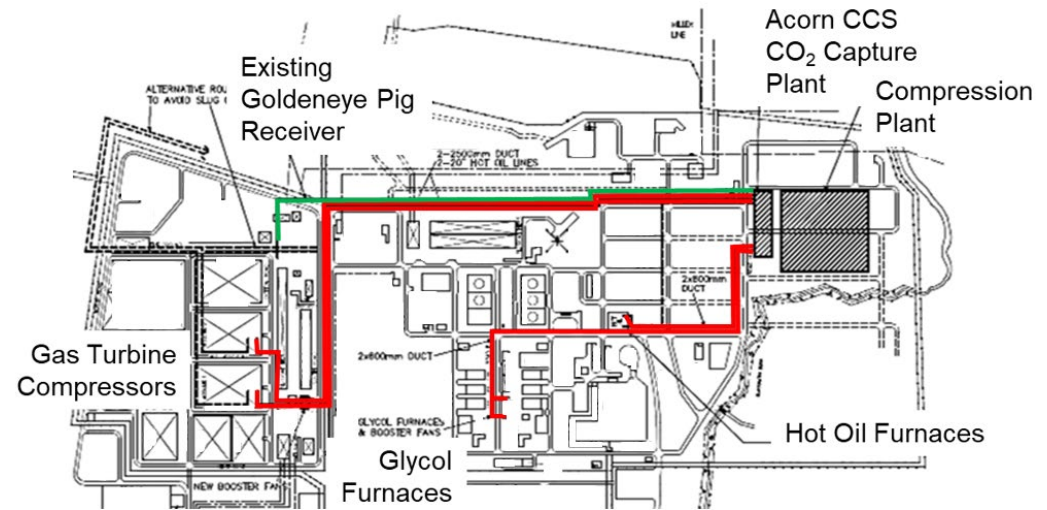


Figure 6-1: NSMP South Ducting Routing

6.2.1.3 National Grid (Option H)

Blackhill is located less than 1km from both the SEGAL and NSMP emission sources, hence scored highly. It is further away than NSMP North and consequently, was scored lower.

6.2.1.4 Split Sites (Options I and J)

Both split site options site the capture plant in close proximity to both emission sources, particularly the SEGAL GTs. Option I was scored lower as it is slightly further away from the SEGAL emissions, the main feed to the CCS plant.

6.2.2 Proximity to Goldeneye Tie-In

The proximity to the tie-in is based on site surveys completed through January/February 2020 and the site assessment report produced by Costain. (Costain, 2020)



6.2.2.1 [SEGAL \(Option A – E\)](#)

The SEGAL sites all located less than 1km from the Goldeneye pipeline tie-in point and scored highly.

6.2.2.2 [NSMP \(Option F & G\)](#)

NSMP North is located less than 1 km away from the Goldeneye tie-in, a mark was deducted as the site is not located on the SEGAL site.

NSMP South is located over 1km from the Goldeneye tie-in, hence was marked down.

6.2.2.3 [National Grid \(Option H\)](#)

Blackhill is located over 1km away from the Goldeneye tie-in, although it is closer than the NSMP site options and was scored slightly higher.

6.2.2.4 [Split Sites \(Option I and J\)](#)

The split site options are both over 1km from the Goldeneye pipeline tie-in point.

6.2.3 Constructability

The following is based on site surveys, a constructability review and site assessment reports completed by Costain. (Costain, 2020)

6.2.3.1 [SEGAL \(Option A – E\)](#)

Whilst no one single SEGAL site has sufficient space to allow for all of the Phase 1 facility to be built within it, the SEGAL site(s) have a number of advantages from a construction perspective:

- Equipment would be located within an already developed area
- Construction would be completed within the existing security fence line
- Essential services are already established onsite for construction (contractor facilities, laydown area)

- Sites are close to the SEGAL turbine WHRUs
- Sites are close to the Goldeneye tie-in
- Offices and welfare facilities are already established onsite
- Based on discussion with the Ops Supervisor, each of the prospective SEGAL sites could potentially have a standalone CoW system, separate to the existing site CoW system
- Construction of the capture/compression plant could be completed outwith existing hazardous areas

The disadvantages from a construction perspective are:

- The plant would need to be split across the site
- Distance of ducting from NSMP emissions sources to capture plant
- Some construction work (exhaust stack tie-ins, WHRU modifications, blower installation) would be completed within hazardous areas
- Increased frequency of lifting over or near live plant
- Decommissioning of Unit 2600 and the Goldeneye onshore facilities would need to happen first.

