Waste Gas Management Plan

RE-EPRA-WNA-WGMP-010

Revision 7

November 2022

WNA Permit Variation

APPROVAL LIST

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1. INTRODUCTION

Rathlin Energy (UK) Limited (Rathlin) is a private company with its head office in Beverley, East Riding of Yorkshire. Rathlin is a petroleum exploration, development and production company with operations in the United Kingdom. Rathlin is the operator of PEDL 183.

Rathlin have prepared an application to the Environment Agency seeking permission to undertake a number of permitted activities in accordance with the Environmental Permitting (England and Wales) Regulations 2016 (EPR2016).

The purpose of this document is to outline the waste gas management arrangements to be implemented at the West Newton A (WNA) Wellsite and demonstrate how Rathlin will manage waste gases associated within its operations.

Rathlin is the holder of a number of Environmental Permits issued by the Environment Agency in accordance with EPR2016. The current activities permitted at the WNA Wellsite permit Rathlin to undertake the following activities, as presented in Table 1.1.

Permit Number	Reference	Description
EPR/BB3001FT	A1	A mining waste operation for the management of extractive waste including gas from prospecting for mineral resources, not involving a waste facility.
	A2	The incineration of hazardous waste in a waste incineration plant or waste co-incineration plant with a capacity exceeding 10 tonnes per day.
	A3	Discharge of rainfall dependent surface water runoff.
	A4	The loading, unloading, handling or storage of, or the physical, chemical or thermal treatment of crude oil with a capacity of 500 tonnes.
EPR/PB3030DJ	SR2014 No4	To operate a standard facility described in standard rules SR2014 no 4: accumulation and disposal of radioactive waste from NORM industrial activity of the production of oil and gas.

Table 1.1: Current Permitted Activities

As the development continues to progress, additional permitted activities have been identified as being necessary. As a result, Rathlin have prepared an application to vary the environmental permits with the purpose of gaining permission to undertake the following activities:

- Further appraisal works and workover activities on the existing WNA-1 and WNA-2 wells for the purpose of gathering additional information over the extent of the hydrocarbon reservoir;
- Drilling of a sidetrack well from each of the existing wells, known as WNA-1z and WNA-2z;
- Drilling of up to six additional wells across the lifetime of the development known as WNA-3 to WNA-8, with a further sidetrack proposed for each well (WNA-3z - WNA-8z);
- The undertaking of well treatments and well clean-up activities for each additional well to be drilled, including sidetrack wells, such activities include acid washing and numerous lifting techniques as dictated by well conditions;
- Appraisal testing of each additional well, including sidetrack wells;
- Long term production of each well (WNA-1 - WNA-8). Including the conducting of routine maintenance, workovers and sidetracks as determined by Rathlin; and
- Well plugging and decommissioning following the cessation of production operations.

2. Scope

This Waste Gas Management Plan is applicable to the WNA Wellsite and all operations permitted therein. It is applicable to Rathlin, its contractors and subcontractors and can be used in support of applications to the Environment Agency under EPR2016.

3. Definitions

"	Inch
BAT	Best Available Technique
CO_2	Carbon Dioxide
CapEx	Capital Expenditure
EPR2016	Environmental Permitting (England and Wales) Regulations 2016
EWC	European Waste Catalogue
EWT	Extended Well Test
HDPE	High Density Polyethylene
Km	Kilometre
m	Metre
M^3	Metres Cubed
MCP	Medium Combustion Plant
MCPSG	Medium Combustion Plant & Specified Generator
MD KB	Measured Depth below Kelly Bushing
mm	Millimetre
MOT	Ministry of Transport
MW	Megawatt
NORM	Naturally Occurring Radioactive Material
OpEx	Operating Expenditure
PDC	Pollution Damage Cost
PEDL	Petroleum Exploration and Development Licence
PSE	Point Source Emission
PVT	Pressure Volume Temperature
RPS	Radiation Protection Supervisor
RWA	Radioactive Waste Advisor
SG	Specified Generator
TVD KB	True Vertical Depth below Kelly Bushing
WCU	Well Clean Up
WNA	West Newton A
WR11	Water Resources Form 11

Table 3.1: Definitions

4. Description of the Facility

4.1 Development Location

The proposed development is being undertaken at the following location:

West Newton A Wellsite
Rathlin Energy (UK) Limited
Fosham Road
Marton
Hull
HU11 5DA

National Grid Ref: TA 19268 39131

Site Area: 3.46 hectares

A Site Location Plan has been provided within Site Plans Document (RE-EPRA-WNA-SP-004) and Appendix 1 of the Site Condition Report.

