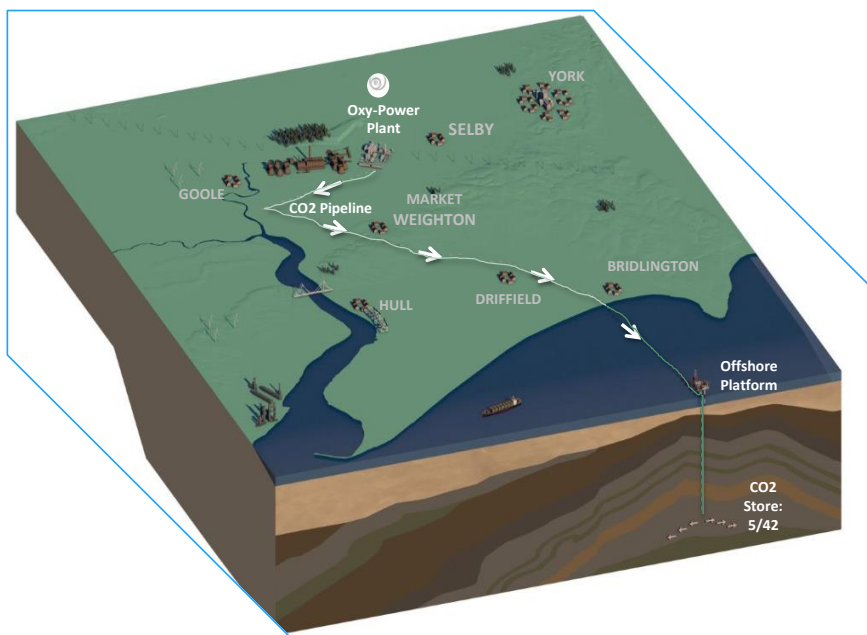




## K25: Full Chain Externally Supplied Utility Summary

*Technical: Full Chain*



# Contents

Chapter	Title	Page
	Executive Summary	i
1	Introduction	1
1.1	Background	1
1.2	Purpose of the Document	3
2	Utility Summary	4
2.1	Oxy Power Plant Utility Summary	4
3	Transport Utility Summary	9
3.1	Potable Water	9
3.2	Electrical Supply	9
3.3	Temporary Utilities / Auxiliary Utilities	10
4	Transport Utility Summary	11
4.1	Seawater	11
4.2	Monoethylene Glycol (MEG) Storage and Injection	11
4.3	Diesel System	12
4.4	Nitrogen	12
4.5	Temporary Water Wash Package	13
4.6	Biofouling Control Package	14
4.7	Fresh Water and Potable Water	14
4.8	Chemical Injection (Corrosion Inhibitor)	14
4.9	Wellhead Hydraulic Power Unit	14
4.10	Electrical	15
4.10.1	Low Voltage Supply	15
4.10.2	High Voltage Supply	15
5	Glossary	16

# Key Words

Key Work	Meaning or Explanation
Carbon Dioxide	A greenhouse gas produced during the combustion process
Carbon Capture and Storage	A technology which reduces carbon emissions from the combustion based power generation process and stores it in a suitable location
Coal	The fossil fuel used in the combustion process for White Rose
Dense Phase	Fluid state that has a viscosity close to a gas while having a density closer to a liquid Achieved by maintaining the temperature of a gas within a particular range and compressing it above a critical pressure
Full Chain	A complete CCS system from power generation through CO <sub>2</sub> capture, compression, transport to injection and permanent storage
Heat and Mass Balance	Heat and mass balance/heat and materials balance is a document produced by process design engineers while designing a process plant. A heat and mass balance sheet represents every process stream on the corresponding process flow diagram in terms of the process conditions.
Key Knowledge	Information that may be useful if not vital to understanding how some enterprise may be successfully undertaken
Storage	Containment in suitable pervious rock formations located under impervious rock formations usually under the sea bed
Transport	Removing processed CO <sub>2</sub> by pipeline from the capture and process unit to storage
Operation	Utilising plant/equipment to produce/provide the designed output commodity/service
Operating Mode	The method of operation of the OPP, which can operate in air or oxy-firing mode
Oxy Boiler	The boiler within the OPP capable of producing full load in either the air or oxy-fired mode of operation
Oxy-firing	The use of oxygen (instead of air) in the combustion process
Oxyfuel	The technology where combustion of fuel takes place with oxygen replacing air as the oxidant for the process, with resultant flue gas being high in CO <sub>2</sub>
Oxy Power Plant	A power plant using oxyfuel technology
Process Flow Diagram	Process Flow Diagram (PFD) is a drawing which describes the process flow for a processing plant. PFD is used to capture the main process equipment, main process streams, process/design conditions in these items of equipment and the basic process control scheme in a single drawing.
White Rose	The White Rose Carbon Capture and Storage project

## Figures

Figure 1.1:	Full Chain Schematic Diagram	1
Figure 1.2:	White Rose CCS Project Artist Impression	2
Figure 1.3:	Geographical overview of the transportation facility	3

## Tables

Table 2.1:	OPP Utility Summary	5
Table 3.1:	Main Power Consumers	9
Table 4.1:	Seawater Consumption	11
Table 4.2:	MEG Storage Tank equipment details	12
Table 4.3:	Diesel Consumption	12
Table 4.4:	Temporary Water Wash Package equipment details	13

# Executive Summary

The Full Chain Externally Supplied Utility Summary was generated as part of the Front End Engineering Design (FEED) contract with the Department of Energy and Climate Change (DECC) for White Rose, an integrated full-chain Carbon Capture and Storage (CCS) Project. This document is one of a series of Key Knowledge Deliverables (KKD) from White Rose to be issued by DECC for public information.

White Rose comprises a new coal-fired ultra-supercritical Oxy Power Plant (OPP) of up to 448 MWe (gross) and a Transport and Storage (T&S) network that will transfer the carbon dioxide from the OPP by pipeline for permanent storage under the southern North Sea. The OPP captures around 90% of the carbon dioxide emissions and has the option to co-fire biomass.