Option B and D were scored lower due to the requirement to remove existing plant. Marks were deducted from Option C due to the proximity to existing live plant (SEGAL slug catcher), which will need to be considered within the CoW system. Option A was scored green as it is located further away from existing process plant and has a lower LSIR relative to the other SEGAL sites.

6.2.3.2 [NSMP North \(Option F\)](#)

This location would allow for the Acorn CCS facility to be built within the security perimeter of the NSMP St Fergus site. There are a number of advantages from a construction perspective as noted below:

- Equipment would be located within an already developed area



- Construction would be completed within the existing security fence line
- Essential services are already established onsite but would need to be routed to new plant area
- Area for temporary offices and welfare facilities has been identified on site and used for previous projects
- Centrally located for all emission source tie-ins
- Shortest distances for pipeline tie-in and for ducting routings
- Considerable amount of ground for future development
- Potential to incorporate use of SEGAL South land
- Standalone CoW system, separate to the existing site CoW system
- Outwith existing hazardous area classification

The disadvantages from a construction perspective are:

- Shortest route for ducting from SEGAL would be routed above existing pipe racks and over the slug catcher causing lifting over live plant
- Potentially “ear marked” for a future project, although NSMP have indicated commercial availability to Acorn CCS project
- Potential to increase risk of major accidents escalating between sites, as area is exposed to SEGAL, National Grid and NSMP hazards.
- A construction village could not be co-located on site due to existing site hazards and would need to be located elsewhere on the NSMP site

Due to the location of NSMP North and exposure to existing site hazards, this option was marked down.

6.2.3.3 [NSMP South \(Option G\)](#)

This location would allow for the Acorn CCS facility to be built within the security perimeter of the NSMP St Fergus site. There are several advantages from a construction perspective as noted in the table below.

- Equipment would be located within an already developed area
- Bulk of construction work would be completed out with hazardous areas
- Security gate for construction access has already been created by BP Miller Decommissioning project
- Construction would be completed within the existing security fence line
- Essential services are already established onsite but would need to be routed to new plant area
- A construction village could be co-located on site

The disadvantages from a construction perspective are noted below:

- Distance of ducting and heating medium pipework from SEGAL emissions sources to capture plant
- Routing of large diameter ducting across the whole NSMP site
- Distance of pipeline from capture plant to Goldeneye tie-in
- Existing hydrocarbon pipelines are in close proximity to the route for the new pipework/duct racks
- Shortest route for ducting from SEGAL would be routed above existing pipe racks and over the slug catcher causing lifting over live plant

NSMP South was scored highly due to separation from the existing hydrocarbon plant and the fact it meets all the defined criteria.

6.2.3.4 [National Grid \(Option H\)](#)

Blackhill would involve the construction of the Acorn CCS Phase 1 facilities outwith the security perimeter of the existing St Fergus site. Blackhill offers several advantages from a construction perspective:

- Undeveloped area clear of all live site controls
- Main plant can be erected under construction contractor control



- Main plant can be erected without placing additional burden on SEGAL or NSMP operations

Whilst the disadvantages from a construction perspective are:

- Unknown ground conditions
- COMAH tier 1 security fencing required around plant and permanently manned security team required
- Distance of ducting from NSMP emissions sources to capture plant
- Duct/Pipeline racks run close to SEGAL flares or cross over the SEGAL access road
- Duct runs close to existing pipeline route within NSMP
- Temporary offices and welfare required
- No existing access roads across the site

Blackhill scored highly, but was marked down slightly due to the fact there are no existing access roads across the site.

[6.2.3.5 Split Sites \(Option I and J\)](#)

Option I incorporates the constructability issues identified with SEGAL South and NSMP South, whilst Option J incorporates those associated with NSMP North/NSMP South

6.2.4 Existing Site Hazards

The following is based on the course hazard identification (HAZID) workshop completed with Pale Blue Dot, Costain, ERM and TDSA Partners. (ERM , 2020)

[6.2.4.1 SEGAL \(Option A – E\)](#)

Option A-E sites the capture and compression plant on SEGAL, which is exposed to existing fire and explosion hazards from the SEGAL plant. Hence, these options were marked down.