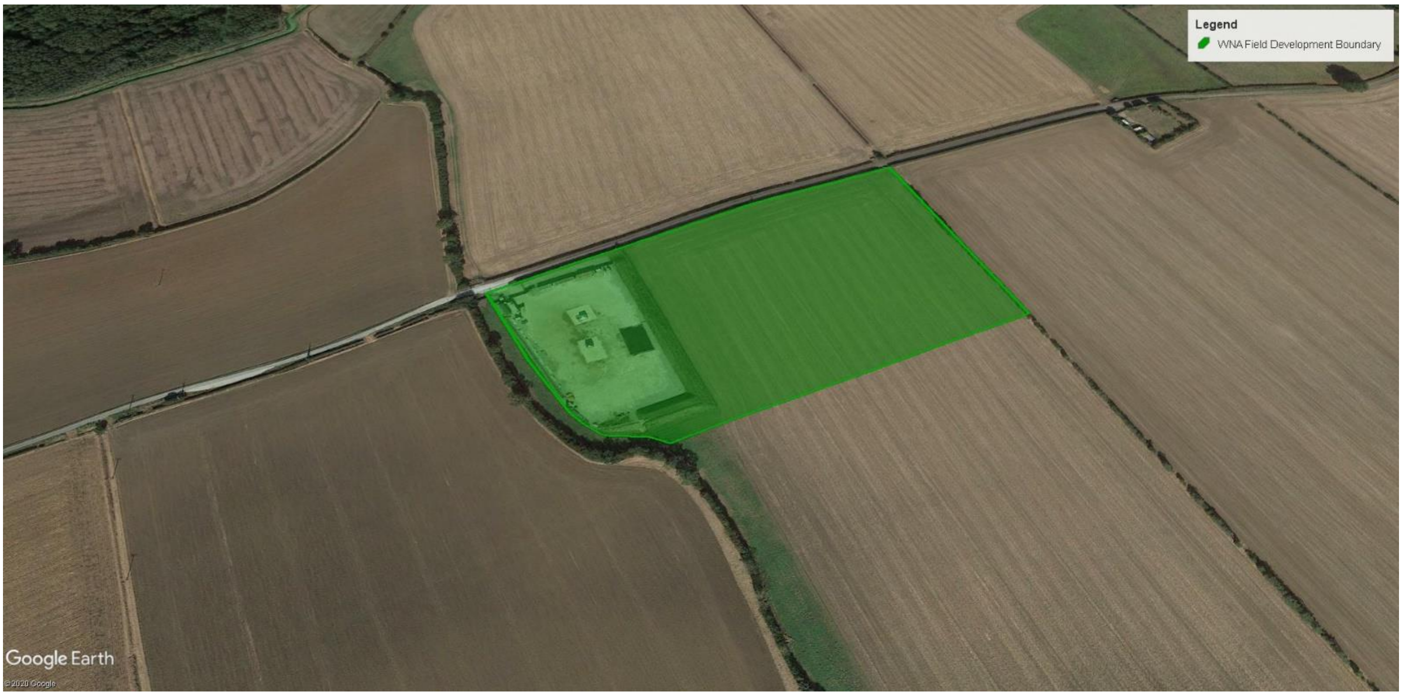

Figure 4.1: West Newton A Wellsite Location (Source: Google Earth August 2020)

4.2 Site Description and Current Status

The site is located to the north of West Newton and east of Marton. It is located within the parish of Aldbrough, in the East Riding of Yorkshire.

The surrounding landscape consists of flat open fields that are interspersed with patches of woodland and divided by hedgerows and ditches. An area of semi-improved grassland lies adjacent to the western boundary and extends 10m into the field. There are a number of mature hedgerows that border the field.

The nearest conurbations are West Newton, circa 1,130m to the south and Marton, circa 800m to the west.

A desktop study was undertaken to identify any designated sites which may be affected by the proposals. The results of the desktop survey using the Multi-Agency Geographic Information for the Countryside (MAGIC) interactive mapping tool have been provided within Table 5.1.

Designated Site	Search Radius[1]	Name	Location from Site[2]
RAMSAR	10km	-	-
Special Area of Conservation	10km	-	-
Special Protection Areas	10km	Hornsea Mere	6.93km North
Marine Protection Areas	10km	Greater Wash	5.44km Northeast
Sites of Special Scientific Interest	2km	Lambwath Meadows	0.79km Northeast
Schedule Ancient Monuments	2km	Burton Constable Medieval Settlement[3]	1.93 South
National Nature Reserve	2km	-	-
Local Nature Reserve	2km	-	-
Local Wildlife Site	2km	The Moors Burton Constable	0.87km South
		Wycliffe North Plantation	0.92km Southwest
		Mill Avenue Burton Constable	1.23km South
		Burton Constable Parkland	1.77km South

Table 4.1: MAGIC Desktop Study Results

[1] Search Radius derived from Environment Agency Guidance: Annex A – Opra Scheme for Installations.
[2] Location from new site boundary.
[3] Burton Constable medieval settlement and field system, north of Burton Constable Hall

5. WASTE GAS MANAGEMENT PLAN

5.1 Objectives of the Waste Gas Management Plan

The objective of this Waste Gas Management Plan is to ensure that any waste gas that arises as part of the proposed development is managed in such a way so as to reduce the quantities of gas emitted to air and minimise environmental impacts so far as available techniques allow.

This objective will be achieved by:

- Identifying Waste Gas Streams;
- Undertaking an initial screening process to remove unavailable or unsuitable techniques;
- Establishing BAT to manage identified Waste Gas Streams for each phase.
- Identifying the specific technologies that meet BAT which are expected to be used.
- Reviewing the Waste Gas Management Plan and revise where necessary and as new technology becomes available.

5.2 Distribution of the Waste Gas Management Plan

Rathlin will communicate the Waste Gas Management Plan to the Wellsite (or Production) Supervisor, with a copy available within the wellsite office. It will be issued as an electronic version or paper copy with a copy of the receipt or transmittal recorded by Rathlin.

Key operational requirements will be communicated to relevant personnel who will have responsibility to comply with the waste gas management plan. Once contractors have been selected the key information will be communicated as part of site briefings or induction.

5.3 Alterations to the Waste Gas Management Plan

Any required changes or deviations from this Waste Gas Management Plan are to be referred to Rathlin or to the Wellsite Supervisor in the first instance. No changes to, or deviations from, this Waste Gas Management Plan are to be implemented until the required changes or deviations have been reviewed and approved by Rathlin. Alterations to the plan will be submitted to the Environment Agency for approval; however, alterations may be implemented as an immediate control measure to resolve an identified problem prior to notification to the Environment Agency.

5.4 Changes to Operations, Processes or Equipment

In the event that there are significant or material changes to operations, processes or equipment during the operations, Rathlin will review the Waste Gas Management Plan. Rathlin will communicate a copy of any revised Waste Gas Management Plan to the Wellsite Supervisor and forward a copy to the Environment Agency.

6. ESTABLISHING BEST AVAILABLE TECHNIQUE

BAT is defined within the Industrial Emissions Directive (2010/75/EU) as *'the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole:*

(a) 'techniques' includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned;

(b) 'available techniques' means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator;

(c) 'best' means most effective in achieving a high general level of protection of the environment as a whole;

6.1 Proposed Operations and the Identification of Waste Gas Streams

Within the onshore oil and gas industry there are a number of activities that produce natural gas which requires management. For the proposed West Newton A operations, the long term production of natural gas will be the main source of gas production, however the wellsite shall also be the subject of isolated periods of Well Clean Up (WCU) and Extended Well Testing (EWT) operations on each additional hydrocarbon well drilled from the site.

The maximum quantity of natural gas that can be produced as a result of the WCU and EWT is 330mmscf. A review of the proposed operations has confirmed the source of each natural gas and has referenced them as Point Source Emissions (PSE).