Delivery of the project is through Capture Power Limited (CPL), an industrial consortium formed by General Electric (GE), BOC and Drax, and National Grid Carbon Limited (NGC), a wholly owned subsidiary of National Grid.

This report provides a summary of the externally supplied utilities to the Full CCS Chain.

This document should be read in conjunction with the following documents:

- K.22 - Full Chain Process Flow Diagrams;
- K.23 - Full Chain Heat and Material Balances;
- K.24 - Full Chain Equipment List;
- K.27 - OPP - Process Description;
- K.29 - Transport - Process Description; and
- K.30 - Storage - Process Description.

# 1 Introduction

## 1.1 Background

The White Rose Carbon Capture and Storage (CCS) Project (White Rose) is an integrated full-chain CCS project comprising a new coal-fired Oxy Power Plant (OPP) and a Transport and Storage (T&S) network that will transfer the carbon dioxide from the OPP by pipeline for permanent storage under the southern North Sea.

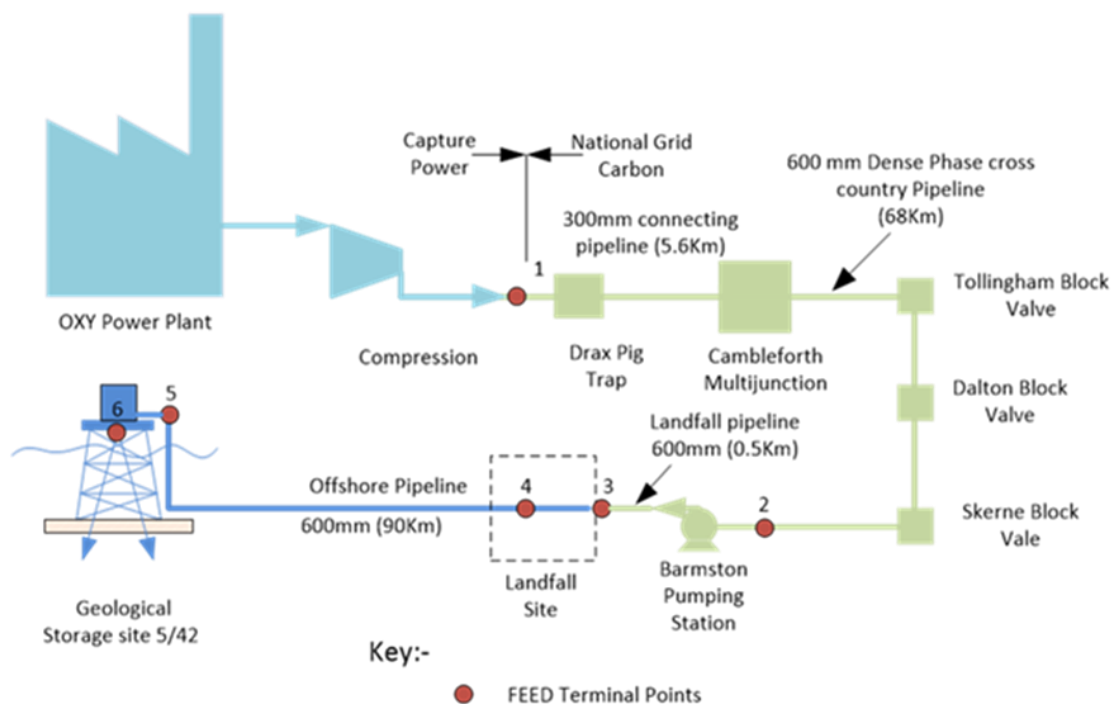
The OPP is a new ultra-supercritical power plant with oxyfuel technology of up to 448 MWe gross output that will capture around 90% of carbon dioxide emissions and also have the option to co-fire biomass.

One of the first large scale demonstration plants of its type in the world, White Rose aims to prove CCS technology at commercial scale as a competitive form of low-carbon power generation and as an important technology in tackling climate change. The OPP will generate enough low carbon electricity to supply the equivalent needs of over 630,000 homes.

White Rose is being developed by Capture Power Limited, a consortium of GE, BOC and Drax. The project will also establish a CO<sub>2</sub> transportation and storage network in the region through the Yorkshire and Humber CCS pipeline being developed by National Grid Carbon Ltd (NGC).

The Full Chain and its component parts (see Figure 1.1) are designed to be operated such that the target of two million tonnes of CO<sub>2</sub> per year can be safely stored.

**Figure 1.1: Full Chain Schematic Diagram**



The standalone OPP will be located to the northeast of the existing Drax Power Station site near Selby, North Yorkshire (see Figure 1.2) within the Drax Power Ltd (DPL) landholding and benefits from fuel import and power transmission infrastructure currently in place. The plant will generate electricity for export to the Electricity Transmission Network while capturing approximately 2 million tonnes of CO<sub>2</sub> per year, some 90% of all CO<sub>2</sub> emissions produced by the plant. The CO<sub>2</sub> will be transported by pipeline for permanent undersea storage beneath the North Sea.

**Figure 1.2: White Rose CCS Project Artist Impression**



The power plant technology, known as oxy-fuel combustion, burns fuel in a modified combustion environment with the resulting combustion gases having a high CO<sub>2</sub> concentration. This allows the CO<sub>2</sub> produced to be captured without the need for additional chemical separation, before being transported for storage.

Figure 1.3 below gives a geographical overview of the proposed CO<sub>2</sub> transportation system.



**Figure 1.3: Geographical overview of the transportation facility**



White Rose will benefit the UK and continued development of CCS technology by:

- Demonstrating oxy-fuel CCS technology as a cost effective and viable low-carbon technology;
- Reducing CO<sub>2</sub> emissions in order to meet future environmental legislation and combat climate change;
- Improving the UK's security of electricity supply by providing a new, flexible and reliable coal-based low-carbon electricity generation option;
- Generating enough low-carbon electricity to supply the energy needs of the equivalent of over 630,000 households; and
- Acting as an anchor project for the development of a CO<sub>2</sub> transportation and storage network in the UK's most energy intensive region thereby facilitating decarbonisation and attracting new investment.