Option A scored slightly higher as the SEGAL Laydown Area has a lower Location Specific Individual Risk (LSIR) relative to the other SEGAL sites.

[6.2.4.2 NSMP \(Option F & G\)](#)

Option F sites the Acorn CCS facilities in the centre of the NSMP plant and is exposed to hazards from SEGAL, NSMP and National Grid. This was highlighted as a risk by NSMP. However, this site option is still considered feasible but was marked down accordingly.

Option G is remote from the existing NSMP plants and there is a lower impact of existing fire/explosion hazards, hence, scored highly.

[6.2.4.3 National Grid \(Option H\)](#)

Option H is located separately from the existing SEGAL/NSMP plants and there is a lower impact of existing fire/explosion hazards, hence, scored highly.

[6.2.4.4 Split Sites \(Option I and J\)](#)

For the split site options the hazards were considered for both the capture plant location and the compression plant location. Option I sites the capture plant on SEGAL South, which is exposed to existing fire and explosion hazards from the SEGAL plant. Hence, this option was marked down. For similar reasons Option J was also marked down.

6.2.5 Introduction of New Site Hazards

The following is based on the course hazard identification (HAZID) workshop completed with Pale Blue Dot, Costain, ERM and TDSA Partners. (ERM , 2020)

[6.2.5.1 SEGAL \(Option A – E\)](#)

Locating the Acorn CCS plant within the SEGAL site introduces a new CO₂ hazard which is not currently present to the same extent. Hence, options A



through E scored poorly. Option A in particular sites the CO₂ asphyxiation hazard on the SEGAL Laydown Area, directly adjacent to the site occupied buildings and muster area. In the event of a leak, this presents an asphyxiation risk to personnel.

6.2.5.2 [NSMP North \(Option F\)](#)

Option F locates the CO₂ hazard in the middle of the NSMP plant, with the potential for any release to impact on neighbouring plant and personnel, hence, scored poorly.

6.2.5.3 [NSMP South \(Option G\)](#)

Option G locates the CO₂ hazard on NSMP South, which is located separate from existing plant and personnel, with prevailing south westerly wind meaning there is increased potential that releases would be blown offshore without impacting plant or personnel. Hence, this option scored highly.

6.2.5.4 [National Grid \(Option H\)](#)

Option H locates the CO₂ hazard on Blackhill which is separate from the existing St Fergus gas terminal complex plant. However, the dense phase CO₂ piping presents a hazard to existing plant occupied buildings and the score was marked down accordingly.

6.2.5.5 [Split Site \(Option I and J\)](#)

Hazards were considered for both locations which make up the split site option. Option I and J introduce a low pressure CO₂ hazards on SEGAL South and NSMP North respectively (product from the capture plant). However, the main CO₂ hazard associated with dense phase CO₂ is located on NSMP South, which is separate from existing plant and personnel. Hence, both these options scored relatively well.

6.2.6 Environmental Impact and Consenting

The following is based on the course environmental impact identification (ENVID) workshop completed with Pale Blue Dot, Costain, ERM and TDSA Partners. (ERM, 2020)

6.2.6.1 [SEGAL \(Option A – E\)](#)

Option A, B, C, D and E, located on the SEGAL site, are not anticipated to present specific consenting challenges. It is outwith the flood plain, visually enclosed with SEGAL terminal and have little habitat of value in close proximity (whilst noting the proximity of the dune habitat to the east, the Goldeneye reception facility is the nearest plant to this and invariable to all options). There is potential for contaminated land to be encountered during construction due to the brownfield nature of these sites. It is assumed that site with current infrastructure would be remediated to a suitable standard prior to construction. Overall, these sites scored highly.

6.2.6.2 [NSMP North \(Option F\)](#)

Option F is located within the existing NSMP site and is not anticipated to present any specific consenting challenges. It is outwith the flood plain, visually enclosed with NSMP terminal and has little habitat of value in close proximity. There is potential for contaminated land to be encountered during construction due to the brownfield nature of these site within the NSMP terminal. Although the NSMP north site is currently undeveloped. Overall, these sites scored highly.