Activity	Unit	PSE	EWC	Total Quantity	
				MMSCF	Tonnes[4]
Well Testing (Gas Incineration)	As Determined by BAT	PSE-01	16 05 04*	330	6,541
Oil Storage & Transfer	Storage Tank(s)	PSE-02	-	Residual Volumes	
Produced Water Tank	Storage Tank(s)	PSE-03	-	Residual Volumes	
Electricity Production	As Determined by BAT	PSE-04	-	99,864	2,544,867.6

Table 6.1: Identification of Waste Gas Streams

A Site Location Plan has been provided Appendix 1 containing the location of the PSE.

6.2 Initial Screening of BAT

The Environment Agency have identified a '*long list of technologies*' within report: **SC170013/R** (the report) which have been summarised below.

- Cold Venting
- Flaring
- Heat Generation
- Power Generation
- Well Reinjection
- Recycling Through to Gas Processing
- Mini Liquefied Natural Gas
- Conversion to Fuels
- Vapour Recovery
- Gas Processing and Natural Gas Liquids Recovery
- Compressed Natural Gas
- Energy Storage

The long list was then screened against the definition of BAT within the report with a number of technologies not currently considered BAT at the time of writing this report. For clarity, BAT as a concept will continue to change as technologies improve or become increasingly available for use within the onshore oil and gas industry.

Table 6.2 provides a list of technologies that have been identified with the potential of being considered BAT for the onshore oil and gas industry. This WGMP has been produced to assess the techniques considered 'best available' for

[4] Tonnes derived natural gas conversion conditions of 0.7 specific gravity, 273.15K & 101.325 kPa at 0^{oC}

well testing (WCU and EWT) and production. As the development progresses, the selected BAT may no longer be considered 'best available' due to either advancement in technologies or changes in the volume of gas produced.

To summarise, where a technology/technique has not been considered suitable for the onshore oil and gas industry this is due to one or more of the following reasons:

- The technology was not readily available for supply in England - due to economics or the lack of supplier base;
- The technology was considered unproven or novel;
- There was no widespread market for the product or resource produced; and/or
- The working capacity and specifications of the technology did not match the onshore oil and gas sector requirements.

Techniques for BAT Assessment					
Option	**Technology / Process**	**WCU**	**EWT**	**PROD**	**Reason for Considering / Not Considering**
Cold Venting	Direct Release to atmosphere	×	×	×	Worst environmental impact with Methane being 28 times greater in global warming potential. Potential use during very short term low flow.
Incineration	Elevated Flares	✓	×	×	Produces a visible flame and excessive noise. May be suitable for sour gas or WCU given its ability to incinerate across a wide range of flow.
	Shrouded Flare	✓	✓	✓	Considered to have a reduced combustion efficiency but able to accommodate variable and unpredictable flow (associated gas).
	Enclosed Flare / Incinerator	✓	✓	✓	Provides the best combustion efficiency and reduced noise and visible flame, but can only operate within a defined range of flow specification.
Heat Generation	Incinerators / Boilers	×	×	✓	No demand for heat, steam or hot water at site ordinarily, however some operators who produce oil will use bath heaters to heat wellbore fluids to ensure good separation. Natural gas may be used to fuel bath heaters but only if the gas volumes and composition allow.
Power Generation	Spark Engines	×	×	✓	Well understood technology and available to rent/buy in the UK. May need to be used in combination with a flare system. Gas may be used to fuel the generators but only after a significant understanding of gas rate and PVT has been established. Small scale spark engines are available.
	Gas Turbines	×	×	✓	Well understood technology and available to rent/buy in the UK. May need to be used in combination with a flare system. Gas can be used to fuel the turbine but only after a significant understanding of gas rate and PVT has been established. Gas volume may hinder their use.
	ORC (heat recovery)	×	×	×	Not available to rent. Used in conjunction with gas turbine.
Well Reinjection	Enhanced Oil Recovery	×	×	×	Would only work for associated gas wells where conditions dictate. No permissions to re-inject in place.
Recycling Through to Gas Processing	Recycling of Waste Gases	×	×	×	Subject to limitations, only after a significant understanding of gas PVT has been established.
	Pipeline Export	×	×	✓	Only considered if pre-existing pipelines are present and available.
Mini Liquefied Natural Gas	Liquefaction of Natural Gas	×	×	×	Lack of equipment in the UK. So not considered available.
Conversion to Fuels	Natural Gas Liquid	×	×	×	Lack of equipment in the UK together with unproven technology.
	Hydrogen	×	×	×	Small scale hydrogen production is available but untested within the UK.
Vapour Recovery	Compression to CNG for collection or direct export.	×	×	×	Logistics and lack of equipment in the UK. So not considered available. Direct export only considered if pre-existing pipelines are present and available.
	Compression to CNG for export via a pipeline	×	×	×	Logistics and lack of equipment in the UK. So not considered available. Direct export only considered if pre-existing pipelines are present and available.
Gas Processing / Gas Liquids Recovery	Recovery of NGL from Natural Gas	×	×	×	Lack of equipment in the UK. So not considered available.
Compressed Natural Gas	Compression to CNG for collection or direct export.	×	×	×	Logistics and lack of equipment in the UK. So not considered available. Direct export only considered if pre-existing pipelines are present and available.
Energy Storage	Electricity - Battery Storage	×	×	×	Intermittent gas supply and supply unknown
	Thermal - Thermal Storage	×	×	×	Technology not yet available.

Table 6.2: Results of Initial BAT Screening

6.3 Short List of Technologies

The technologies which have been considered for a more detailed assessment to establish whether they can be considered BAT are outlined below within each subsection. For clarity this information has been sourced from the Environment Agency Report: **SC170013/R** and its suitability for the proposed operations.

In short, the hierarchy for management waste gas can be classified as follows:

- Harness natural gas for alternative use;
- Incineration of natural gas; and
- Cold venting of natural gas directly to atmosphere.

For clarity, this section evaluates whether the short list of activities identified below can be considered for the management of waste gas with regards to the development. For clarity this includes:

1. Waste gas associated with well testing operations; and
2. Waste gas associated with the Production operations.

6.3.1 Harness of Natural Gas for Alternative Use

The extent of the sub surface formation has not been fully appraised after the discovery of hydrocarbons during the exploration phase. Therefore, the assumptions on how to harness natural gas are multiple and will be refined as further appraisal data improves the understanding of natural gas production.