## 1.2 Purpose of the Document

This document provides a summary of the externally supplied utility for the Full Chain consisting of:

- utility type with a brief description;
- design and operating mass flow rates (at nominal case point); and
- design and operating conditions (at nominal case point).



## 2 Utility Summary

### 2.1 Oxy Power Plant Utility Summary

A description of the metering for the main utilities supplied to the OPP is given in K27 – Oxy Power Plant Process Description.

Table 2.1: OPP Utility Summary

ID	Product	Utilisation	Physical State	Pressure (barg) Nominal / Design	Temperature (°C) Min. /Max.	Storage in operation in workshop	Location in operation in workshop	Physical State of final product in operation in workshop	Consumption and quantity in operation
	Coal Supply	Main fuel for the combustion process.	Solid	N/A	N/A			Solid (pulverised powder)	Approx. 160 t/h conveyor capacity max. 2 x 650 t/h
	Biomass Supply	Supplementary fuel for the combustion process.	Solid (Timber pellets)	N/A	N/A			Solid (pulverised powder)	Max. flow to boiler 35 t/h, conveyor capacity max. 80 t/h
	Light Fuel Oil (LFO)	Start-up and shutdown fuel for low load operations.	Liquid	N/A	N/A			Liquid	40 m³/h
	Raw Limestone	Limestone is used as reagent for limestone/gypsum wet FGD for SO <sub>2</sub> removal from the flue gas. Delivered either from existing DRAX main storage or by trucks.	Solid	N/A	N/A	670 ton	Location is limestone silos	Slurry Solution	Approx. 13 t/h conveyor capacity max. 60 t/h
	Raw Water	Pre-treated river water for cooling tower make-up.	Liquid	2 / 4	Ambient / 30			Liquid	Nom. 1,382 m³/h / max. 1,650 m³/h
	Drinking Water from existing network	Drinking water supply from Yorkshire water.	Liquid	3/6	Ambient / 20			Liquid	Nom. 13 m³/h / max. 20 m³/h
	11 kV connection	The new Oxy Power Plant will require back-up power supply at 10 MVA, 11kV electrical interconnection from Drax to provide auxiliary power as required. The 11kV feed for interconnector 'A' supply is to be taken from Drax FGD Unit Board 4 and the 'B' supply from its equivalent board (Unit Board 5).  Each new 11kV feeder will be capable of supplying the full requirement of 10 MVA to the Oxy Power Plant, the second feeder is therefore provided for redundancy. Both supplies will be metered to the required commercial standard.	Electricity	N/A	N/A		Alstom distribution board	Electricity	Nom. 9 MVA / max. 10 MVA
	Turbine lubrication oil, turbine control oil, generator sealing oil	In operation, steam turbine and generator need a permanent supply of lubrication oil for the common shaft, turbine control oil for operation of oil as well as sealing oil to separate inner gas room of turbo generator to the atmosphere of turbine hall. A common sort of oil is used for these three different purposes.  Turbine lubrication and control oil are stored together in a common oil tank, whereas generator seal oil is stored in a separate unit. All these oils circulate without any consumption.  Please note that Steam turbine lube and control oil systems are separate systems with own pumps, filters, cooler feed from a common tank. Therefore, the hydraulic fluid is not fire resistant. Instead, Alstom implements passive fire protection.	Liquid			1) 29 000 l (oil stored is the oil in operation) 2) N/A	Turbine hall B63 on general layout N/A	Combined lube / control oil tank: design pressure: atmospheric vessel; design temperature 80°C; Operating temperature 59°C;  Seal oil system: maximum permissible pressure 16 bar, Quantity 4,000 l	29,000 l
	CO <sub>2</sub>	Purity : ≥ 99.5%	Liquid				B63 -	Liquid	For one cycle: To purge H <sub>2</sub> : 164 Nm³ To purge Air 148 Nm³
	H <sub>2</sub>	Purity : ≥ 99.5%	Gaseous				B63 -	Gaseous	For one cycle: To purge CO <sub>2</sub> : 247 Nm³  To fill the generator to operating pressure: 302 Nm³ Permissible leakage according to IEC 60034-3 (less than 18 Nm³/day) Gas volume of generator: 82 m³
	Catalyst solid	SCR	Solid			1) 400 m³ 2) NA	SCR (B01) NA	Solid	Quantity Installed : 400 m³ No consumption
	Anhydrous Ammonia	Anhydrous ammonia is a reagent for NO <sub>x</sub> control in the Selective Catalytic Reduction (SCR) system. It will be supplied by trucks (24t) from external supplier.  Anhydrous ammonia is commonly stored as a compressed liquid. It is vaporized and diluted to below 5% by volume in	Liquid			14 days of supply Storage : 2 x 76 m³	G21	Location of tank: G21 on general layout Design temperature and pressure of storage vessel.	212 kg/h