6.2.6.3 [NSMP South \(Option G\)](#)

Option G was marked down as developing the plant to the south of existing gas plant infrastructure would increase the visibility of St Fergus infrastructure to some local residents in St Fergus. This is known from recent planning



applications in the area to be a local community issue of concern. However, it is recognised that this site is adjacent to the now decommissioned Miller gas plant, and is within terminal security fence and area designated in the Aberdeenshire Local Plan for oil and gas related development. The site is outwith the flood plain (to the east of the burn) and, whilst adjacent to the decommissioned Miller facility, has not previously been developed. The use of this site would result in an increased length of dense phase pipeline in close proximity to the dune habitats to the east.

6.2.6.4 National Grid (Option H)

Option H was marked down due part of the site being within the floodplain which could increase the complexity of the consenting process.

6.2.6.5 Split Site (Option I and J)

Options I and J were marked down slightly due to the potential consenting issues presented by NSMP South.



7.0 Conclusions and Preferred Options

Of the ten options assessed the four options which scored highest are:-

- Option I (Split Site – SEGAL South Capture, NSMP South Compression)
- Option J (Split Site – NSMP North Capture, NSMP South Compression)
- Option G (NSMP South both Capture & Compression)
- Option F (NSMP North both Capture & Compression)

These are considered technically preferable options for Acorn CCS project.

It has been concluded that these site options are technically attractive for the following reasons:

- Sites have been identified as available by their respective owners.
- Sites are located within the existing St Fergus security site boundaries.
- NSMP South and NSMP North has sufficient space for build-out of the compression system in the future to accommodate CO₂ from hydrogen generation, CO₂ from Feeder 10 or CO₂ imported from Peterhead.
- Construction access is available to these sites, with space available nearby for construction support facilities.
- Siting the Phase 1 compression and future compression at NSMP South provides the easiest tie-in for future CO₂ sources, which will come from the south of St Fergus (Peterhead / Grangemouth).
- Locating the dense phase CO₂ hazard within areas of St Fergus which are separate from the existing plant and is a normally unoccupied area (e.g. NSMP South) and routing the dense phase pipeline along the east of the NSMP minimises personnel risk.

- Reducing the length of SEGAL gas turbine ductwork and providing a more straightforward re-use of waste heat from the SEGAL flue gas will achieve considerable cost savings.
- Consenting risk could be minimised by locating the tall vessels (e.g. CO₂ absorber) on either SEGAL South or NSMP North, minimising the visual impact on the St Fergus residents existing sea view.

This study has provided a strong basis upon which to continue to progress the commercial dialogue with the site owners and advance toward Concept Select phase.



8.0 Acronyms

Acronym	Defintion
ALARP	As low as reasonably practicable
ATEX	Atmospheres explosible
BEIS	Department of Business, Energy and Industrial Strategy
Capex	Capital expense
CCS	Carbon capture and storage
CCSL	Carbon Capture Solutions
CDM	Construction, Design & Management Regulations 2015
CES	Crown Estate Scotland
CO₂	Carbon dioxide
COMAH	Control of Major Accident Hazards Regulations
CoW	Control of Work
DCC	Direct contact cooler
ENVID	Environmental impact identification
FID	Final investment decision

FUKA	Frigg UK Association
GT	Gas turbine
H₂S	Hydrogen sulphide
HAZID	Hazard identification
HP	High pressure
HSE	Health, safety and the environment
LP	Low pressure
LSIR	Location Specific Individual Risk
NG	National Grid
NGG	National Grid Gas
NSMP	North Sea Midstream Partners
NTS	National Transmission System
OGA	Oil and Gas Authority
Opex	Operating expense
PBDE	Pale Blue Dot Energy
PCI	Project of Common Interest
PDMS	Plant Design Management System



RfS	Request for Services
SAGE	Scottish Area Gas Evacuation
SAPLING	(CO ₂) Shipping and Pipeline Infrastructure and North Sea Regeneration
SEGAL	Shell Esso Gas and Liquids
TDSA	Technical Development Services Agreement
UPS	Uninterruptible power supply
WHRU	Waste heat recovery unit



9.0 References

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