The preferred method for waste gas management is to harness the associated gas. This could be a number of options including installation of a pipeline or the use at the site to produce energy i.e. electrical/heat or transmitted offsite. This has many benefits including reducing the running cost of the site and reduces the carbon intensity by displacing diesel powered generators. Following the initial screening process, a number of options have been assessed further for the harnessing of associated gas.

6.3.1.1 Onsite Power Generation

It is the intention of Rathlin to produce oil with associated gas from the WNA Wellsite. As such there shall be a significant period of time in which associated natural gas may be produced. Given that the application is for production operations it is reasonable to assume that there may be scope to harness the natural gas to produce electricity for site use. The ability to harness the associated gas within the current operations is technically possible, however it is contingent on gas volumes.

The harnessing of natural gas for the purpose of providing electricity for internal use only has been considered further as part of the WNA production operations.

It is anticipated during the well testing phase that the associated natural gas will reach a steady state with regards to flowrates and pressures. During the initial part of the EWT it is unlikely that the harnessing of associated natural gas can be achieved. Representative samples of gas will need to be taken and analysed to determine the gas composition. With this in mind the use of a temporary ‘gas fuelled’ generator could be considered part way through the EWT, however by the time the relevant information has been obtained it is likely that the EWT will have been completed and therefore no longer required. It is not feasible at this stage to design or order appropriate generators due to having unknown/unreliable gas composition or PVT.

The harnessing of natural gas for the purpose of providing electricity for internal use only has not been considered further as part of the WNA well testing operations.

6.3.1.2 Power Export (Gas to Wire)

Having considered the potential to harness the gas for onsite power generation the next step is to consider whether there is the potential to export surplus electricity offsite. Interpretation of the information obtained from the current field data suggests that the gas volumes are likely to provide enough electricity to meet the demands of the site (site load) and therefore there is the potential to export electricity from the site.

The harnessing of natural gas for the purpose of providing electricity for export has been considered further as part of the WNA production operations.

For the reasons set out in section 6.3.1.1 the harnessing of natural gas for the purpose of providing electricity for export has not been considered further as part of the well testing phase, not least due to the short duration of the EWT and the infrastructure required to achieve this.

6.3.1.3 Gas Export (Gas to Grid)

The volume of associated gas anticipated during the production operations is expected to be below the volumes that would make commercial benefit for a grid entry and so unlikely to be feasible in the first instance. A proposal to export natural gas with the sites current arrangement is not considered possible as further assessment is required on the gas composition to demonstrate compliance with the Gas Safety (Management) Regulation 1996 and subsequent Safety Case for grid entry. Additional plant may also be required to introduce mercaptan to the gas so it becomes odorous and identifiable, depending on the receiving pipeline i.e. NTS or private. This would also create additional emission points. Depending on the composition of the gas and its pressure, further treatment packages e.g., compressor, dehydration, dual monitoring skids, may also be required to ensure it meets the minimum standard of the National Transmission System. Nevertheless, the technique will need to be considered further as the technology does exist and is available within the UK.

The harnessing of natural gas, specifically providing natural gas for export has been considered further as part of the WNA production operations.

6.3.1.4 Heat Generation

The WNA Wellsite will have a bath heater on location and installed as part of the well testing and production equipment. The purpose of the bath heater is to heat up the hydrocarbons and produced water to aid in the separation of each substance. The bath heater has yet to be selected however it is common for them to be fuelled by diesel, natural gas, or electricity.

The harnessing of natural gas as a fuel for the bath heater has not been considered further as part of the WNA well testing operations. A suitable diesel or electrical unit shall be used, if required, for the well testing phase.

During production operations natural gas volumes may be sufficient to meet the required input parameters of the bath heater. Although the initial cost would be significant in this instance Rathlin acknowledge that the initial cost may be offset by the saving in fuel throughout the lifetime of the production site.

The harnessing of natural gas, specifically using gas as a fuel within the bath heater has been considered further as part of the production operations, however any such bath heater shall be fuelled by either natural gas or electricity, either of which shall be sourced directly from the site during the production operations. As such the use of a bath heater shall now be considered further as part of the production operations.

6.3.2 Incineration of Natural Gas

Hydrocarbon gases, such as methane (CH_4), have a Global Warming Potential (GWP) twenty-eight (28) times greater than Carbon Dioxide (CO_2e), based on a 100-year time horizon, therefore, venting of unburnt hydrocarbons represents an increased environmental impact over incineration of natural gas. In addition, the venting of large volumes of hydrocarbons presents an increased risk of fire and/or explosion.

6.3.2.1 Enclosed Flares and Incinerators

Enclosed units, such as those used in landfill, are designed with either a single or multiple burner, to incinerate natural gas with lower methane contents, typically around 56% methane and 31% Carbon Dioxide (CO_2). However, their environmental performance is based on consistent pressures and flow rates. These flares are limited insofar as inlet pressure and flowrate capabilities, therefore, can only be used for oilfield purposes when there is significant confidence that any associated natural gas pressures and/or flow rate is low.

Whichever unit is selected needs to have the capability to operate as a gas management technique and also as a safety device, where flow rates may be very high in the first instance, before being reduced and the well(s) closed in.

Rathlin have identified an incinerator (suite of incinerators) as being a viable option during the well testing operations and production operations.

Although a lesser preferred option to that of harnessing waste gas, the incineration of natural gas is being considered further for both well testing and production operations.

6.3.2.2 Shrouded Flare

A shrouded flare, is essentially an open pipe flare, which is designed to incinerate natural gas with high methane content across a significantly variable range of flowrates and inlet pressures, such as those likely to be experienced during the initial phase of hydrocarbon exploration, such as WCU and EWT, where the gas composition, pressure and flow rates are unknown.

Whilst having a lower combustion efficiency due to not having multiple burners, a shrouded flare provides confidence of natural gas combustion across the significantly variable range of flowrates and inlet pressures. Historically, pre August 2013, open pipe flares have been used extensively onshore UK without significant impact or concern.

The shroud placed around the flare tip aids in the reduction of the environmental impact, with respect to noise and visual impact. The size of the shroud is largely dictated by transportation restrictions onshore UK. As stated in National Planning Policy Framework (NPPF), minerals, which includes oil and gas, 'can only be worked where they are found', often resulting in wellsites being located in areas with minimal and restrictive highway infrastructure.