ID	Product	Utilisation	Physical State	Pressure (barg) Nominal / Design	Temperature (°C) Min. /Max.	Storage in operation in workshop	Location in operation in workshop	Physical State of final product in operation in workshop	Consumption and quantity in operation
		air before it is injected as a gas upstream of the SCR catalyst.						- Design Temperature and pressure of storage vessel will be in compliance with 12952 part 14	
	Sodium Carbonate (soda ash)	Sodium carbonate (also known as soda ash), Na <sub>2</sub> CO <sub>3</sub> is a sodium salt of carbonic acid. It is a reagent for SO <sub>3</sub> mitigation in the flue gas. It will be delivered in powder form by pneumatic hopper trucks (24t) from external supplier. The dry solids are conveyed to a solid wetting device where they are wetted and dissolved in a reagent storage tank.	Solid (powder)			Depends on required days of storage: 7 days : 250 m <sup>3</sup> solution 25% 14 days : 2 x 250 m <sup>3</sup> solution 25%	Close to Boiler island area B01 (SO <sub>3</sub> sorbent skid) - This system is expected to be located next to the boiler area (steel columns)	Sodium carbonate delivered as dry powder and dissolved with warm water as solution 25 wt%.	388 kg/h (dry)
	Boiler miscellaneous grease, oil, consumables								
	Heavy gear Oil	Gulf/EP250	liquid			Approx. 200 gallons (760 l)			
	Medium Gear Oil	Mobil/DTE	liquid			Approx. 100 gallons (380 l)			
	Multi-Purpose Grease					Approx. 50 gallons (190 l)			
	Oil	Mobil EP111	liquid			Approx. 400 gallons (1,515 l)			
	Oil	Mobil Gear 600 XP 320	Liquid			Approx. 1500 gallons (5,680 l)			
	Acetylene	Bottles required for cutting torch	Gas						
	Oxygen	Bottles required for cutting torch	Gas						
	Argon	Bottles required for cutting torch	Gas						
	Propane	Bottles required for heat source	Gas						
	Hydraulic Oil	High water level valves and Submerged scrapper systems	Liquid			Approx. 150 gallons (570 l)			
	Mineral Oil	Mineral oil are used for cooling purpose of the TR Set (Transformer Rectifier set), cooling method used is Oil Natural Connection cooling. The used mineral oil meets the requirement of IEC : 296-I.	Liquid			13,000 l			
	Lubrication Oil	Lubrication Oil will be used for lubrication purpose of Emitting, Collecting & Inlet GD (Gas distribution) Rapping Geared Motors	Liquid			500 l			
	Refrigerant Fluid R134A + R404A	Refrigerant fluid for chiller unit used for drying air (ash handling system)	Liquid / Gas			To be advised later			
	Lubricating oil	Lubrication oil will be used in the gearbox of the oxidation blower and relevant bearings, in the (eventual) gearbox of the absorber recycle pumps, in the gear box of the agitators, in the bearings of the ball mills and eventually for the Medium Voltage electrical motors bearings	Liquid			Approx. 2,000 liters in total	Locations of the various oil tanks correspond to relevant equipment location (oil tanks are integral to the equipment)	1) Liquid	
	Grease	Grease will be used for lubrication of the pinion of ball mill, for all bearings not oil lubricated	Liquid/Solid			Approx. 500 liters in total	Locations will be nearby the ball mills and in correspondence of single equipment	1) Liquid / Solid	
	Radiometric density meter	Control of the preparation of the Limestone	Solid			One in operation	Limestone preparation tank	1) Solid	
	NaOH	30% for neutralisation of Waste Water Stream	liquid			1) 100 m <sup>3</sup> 2) NA	close to direct contact cooler	liquid	Max. 550 kg/h
	Lube Oil	Lube oil for Flue gas compressors GPU located close to compressor skid	Liquid			1) 10 m <sup>3</sup> 2) NA	located close to flue gas compressor skid	Liquid	

ID	Product	Utilisation	Physical State	Pressure (barg) Nominal / Design	Temperature (°C) Min. /Max.	Storage in operation in workshop	Location in operation in workshop	Physical State of final product in operation in workshop	Consumption and quantity in operation
	Lube Oil	Lube oil for CO <sub>2</sub> compressor GPU located close to compressor skid	Liquid			1) 5 m <sup>3</sup> 2) NA	located close to CO <sub>2</sub> compressor skid	Liquid	
	Refrigerant Fluid	Refrigerant fluid for chiller unit	Liquid			To be advised later	GPU area	Liquid	
	Closed water loop chemical	Chemicals for conditioning the closed water loop to very low temperature. Could be Glycol/water	Liquid			To be advised later	GPU area	Liquid	
	Transformer oil	Transformer oil (GSUT and UAT) in the transformer area	Liquid			A very preliminary estimation of the quantity of - oil of the GSUT is 73,000 kg - 5 auxiliary transformers: around 35,000 kg			
	Acid	Acid of the batteries The batteries are located in dedicated rooms with specific protections means (gas detection, eye wash, etc.)	Liquid						
	Ferric chloride FeCl <sub>3</sub> 41%	Ferric chloride used for raw water treatment plant	Solution			30 to 50 m <sup>3</sup> to be confirmed 12 days		Solution 41% in water	3,860 L/day of FeCl <sub>3</sub> 41%
	Polymer	Polymer used for raw water treatment plant	Solution			1 m <sup>3</sup>		product conditioned in water	75 kg/day
	Sulphuric acid H <sub>2</sub> SO <sub>4</sub> 98%	Concentrated sulphuric acid used for demineralised water production	Solution			15 m <sup>3</sup> to be confirmed		1) 96-98% stocked in G05 2) N/A	
	Caustic soda NaOH 48%	Concentrated caustic soda used for demineralised water production	Solution			15 m <sup>3</sup> to be confirmed		1) 48% stocked in G05 2) N/A	
	Reducing Agent	Proprietary reducing agent product used for Water Treatment Plant	Solution / powder			1 m <sup>3</sup> 3 m <sup>3</sup> to be confirmed		product conditioned in water product conditioned in water	
	Anti-scaling	Proprietary anti-scaling agent product used for Water Treatment Plant	Solution / powder			1 m <sup>3</sup> 3 m <sup>3</sup> to be confirmed		product conditioned in water product conditioned in water	
	Biocide	Proprietary biocide agent product used for Water Treatment Plant	Solution / powder			1 m <sup>3</sup> 3 m <sup>3</sup> to be confirmed		product conditioned in water product conditioned in water	
	Cleaning Agent	Proprietary cleaning agent product used for Water Treatment Plant	Solution / powder			1 m <sup>3</sup> 3 m <sup>3</sup> to be confirmed		product conditioned in water product conditioned in water	later
	Hydrochloric Acid 33%	Concentrated sulphuric acid used for condensate polishing plant	Solution			15 m <sup>3</sup>	B63 Steam Turbine Hall	1) 33% stocked in G05 2) N/A	310 kg 100% per regeneration (10 days) To be confirmed
	Caustic soda NaOH 48%	Concentrated caustic soda used for condensate polishing plant	Solution			15 m <sup>3</sup>	B63 Steam Turbine Hall	1) 48% stocked in G05 2) N/A	230 kg 100% per regeneration (10 days) To be confirmed
	Sulphuric acid H <sub>2</sub> SO <sub>4</sub> 98%	Concentrated sulphuric acid used for cooling tower circuit dosing	Solution			25 m <sup>3</sup>	Cooling Tower Area	1) 96-98% stocked in Cooling Tower Area 2) N/A	100-110 g/m <sup>3</sup> 15 days of autonomy (to be confirmed)