A shrouded flare unit is being considered for use as part of the well clean-up operations, largely due to its design to accommodate a wide variance of flowrates and ensure high combustion efficiency across the expected range.

6.3.3 Cold Venting

Ordinarily, venting of natural gas is only considered in the event that low volumes of natural gas are anticipated and, evidence is available to demonstrate that the cost of installing a flare for this activity would be disproportionate to the environmental benefit and subject to the health and safety risks of cold venting having been deemed as being as Low as Reasonably Practicable (ALARP). When determining BAT for onshore oil and gas exploratory operations, the following points are considered with respect to cold venting:

- An increase in environmental impact;
- An increase of the risks associated with safety; and
- Minimal cost increase using a unit, which in turn reduces both environmental impact and safety risks.

Cold venting of waste gases can be considered in the event that the volume of waste gas is significantly low and the cost to install a unit is disproportionate to environmental benefit. This would be applicable to activities involving storage and transfer of crude oil where Volatile Organic Compounds (VOCs) may be emitted.

During periods of well testing, the atmospheric stock tanks will either be vented to air via a common vent header line, or individually. The stabilisation of crude oil would have the potential to emit VOC's, all tanks will be connected to a breather/vent line which would be flowed to a scrubber vessel / drum to remove VOC's contents. The flow from the storage tanks is expected to be minimal.

During production operations Rathlin are proposing to recover any vapour emitted from the stock tanks for use within the gas-fuelled electricity generator, removing unnecessary cold venting operations.

Venting is being considered in part for stock tank emissions. During well lifting there may be scenarios where short term cold venting takes place, though this is not the desired outcome, as propane shall be installed to raise the calorific value of the gas mix during well lifting, it may occur and is considered.

6.4 Initial Conclusion on Potential Techniques

Following an appraisal of each available technology initial conclusions have been made as to the BAT for the proposed WNA well testing and production operations. This is detailed within Table 6.4.

Option	Technology	Considered	Reason
Harness Gas	Onsite Power Generation	Yes	Waste gas from production operations is consistent enough to be used as a fuel for spark engines. Waste gas from EWT will however be too inconsistent and cannot be used until brought into production. The use of micro gas turbines has also been investigated but the input parameters again are not suitable with the gas production at the WNA wellsite. Only Spark ignition engines are being considered further.
	Gas to Wire	Yes	Waste gas from production operations is consistent enough to be used as a fuel for spark engines or gas turbines with the potential for the site to provide enough electricity to fully meet or exceed the site demand. Initially the option to export electricity may not be feasible. However additional production wells, subject to permit approval may be able to facilitate this approach.
	Gas to Grid	Yes	Waste gas from production operations may be suitable (subject to treatment) to be sent into the NTS. Though this will have significant cost to firstly treat the gas to raise it to NTS standards.
	Heat Generator	Yes	A bath heater may be in place at the site with the capability to run off either diesel, natural gas or electricity. It may be feasible to switch out the bath heater to a duel fuel system in the future but would depend on the costs incurred.
Incineration	Enclosed Flares & Incinerators	Yes	Enclosed flares and incinerators have the capability to incinerate gas over a wide flowrate range, including as a waste disposal and as a safety device. In addition, the unit identified for the EWT operations provides for excellent combustion efficiency and wide flow rate capabilities when used in sequence.
	Shrouded Flares	No	Having identified a suitable enclosed unit a shrouded flare is not considered necessary due to having a perceived reduced environmental performance.
Vent	-	Yes	For storage tank emissions (VOCs) venting can be considered due to minute volumes. Potential for cold venting during well clean up.

Table 6.4: Results of Initial Conclusions

6.5 Quantitative BAT Assessment

6.5.1 Well Clean Up and Extended Well Test

It is anticipated during the EWT phase that the associated natural gas will reach a steady state with regards to flowrates and pressures. During the initial part of the well testing, it is unlikely that the harnessing of associated natural gas can be achieved. Representative samples of gas will need to be taken and analysed to determine the gas composition. With this in mind the use of a temporary 'gas fuelled' generator could be considered part way through well testing, however by the time the relevant information has been obtained it is likely that the well testing phase will have been completed and therefore no longer required. Resulting in significant time and effort without any benefit. It is not feasible at this stage to design or order appropriate generators due to having unknown/unreliable gas composition or PVT.

To this end a quantitative BAT assessment has not been undertaken, as the only safe option is to incinerate the gas whereby the fluctuation in flowrates and composition can be safely managed. It is acknowledged that this perhaps is not the most environmentally beneficial, however the safe undertaking of the well test is paramount.

6.5.2 Production Operations

A Cost Benefit Analysis (CBA) has been prepared and has been provided within Appendix 3. The CBA has considered a base case (enclosed ground flare) against that of using gas powered generators to produce electricity for internal use and export, and against that of a gas to grid development. As the developments main commodity is oil, and the gas volumes at this stage considered variable and unpredictable, a low and high gas volume scenario has been presented within the CBA and can be summarised as follows.

High Gas Volume:

- Option 1A (incineration) has calculated a Net Present Value (NPV) of **-£21,586,343.53**. No benefit (income) was identified due to exportation of gas / electric not being considered.
- Option 2A (power export) has calculated an NPV of **£2,021,701.26**. The income from offsetting carbon emissions and producing electricity was considered, and provided a benefit outweighing overall cost.
- Option 3A (gas export) has calculated an NPV of **-£11,660,825.10**. the income from offsetting carbon emissions and producing and treating natural gas for export was considered, and provided a cost outweighing the overall benefit.

Low Gas Volume:

- Option 1B (incineration) has calculated a Net Present Value (NPV) of **-£14,154,076.91**. No benefit (income) was identified due to exportation of gas / electric not being considered.
- Option 2B (power export) has calculated an NPV of **£1,378,202.76**. The income from offsetting carbon emissions and producing electricity was considered, and provided a benefit outweighing overall cost.
- Option 3B (gas export) has calculated an NPV of **-£18,687,682.94**. the income from offsetting carbon emissions and producing and treating natural gas for export was considered, and provided a cost outweighing the overall benefit.

All figures presented above consider CapEx, OpEx and PDC throughout the 20-year production periods at the WNA Wellsite.

The CBA has determined that Option 2A/B - 'Harnessing of Natural Gas for Electricity Production is considered BAT based on quantitative assessment alone for the production operations.