ID	Product	Utilisation	Physical State	Pressure (barg) Nominal / Design	Temperature (°C) Min. /Max.	Storage in operation in workshop	Location in operation in workshop	Physical State of final product in operation in workshop	Consumption and quantity in operation
	Sodium hypochlorite 12%	Diluted sodium hypochlorite for cooling tower circuit dosing	Solution			15 m <sup>3</sup>	Cooling Tower Area	1 ) 12% stocked in Cooling Tower Area 2) N/A	0.5-1 mg/l continuous (30 days of autonomy) to be confirmed
	Non Oxidizing Biocide	Proprietary biocide product used for cooling tower circuit dosing Ferocide 8583 or equivalent	Solution			6 m <sup>3</sup>	Cooling Tower Area	1 ) Product stocked in Cooling Tower Area 2) N/A	50 ppm (shock treatment)
	Anti-scaling	Proprietary anti scaling product used for cooling tower circuit dosing Ferrofos 8500 or equivalent	Solution			15 m <sup>3</sup>	Cooling Tower Area	1 ) Product stocked in Cooling Tower Area 2) N/A	50 ppm (30 days of autonomy) to be confirmed
	Bio and Oil dispersant (to be confirmed)	Proprietary product used for cooling tower circuit dosing Turbodispin D83 or equivalent	Solution			1 m <sup>3</sup> 2 m <sup>3</sup>	1) Cooling Tower Area 2) Chemical Storage area	1 ) 12% stocked in Cooling Tower Area 2) Chemical Storage area	10 ppm (shock treatment)
	Sulphuric acid H <sub>2</sub> SO <sub>4</sub> 98% or HCL 33%	Concentrated sulphuric acid used for waste water treatment plant	Solution			10 m <sup>3</sup>		Waste water treatment Plant	
	Caustic soda NaOH 48%	Concentrated caustic soda used for waste water treatment plant	Solution			10 m <sup>3</sup>		Waste water treatment Plant	
	Ferric chloride FeCl <sub>3</sub>	Ferric chloride used for waste water treatment plant	Solution			1 m <sup>3</sup>		Waste Water Treatment Plant	
	Polyelectrolyte	Polyelectrolyte used for waste water treatment plant	Solution			1 m <sup>3</sup>		Waste Water Treatment Plant	
	Heavy metal precipitation aid (e.g. TMT15 or sodium sulphite)	Heavy metal precipitation aid used for waste water treatment plant	Solution			1 m <sup>3</sup>		Waste Water Treatment Plant	
	Source of Carbon for biological treatment	To be defined according biological treatment. Could be Methanol or equivalent.	Solution / powder			30 m <sup>3</sup>		Waste Water Treatment Plant	
	Calcium hydroxide Ca(OH) <sub>2</sub>	Calcium hydroxide used for waste water treatment plant	Solid			Silo 50 m <sup>3</sup> prep 3 m <sup>3</sup>		Waste Water Treatment Plant	
	Tri Sodium phosphate	Solid crystals of sodium phosphate used for CCW pH adjustment (can be replaced by Proprietary closed cooling circuit additives	Solution / powder			- 500 kg	B63 Chemical Storage area	No chemical stored in B63 Turbine Hall except the chemicals in use	No consumption of the closed circuit is tight
	Ammonia 25%	Aqueous ammonia solution for water-steam cycle dosing	Solution			2 m <sup>3</sup> diluted to 1-3% 2 m <sup>3</sup> stored as 25%	B63 Chemical Storage area	No chemical stored in B63 Turbine Hall except the chemicals in use	30kg of ammonia 25%/month
	Oxygen O <sub>2</sub>	Oxygen bottles used for water-steam cycle dosing	Gas			24 x 50 l, 200 bar	B63	No chemical stored in B63 Turbine Hall except the chemicals in use	160 kg/month
	Carbon dioxide CO <sub>2</sub>	Carbon dioxide used for generator hydrogen purging	Liquid			20 x 50 l, 60 bar	B89		later
	Hydrogen H <sub>2</sub>	Hydrogen used for generator cooling circuit	Gas			100 x 50 l, 200 bar	B89		later
	Nitrogen	Nitrogen used for water-steam cycle inerting	Gas			80 x 50 l, 200 bar	B63		later
	Tri Sodium phosphate	Solid crystals of sodium phosphate used for auxiliary boiler pH adjustment	Solid			50 kg 500 kg (to be confirmed)	G17 Auxiliary boiler	No chemical stored in G17 Turbine Hall except the chemicals in use	to be defined
	Oxygen Scavenger	Aqueous Hydrazine (or Carbo-Hydrazide) solution used for auxiliary boiler pH adjustment	Solution			2-10 m <sup>3</sup> (to be confirmed) will depend if delivered as ready to use	G17 Auxiliary boiler	No chemical stored in G17 Turbine Hall except the chemicals in use	to be defined
	Ammonia 25%	Aqueous ammonia solution used for auxiliary boiler pH adjustment	Solution			2 m <sup>3</sup> diluted to 1-3% 2 m <sup>3</sup> stored as 25%	G17 Auxiliary boiler	No chemical stored in G17 Turbine Hall except the chemicals in use	to be defined

## 3 Transport Utility Summary

### 3.1 Potable Water

Since the Barmston Pumping Facility is normally unmanned, potable water will only be required during occasional visits for sanitary and equipment cleaning purposes. Supply of potable water would be provided from the local water supply. Potable water demand is sized using the following basis and assumptions:

- 20 people at site (max);
- 300 l/day/person (considered a conservative maximum);
- 1 day at site; and
- Nominal equipment cleaning consumption of 2 m<sup>3</sup>.

This yields a total volume of 8 m<sup>3</sup> per visit.

### 3.2 Electrical Supply

Power would be required to operate major equipment within the transport system such as the:

- CO<sub>2</sub> Booster Pumps (first load and future);
- Air Cooler Fans;
- Compressed Air and Dryer package; and
- Metering and Analysis package.

In addition, power is required for the support and control systems such as (but not limited to):

- buildings;
- Integrated Control and Shutdown System (ICSS) via the uninterruptable power supply (UPS) system;
- telecommunications; and
- motor operated valves.

At the Barmston Pumping Facility a dual circuit 66 kV power supply, connected to the Driffeld to Marton Gate T1 circuit, and transported by underground cable, would be provided. The pumping facility electrical scope will terminate at the supply point prior to the disconnect on the customer's side of the circuit breaker. The voltage would be stepped down to 6.6 kV and 400 V using transformers at the Barmston Pumping Facility. Equipment would be operated from either the 6.6 kV (CO<sub>2</sub> Booster Pumps) switchboard or 400 V switchboard (all other equipment).

Drax, Camblesforth, Tollingham, Dalton and Skerne AGIs would operate from 400V switchboards. The main power consumers are detailed below.

**Table 3.1: Main Power Consumers**

Equipment Description - Consumer	Power Demand (kW)	Intermittent/ Continuous
CO <sub>2</sub> Booster Pumps	1,200 (each) (Note 5)	Continuous
Future CO <sub>2</sub> Booster Pumps (Year 5)(Note 1)	1,200 (each) (Note 5)	Continuous
Future CO <sub>2</sub> Booster Pumps (Year 10)(Note 1)	1,200 (each) (Note 5)	Continuous

Equipment Description - Consumer	Power Demand (kW)	Intermittent/ Continuous
Compressor & Dryer Package	15.3 (Note 5)	Continuous
CO <sub>2</sub> Booster Pump Recycle Cooler	15.3 (Note 2) (Note 5)	Intermittent
Metering & Analysis Package	10	Continuous
Motor Operated Valves	6.8 (each) (Note 3)	Intermittent
ICSS (Barmston)	13	Continuous
Buildings (Barmston)	179 (Note 4)	Continuous

Notes on Table 3.1 above:

- (1) Future Demand;
- (2) Power provided per fan. There would be three fans in total;
- (3) Motor Operated Valves would be provided at the following locations:
  - Camblesforth (3 valves) and Barmston (11 + 2 future valves);
- (4) A nominal 2.5kW demand has been specified for buildings located at Drax, Camblesforth, Tollingham, Dalton and Skerne AGIs;
- (5) Absorbed Power.

Back-up power to each site would be via a suitably sized UPS system (battery with supply for 8 hrs).

Electrical power for C&I equipment is derived from the external electrical (mains) supply and provided to the C&I equipment via the UPS systems (includes battery charger systems). All UPS systems are sized to provide a minimum of 8 hours of operation of C&I equipment following a loss of external electrical (mains) power. The UPS system would permit the use of the telecommunication system and ICSS.

Valves at the block valve stations and the isolation valves at Drax and Camblesforth would be operated by electro-hydraulic actuators; on loss of electrical supply, the accumulator should still be capable of performing a minimum of two sequential operations.

A cathodic protection transformer/rectifier would be provided at each site.

### 3.3 Temporary Utilities / Auxiliary Utilities

Space would be provided at the Barmston Pumping Facility and other AGIs for site nitrogen quads/cylinders to permit purging of equipment during maintenance activities; temporary hoses would be connected to the systems that require intervention.

Lube-oil for the CO<sub>2</sub> booster pumps would be provided on the same skid as the pumps, however the pump seal system top-up oil would be provided on a separate skid located between the two pump houses. The pump Seal System Top-up Skid would serve four CO<sub>2</sub> booster pumps, a future skid would be provided later for the four future CO<sub>2</sub> booster pumps.



## 4 Transport Utility Summary

### 4.1 Seawater

Seawater is pumped from the Seawater Lift Pumps to the Seawater Lift Pumps Filter. The filtered seawater is then routed to the following users:

- seawater to the temporary water wash skid;
- platform utility water; and
- cooling water for the Future CO<sub>2</sub> Booster Pumps Recycle Cooler.

The table below details the seawater users, with respective consumption figures:

**Table 4.1: Seawater Consumption**

Equipment Description -Consumer	Seawater Flowrate (m <sup>3</sup> /hr)	Temp in (C)	Temp out (°C)	Intermittent/Continuous
Temporary Water Wash Package	41.7 (note 1)	4 – 19	-	Intermittent
Future CO <sub>2</sub> Booster Pumps Recycle Cooler (note 2)	447 (note 3)	4 – 19	27	Intermittent
Platform utility water (note 5)	NNF (Note 4)	4 – 19	-	Intermittent

for a duration of 7 days per year per well;

Notes on Table 4.1 above:

- (1) Water wash injection is used to avoid halite build up when CO<sub>2</sub> injection is shut in. The injection rate is 1000m<sup>3</sup>/day (41.7m<sup>3</sup>/hr) for a duration of 7 days per year per well;
- (2) Future demand – equipment is not required at first load flowrate;
- (3) Pump proving facilities upon start-up (for commissioning/proving purposes) of a Future CO<sub>2</sub> Booster Pump.
- (4) NNF = Normally No Flow;
- (5) Allowance included in the seawater lift pumps design for utility station use concurrent with wash water activities.

### 4.2 Monoethylene Glycol (MEG) Storage and Injection

MEG would be injected before the initial start-up and before/after water wash injection to prevent hydrate formation in the well tubing should cold CO<sub>2</sub> contact directly with formation water or seawater from the water wash. MEG at a concentration of 57% by weight is required to prevent hydrate formation in the CO<sub>2</sub> injection wells during wash water activities.

MEG at a concentration of 90% by weight would be loaded to the MEG Storage Tank from supply boats. The MEG Storage Tank would have a capacity which is sufficient to inject MEG for maintenance of a single platform well; this would consist of the displacement of the entire well twice before and after water wash injection. Equipment details are provided in the table below.