6.6 Qualitative BAT Assessment

This section details the qualitative risk assessment that has been undertaken for assessing the impact each proposed option will pose. The methodology has been utilised from the Environment Agency Report **SC170013/R**.

6.6.1 Well Testing

It is anticipated during the WCU and EWT phase that the associated natural gas will reach a steady state with regards to flowrates and pressures. During the initial part of the well testing phase it is unlikely that the harnessing of associated natural gas can be achieved. Representative samples of gas will need to be taken and analysed to determine the gas composition. With this in mind the use of a temporary 'gas fuelled' generator could be considered part way through the well test, however by the time the relevant information has been obtained it is likely that the well test will have been completed and therefore no longer required, resulting in significant time and effort without any benefit. It is not feasible at this stage to design or order appropriate generators due to having unknown/unreliable gas composition or PVT.

To this end a qualitative BAT assessment has not been undertaken, as the only safe option is to incinerate the gas whereby the fluctuation in flowrates and composition can be safely managed. It is acknowledged that this perhaps is not the most environmentally beneficial, however the safe undertaking of the well test is paramount.

6.6.2 Production Operations

6.6.2.1 Considerations of the Assessment

The application site is approximately 3.46 hectares in size and comprises of a single site known as the WNA Wellsite. The site resides within the jurisdiction of East Riding of Yorkshire Council, the surrounding area is rural in nature with farmland being the predominant feature within the area. The village West Newton is located circa 1.11km south from the wellsite.

A 2km radius was established from the site and a study was taken to identify how many district wards were present within the 2km radius. The following wards were identified and were checked against data from the 2019 Office of National Statistics Estimates:

- Aldbrough Civil Parish (1,263);
- Burton Constable Civil Parish (229); and
- Withernwick Civil Parish (416)

Ellerby Civil Parish is also recognised as being within 2km of the wellsite boundary, however, the portion within 2km is without dwellings. Therefore, it has not been considered within the population estimates.

The population based on the surrounding wards is estimated to be 1,908. However, when viewing the number of dwellings within a 2km radius of the development the population is expected to be much lower as the village of Aldbrough is outside of the 2km boundary.

6.6.2.2 Assessment Matrices

The following matrices and calculation of magnitude of risk have been developed with consideration of the Environment Agency Report: **SC170013/R**. Rathlin has considered for the purpose of this qualitative assessment that a base case for the choice of technology used to manage the associated gas as being an enclosed flare, consistent with the Environment Agency's position.

The development is considered to fall within a general population of 1,001-10,000 based on a 2km radius from the wellsite. However, the actual number of people affected is expected to be much lower (<100), due to the distance of the site to the nearest receptors and the receptors benefitting from mature natural screening.

	Number of People Likely to be Affected				
	General Population				
Increase / Decrease of Risk / Benefit	1-10	11-100	101-1000	1001-10k	>10k
	Disadvantaged Groups				
	NA	NA	10-100	101-1000	>1000
Very Small (VS)	NC	VS	S	S	M
Small (S)	VS	S	S	M	M
Modest (M)	S	M	M	M	L
Large (L)	M	M	L	L	VL
Very Large (VL)	M	L	L	VL	VL

Table 6.4: Scale of Impact Matrix

Impact Criteria	Generator
Visual	NC
Noise	+S
Land Take	NC
Smoke / Efficiency	+S
Impact Criteria	**Turbine**
Visual	NC
Noise	+S
Land Take	NC
Smoke / Efficiency	+S

Table 6.5: Impact of Export

Having established that the impact on local receptors from smoke/noise from a generator or turbine unit as being a small positive, compared to that of an enclosed unit, the next phase is to establish the magnitude of the risk based on the longevity of the impact. The impact score within Table 6.6 is carried forward to Table 6.7 for this assessment.

	Scale of effect.				
	Impact Score				
Duration of effect	VS	S	M	L	VL
Few days / one-off event	VS	VS	VS	S	M
Weeks / Months / Repeated Event	VS	VS	S	M	L
Up to 1 year	VS	S	M	L	VL
1-3 Years	VS	S	M	L	VL
4-6 Years	VS	M	L	L	VL
More than 6 years	VS	M	L	VL	VL

Table 6.6: Magnitude of Risk Matrix

Magnitude Output	Score
Very Large Positive	+10
Large Positive	+8
Medium Positive	+6
Small Positive	+4
Very Small Positive	+2
Neutral	0
Very Small Negative	-2
Small Negative	-4
Medium Negative	-6
Large Negative	-8
Very Large Negative	-10

Table 6.7: Magnitude Score

Given the proposal is for a long term development in excess of 6 years, the final impact score for each risk/benefit is a 'medium positive'.

Impact Criteria	Enclosed Unit	Generator	Compression
Visual	0	0	0
Noise	0	+6	+6
Land Take	0	-6	-6
Smoke / Efficiency	0	+6	+6

Table 6.8: Result of Analysis

6.6.3 Results of the Qualitative Assessment

The results of the qualitative assessment have demonstrated that the impact of using a gas fuelled generators (spark engine) or gas compressors over an enclosed ground flare as provides a 'Medium Positive Impact' on two criteria. With a 'Medium Negative Impact' on a single criterion.

This assessment considered both the positive and negative impacts of choosing a generator or compressors over an enclosed unit. For each option there were two positive impacts which was the reduction in 'Noise' from the site, and a reduction in visible smoke and emissions.

Visually it is unlikely that any receptors will be impacted by the appearance of a generator or compressor due to the height of the units, and the distance of the nearest receptors. However, as an incineration unit will be present at the site regardless to perform a safety function, the use of a generator or compressor will not remove the incineration unit from the site, as such the visual impact does not change.

Due to an incineration unit being present at the site as a safety device regardless, additional land will need to be considered for the placement of generators and compressors, resulting in a 'Medium Negative Impact'.

The result of the qualitative assessment demonstrates that the use of either gas fuelled generators or gas compressors should be used ahead of the incineration unit, as either option would result in an aggregate score of +6 resulting in a 'Medium Positive Impact' by comparison.

6.7 BAT Conclusion

This Waste Gas Management Plan has been produced to demonstrate the process which has been undertaken to identify the Best Available Technique with regards to the management of waste gas. This Waste Gas Management Plan has been written with consideration for the Environment Agency Report: SC170013/R 'Waste gas management at onshore oil and gas sites: framework for technique selection'.

It has considered the two scenarios in which waste natural gas may be produced, Well Testing on subsequent exploration wells and Production throughout the lifetime of the development. Exploration wells will be tested to ascertain whether commercial hydrocarbon rates can be achieved.

The main commodity at the WNA Wellsite is expected to be oil with associated natural gas being produced in parallel, though the volumes of which are as yet unknown. During production operations oil will be flowed with natural gas before being separated at surface. The production operations are expected to continue for a period of 20+ years.

The Environment Agency has identified a 'long list of technologies' within report: SC170013/R which provided the initial list of technologies that had the potential to be considered BAT. The long list was then screened against the definition of BAT and the proposed operation which resulted in a number of technologies being screened out and not being considered further. For clarity, BAT as a concept will continue to change as technologies improve or become increasingly available for use within the onshore oil and gas industry.

Technologies which have passed through the initial screening process have been considered for a more detailed assessment to establish whether they can be considered BAT. The technologies which were the subject of further assessment were placed onto a short list. Each technology was then assessed for compatibility against the proposed development. In the case of well testing the only safe and viable option was the incineration of natural gas whilst the production operations had the choice of either harnessing the gas (either through a spark ignition engine or gas compression for export) or incinerating the gas.

The incineration unit(s) being proposed are designed to accommodate the fluctuating / low flow natural gas encounters for onshore exploration wells and can be used in sequence or in parallel. To this end no further assessment was carried out on the well testing operations as BAT had already been established.

With regards to the production operations further assessment was required with regards to establishing BAT. As such a CBA was undertaken by Rathlin to provide an informed decision over the financial and pollution damage costs. The results of the CBA showed that the harnessing natural gas to generate electricity for internal use and exportation was considered BAT due to the benefit outweighing the cost (financial and environmental). Therefore, the 'Quantitative Assessment' concluded that the 'Harnessing of Natural Gas' via gas fuelled electrical generators is BAT.

A 'Qualitative Assessment' was undertaken by Rathlin on the use of both gas fuelled electrical generators and gas compressors compared to that of incinerating the natural gas. The incineration of natural gas (base case) was considered the least feasible option when considering potential impact (noise, visual, land take and smoke) on the local population. The impact of the of the generator and/or compressor against that of the enclosed flare provided a 'Medium Positive Impact' by comparison. Therefore, the 'Qualitative Assessment' concluded that harnessing natural gas via gas fuelled electrical generators or gas compressors and compression is BAT.

The WGMP has concluded that the BAT for the management of waste gas during well testing operations is incineration, whilst the harnessing of waste gas using gas fuelled electrical generators is considered BAT for the production operations.

7. DESCRIPTION OF PROPOSED OPERATIONS

This section outlines the proposed operations which are to be undertaken as part of the development. Additional activities including acidisation etc. are also being proposed, however these activities are not within the scope of the Waste Gas Management Plan as they do no produce waste gas. A description of these additional activities has been provided within the Waste Management Plan.

7.1 Well Testing Operations

Once drilled, the well(s) will be the subject of subsequent clean up and testing. The purpose of the well test is to evaluate the commercial viability of the hydrocarbon reservoir, if encountered. The test will be conducted in 2 (two) parts consisting of a Well Clean Up (WCU) and an Extended Well Test (EWT). During the well test hydrocarbons will be produced.

For clarity, the WCU and EWT may be undertaken several times throughout the development after each well is drilled. The proposal is to target several isolated zones within the Permian section, each zone has the potential to contain oil, gas or a combination of the two. The reason for multiple well tests is due to the zones within the Permian section being distinct and isolated. Information obtained from a specific zone is highly unlikely to inform the behaviour of the other zones within the target formation due its natural variability.

7.1.1 Well Clean-up Phase

A WCU will involve the use of a well testing spread, typically consisting of at least a choke manifold, surface safety valve, three-phase separator, fluid storage tanks, vent line(s) and a combustion unit(s). Ordinarily, natural gas flows to surface unaided however, during a WCU the rate of natural gas produced is likely to fluctuate unpredictably. Any natural gas composition data acquired during WCU may not be accurate due to being comingled with borehole fluids.

Once at surface, produced fluids will be diverted by temporary pipework to a three-phase separator, which will separate out oil and condensate, water and gas. Oil and condensate, which for clarity is not a waste, will be diverted via temporary pipework to dedicated storage tanks onsite for subsequent offsite removal by a licenced haulier for sale. Water, which is considered a waste, will be diverted via temporary pipework to dedicated storage tanks onsite for subsequent offsite removal by a licenced haulier to an Environment Agency permitted water treatment facility where it is processed, treated and discharged in accordance with the permitted controls of the water treatment facility.

7.1.2 Extended Well Test

Should the WCU phase indicate that hydrocarbons are present then testing operations will continue with the EWT stage. An EWT is a longer duration test, which is carried out to assess the commercial viability of the well and establish detailed gas and oil composition.

Once at surface, produced fluids will be diverted by temporary pipework to a three-phase separator, which will separate out oil and condensate, water and gas. Oil and condensate, which for clarity is not a waste, will be diverted via temporary pipework to dedicated storage tanks onsite for subsequent offsite removal by a licenced haulier for sale. Water, which is considered a waste, will be diverted via temporary pipework to dedicated storage tanks onsite for subsequent offsite removal by a licenced haulier to an Environment Agency permitted water treatment facility where it is processed, treated and discharged in accordance with the permitted controls of the water treatment facility.

Formation water produced during the EWT has the potential to contain low levels of Naturally Occurring Radioactive Material (NORM). Samples of formation water will be sent to a laboratory holding the appropriate accreditations for radionuclide analysis by gamma spectrum. Depending on the outcome of radionuclides analysis, formation water will be transported via a licenced haulier to either an Environment Agency permitted waste water treatment works facility where it is processed, treated and discharged in accordance with the permitted controls of the water treatment facility, or to a bespoke RSR permitted waste treatment facility for treatment and disposal in accordance with the Best Available Technique (BAT).

Any natural gas separated during the three-phase separation will be managed in accordance with the identified BAT as identified within the Waste Gas Management Plan.