**Table 4.2: MEG Storage Tank equipment details**

Equipment Description	Capacity (m <sup>3</sup> )	Design Conditions		Operating Conditions	
		Pressure (barg)	Temp (C)	Pressure (barg)	Temp (C)
MEG Storage Tank	45 (note 3)	0.07 + LH (note 1))	-10/50	ATM + LH (notes 1 & 2)	-3/20

Notes on Table 4.2 above:

- (1) LH = liquid head (Designed completely full of MEG);
- (2) ATM = atmospheric pressure; and
- (3) working capacity of 33m<sup>3</sup>.

### 4.3 Diesel System

Diesel would be supplied by boat and loaded into the Crane Pedestal Diesel Storage Tank before being pumped to the Diesel Service Tank, which supplies the diesel engines for power generation. Diesel would also be used for the platform crane, water wash facilities and lifeboat (TEMPSC). The subsections following provide equipment details.

The diesel generator packages (100 kW) would be configured as a set of each capable of providing 50% of the operational load (3 x 50%) and operate with one duty (approximately 34% load) and two spare during unmanned periods and two duty (approximately 67% load) and one spare during manned operations. The total diesel consumption figures are provided in the table below.

**Table 4.3: Diesel Consumption**

Equipment Description - Consumer	Manned Consumption (l/hr)	Unmanned Consumption (l/hr)	Intermittent/Continuous
Diesel Generator Package	40.58	11.96	Continuous
Temporary Water Wash Package	NNF (Notes 1 & 2)	-	Intermittent
Platform Crane	NNF (Note 1)	-	Intermittent
TEMPSC	NNF (Notes 1 & 3)	-	Intermittent

Notes on Table 4.3 above:

- (1) NNF = Normally No Flow;
- (2) Water Wash Package contains integral diesel storage system, for power generation purposes. Diesel would be supplied to the temporary wash water skid for filling purposes only;
- (3) Containers filled using platform crane filling point and used to refuel the TEMPSC.

### 4.4 Nitrogen

The Nitrogen Package would consist of a 16 cylinder quad loaded onto the platform laydown. The nitrogen required is during CO<sub>2</sub> injection wells water wash activities and start-up activities. The quantity of nitrogen required is based on raising the tubing head pressure to 40barg after well water wash activities. A pressure of 40barg is required to limit the temperature drop across the choke valve following restart to limit

the formation of hydrates. A nitrogen mass of 186kg is required to pressure the well to 40 barg. A 16 cylinder quad provides sufficient nitrogen to create the gas cap for two wells once or one well twice.

The nitrogen would also be used during commissioning and for maintenance purposes. No flow from utility connections would be expected during normal operation.

#### 4.5 Temporary Water Wash Package

Water wash injection would be used to avoid halite build-up when CO<sub>2</sub> injection is shut in. The injection rate would be 1,000 m<sup>3</sup>/day for a duration of 7 days per year per well. The coarse filtered sea water from the Seawater Lift Pumps would be filtered, chemically treated and pumped in the temporary Water Wash Package prior to injection into the wells.

The skid mounted package would be lifted to a laydown area by crane. The package would include:

- cartridge filter;
- cartridge fine filter;
- chemical injection package including storage and pumps for oxygen scavenger, biocide, scale inhibitor and corrosion inhibitor;
- wash water service tank; and
- water injection two full duty pumps (2 x 100%) and integral diesel power generation (tank and diesel engine).

The table below provides the individual equipment design and operating conditions within the package.

**Table 4.4: Temporary Water Wash Package equipment details**

Equipment Description	Capacity (m <sup>3</sup> /hr)	Power Consumption (kW)	Design Conditions		Operating Conditions	
			Pressure (barg)	Temp (C)	Pressure (barg)	Temp (C)
Wash Water Cartridge Filter	46	-	15	-10/50	5 - 7	4/17
Wash Water Cartridge Fine Filter	46	-	15	-10/50	5 - 7	4/17
Wash Water Chemical Injection Package	46	-	5	-10/50	0	-3/20
Wash Water Injection Pump	46	147 (Note 3)	100	-10/50	0 – 83	4/17
Injection Pump Diesel Engine	-	-	-	-	-	-
Wash Water Service Tank	(Note 4)	-	0.07+LH (Note 1)	-10/50	ATM+LH (Notes 1 & 2)	4/17

**Notes:**

(1) LH = Liquid Head (designed full of water);

(2) ATM = Atmospheric pressure;

(3) Wash water pumps have a stand-alone diesel system for power generation. Diesel is supplied to the skid edge;

(4) Wash Water Service Tank has a capacity of 16m<sup>3</sup>.

#### 4.6 Biofouling Control Package

The Biofouling Package would prevent fouling due to marine growth in the following equipment:

- Sea Water Lift Caissons;
- Sea Water Lift Pumps; and
- Produced Water Caisson.

The package would consist of a control panel that feeds an electrical current to copper and aluminium anodes housed within steel frameworks located in each of the caissons (below the pumps if applicable) resulting in the production of copper ions (which are a deterrent for marine growth). The level of copper dosing would be adjusted by regulating the current. At times when the seawater lift pumps would not be running a reduced current would be supplied to prevent fouling over time in the caisson and pump. Typically, the package would have power consumption less than 1kW.

#### 4.7 Fresh Water and Potable Water

Since the facility would be normally unattended, fresh water will be supplied by tote tanks as required. The quantity of tote tanks to be provided per visit is based on the following sizing basis:

- 12 max POB;
- 300 l/day/person; and
- Water requirement to meet the daily demands of the personnel forced to stay overnight for one night.

This yields a maximum daily consumption of 3.6 m<sup>3</sup>. A supply line from the tote tank would have electrical trace heating to prevent freezing during low ambient conditions. Drinking water would be brought on-board in bottles by the visiting crew.

#### 4.8 Chemical Injection (Corrosion Inhibitor)

Depending on the well materials selection, provision for permanent corrosion inhibitor injection facilities may be required, particularly at the base of the well where CO<sub>2</sub> contacts saline water until the saline water near the wellbore region is displaced. The corrosion inhibitor would be brought to the platform in tote tanks, which will be placed at the weather deck. Injection pumps would increase the pressure sufficiently to inject into the wellheads upstream of the choke valves. Two corrosion inhibitor manifolds are envisaged, one for the platform CO<sub>2</sub> injection wellheads and one for the future subsea CO<sub>2</sub> injection well.

#### 4.9 Wellhead Hydraulic Power Unit

The Wellhead Hydraulic Power Unit (HPU) would supply hydraulic power to the topsides well valves and the riser valves. The HPU covers the maximum number of six platform wells. The system would be configured with two high pressure (HP) pumps and two low pressure (LP) pumps in an auto/standby arrangement.

The high pressure system would supply hydraulic power to the three initial wellhead Subsurface Safety Valves (SSSVs) and the three future wellhead SSSVs and also the hydraulic power for actuated topside Emergency Shutdown Valves (ESDVs).

The low pressure system would supply hydraulic power to operate the Wing Valves (WVs) and Upper Master Valves (UMVs) and three future wellhead wing and master valves. In addition the LP system services various topside valves.

### 4.10 Electrical

#### 4.10.1 Low Voltage Supply

All equipment at the Offshore Storage Facility would have low voltage power supply (typically 400 V 3-phase and neutral 50 Hz from diesel generators) until the storage capacity is reached at the first NUI location. In year 10, CO<sub>2</sub> will be transported onwards via the hub platform to other CO<sub>2</sub> storage sites or EOR sites, which will require the use of Future CO<sub>2</sub> Booster Pumps.

#### 4.10.2 High Voltage Supply

Future CO<sub>2</sub> Booster Pumps would have a power requirement of 4,000 kW each and will be powered by a high voltage (HV) electric subsea cable or cables from shore.

Due to future CO<sub>2</sub> booster pumps being supplied with variable speed drive units (VSD), a harmonic filter/reactor may be required to compensate the subsea cable(s) capacitance. Power transformer(s) would be required on the platform to step down the HV subsea cable supply to a voltage suitable for the VSDs.

## 5 Glossary

Abbreviations	Meaning or Explanation
<b>AG</b>	above ground
<b>AGI</b>	Above Ground Installations
<b>Ar</b>	Argon
<b>ASU</b>	Air Separation Unit
<b>ATM</b>	Atmospheric Pressure
<b>BAC</b>	Boosted Air Compressor
<b>bara</b>	Bar absolute
<b>barg</b>	Bar gauge
<b>BFD</b>	Block Flow Diagram
<b>CCS</b>	Carbon Capture and Storage
<b>CCW</b>	Closed Circuit Cooling Water
<b>CO<sub>2</sub></b>	Carbon Dioxide
<b>CS</b>	Carbon Steel
<b>Cr</b>	Chromium
<b>CPL</b>	Capture Power Limited
<b>DECC</b>	The UK Government's Department of Energy and Climate Change
<b>Dense Phase</b>	Fluid state that has a viscosity close to a gas while having a density closer to a liquid. Achieved by maintaining the temperature of a gas within a particular range and compressing it above its critical pressure.
<b>ESDV</b>	Emergency Shutdown Valve
<b>ESP</b>	Electrostatic Precipitator
<b>FEED</b>	Front End Engineering Design
<b>FGD</b>	Flue Gas Desulphurisation
<b>GAN</b>	Gaseous Nitrogen
<b>GAP</b>	Gaseous Air (Pressurised)
<b>GE</b>	General Electric
<b>GOX</b>	Gaseous Oxygen
<b>GPU</b>	Gas Processing Unit – processes the flue gases to provide the dense phase carbon dioxide
<b>HP</b>	High Pressure
<b>H<sub>2</sub>O</b>	Water
<b>ICSS</b>	Integrated Control and Shutdown System
<b>ID</b>	Induced Draft
<b>IP</b>	Intermediate Pressure
<b>kg/h</b>	Kilogrammes per hour
<b>kg/m<sup>3</sup></b>	Kilogrammes per cubic meter
<b>kg/s</b>	Kilogrammes per second
<b>KKD</b>	Key Knowledge Deliverable
<b>LFO</b>	Light Fuel Oil
<b>LH</b>	Liquid Head

Abbreviations	Meaning or Explanation
<b>LIN</b>	Liquid Nitrogen
<b>LOX</b>	Liquid Oxygen
<b>LP</b>	Low Pressure
<b>m</b>	Meter
<b>m<sup>3</sup></b>	Cubic meter
<b>MAC</b>	Main Air Compressor
<b>MCW</b>	Main Cooling Water
<b>MEG</b>	Monoethylene Glycol
<b>MP</b>	Medium Pressure
<b>NaOH</b>	Sodium Hydroxide
<b>NC</b>	Normally Closed
<b>NGC</b>	National Grid Carbon Limited
<b>NH<sub>3</sub></b>	Ammonia
<b>NNF</b>	Normally No Flow
<b>N<sub>2</sub></b>	Nitrogen
<b>OPP</b>	Oxy Power Plant
<b>O<sub>2</sub></b>	Oxygen
<b>PFD</b>	Process Flow Diagram
<b>PIG</b>	Pipeline Inspection Gauge: a unit, which is inserted into the pipeline, to clean and/or monitor the inner bore surface of the pipe.
<b>SO<sub>3</sub></b>	Sulphur Trioxide
<b>SO<sub>x</sub></b>	Sulphur Oxides
<b>SSSV</b>	Subsurface Safety Valve
<b>TEMPSC</b>	Totally Enclosed Motor Propelled Survival Craft
<b>t/h</b>	Tonnes per hour
<b>T&amp;S</b>	Transportation and Storage
<b>UG</b>	Underground
<b>UPS</b>	Uninterruptable Power Supply
<b>VSD</b>	Variable Speed Drive
<b>WR</b>	White Rose
<b>WV</b>	Wing Valve
<b>UMV</b>	Unmanned Valve