The purpose of an extended well test is to analyse the flow characteristics of a formation, which may contain petroleum, over an extended period. The duration of the extended well test will differ, dependent upon the parameters of the reservoir being tested.

7.2 Production Operations

The main phase of the proposed development is the production of oil and/or gas from the WNA Wellsite. During the development it is anticipated that an increasing number of wells will be drilled and eventually brought online into production.

Production will be conducted through surface-based equipment, which provides for:

- Shutting in the well at any time with a remotely operable safety valve;
- Control of the production via a “choke manifold”;
- Flow of produced reservoir fluids through pipework;
- Separation of the produced fluids into individually controllable and metered flow streams; and
- Storage of produced oil and produced water in segregated, vented tanks;

Produced fluids (oil and production water) will either free flow to the surface naturally or with the aid of surface pumps, artificially lifting fluids to surface.

At surface, produced fluids and natural gas may be diverted by pipework to an oil heater, heating the fluid to aid in the separation process, which will separate out oil, water (if present) and natural gas. Oil, which for clarity is not a waste, will be diverted via pipework to dedicated storage tanks onsite for subsequent offsite removal by a licenced haulier to a permitted refinery for sale.

Water, if present, will be diverted via pipework to dedicated storage tanks onsite for subsequent offsite removal by a licenced haulier to either Environment Agency permitted water treatment facility where it is processed, treated and discharged in accordance with the permitted controls of the water treatment facility.

Water produced during hydrocarbon production has the potential to contain low levels of Naturally Occurring Radioactive Material (NORM). A competent Radiation Protection Supervisor (RPS) and/or Radioactive Waste Advisor (RWA) shall be appointed to ensure that NORM is managed correctly.

Natural gas shall be managed in accordance with the identified BAT.

7.3 Well Lifting Techniques

7.3.1 Gas Lifting

To aid in the initial flow of hydrocarbons it is common for a gas (Nitrogen gas (N_2) or Carbon Dioxide (CO_2)) to be introduced into the wellbore to displace wellbore fluids introduced during drilling or completion operations.

The gas will displace any liquids in the tubing or wellbore which reduces the hydrostatic pressure and allows the well to flow.

As the wellbore fluids, introduced gas and natural gas rise to surface they will be diverted via temporary pipework to a three-phase separator, which will separate oil, formation water and gas (introduced gas and natural gas) from each other. Oil (including condensate) will be transferred via temporary pipework to storage tanks pending collection, with produced water being transferred via separate temporary pipework to separate storage tanks.

Initially, following artificial lifting, gas separated from the produced fluid will heavily consist of Nitrogen (N_2), with small volumes of natural gas, and will be diverted through temporary pipework to a combustion unit where the following two processes will occur should artificial lifting be used:

1. The volume of gas to be introduced into the wellbore will depend on the volume of wellbore fluid requiring lifting. Initially the recovered gas mixture will largely be the introduced gas with entrained natural gas. The gas flow from the well will be cold vented to atmosphere via the stack for a short period of time. It is proposed to raise the calorific value of natural gas to minimise/negate any form of cold venting.
2. As the lifting operations continue, the volume of introduced gas will decrease whilst the volume of natural gas will increase. Once a suitable mix of natural gas to oxygen has been achieved (once Nitrogen (N_2) / Carbon Dioxide (CO_2) has reduced and cannot blanket ignition) the pilot light will ignite the gaseous waste stream.

The pilot light is always on and will ensure that no unnecessary cold venting will take place by igniting the gas as soon as it is physically possible to do so.

Nitrogen (N_2) and Carbon Dioxide (CO_2) are odourless gases and therefore do not directly cause odour issues, however they will prevent the ignition of natural gas by providing an 'ignition blanket', meaning that un-incinerated natural gas (although in small quantities) may present an odour at the site, albeit for a short duration. An Odour Management Plan has been provided which considers odour and associated management techniques for cold venting.

7.3.2 Justification for the use of Gas Lift to Lift Wells

There have been questions raised from the Environment Agency surrounding the use of Nitrogen (N_2) / Carbon Dioxide (CO_2) to undertake 'well lifting' operations. In particular why natural gas (external from the well) cannot be used to displace fluids and lift the well, as this would ensure that cold venting is prevented and all gas is combusted.

Whilst it is technically possible to use Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) this is unlikely to be undertaken until appropriate equipment has been installed at the site, such as modified wellheads, annular safety valves and ESD systems, following a successful well test and once the reservoir properties are better understood, i.e. moving into the production phase of a development.

Additionally, the infrastructure of exploration wells is not able to accommodate the use of CNG and LNG, as they also pose additional risks with regards to health and safety, not least failing to adopt the ALARP principle with regards to the management of risks.

The Health and Safety at Work etc. Act 1974 states inter alia:

*It shall be the duty of every employer to ensure, **so far as is reasonably practicable**, the health, safety and welfare at work of all his employees.*

Without prejudice to the generality of an employer's duty under the preceding subsection, the matters to which that duty extends include in particular—

*a) the provision and maintenance of plant and systems of work that are, **so far as is reasonably practicable**, safe and without risks to health;*

*b) arrangements for ensuring, **so far as is reasonably practicable**, safety and absence of risks to health in connection with the use, handling, storage and transport of articles and substances;*

*c) the provision of such information, instruction, training and supervision as is necessary to ensure, **so far as is reasonably practicable**, the health and safety at work of his employees;*

*d) **so far as is reasonably practicable** as regards any place of work under the employer's control, the maintenance of it in a condition that is safe and without risks to health and the provision and maintenance of means of access to and egress from it that are safe and without such risks;*

*e) the provision and maintenance of a working environment for his employees that is, **so far as is reasonably practicable**, safe, without risks to health, and adequate as regards facilities and arrangements for their welfare at work.*

*It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, **so far as is reasonably practicable**, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety.*

The Health and Safety Executive have also published document *'Reducing Risks, Protecting People'* which provides the following statement: *'It is useful to note that SFAIRP is not the only qualification. There are other* similar *qualifications such as 'as low as reasonably practicable' (ALARP); 'as low as reasonably achievable' (ALARA).*

Rathlin consider that the use of Nitrogen (N_2)/Carbon Dioxide (CO_2) as opposed to CNG/LNG demonstrates its commitment to ensuring that risks are managed in accordance health and safety legislation and reinforced by its own moral obligations to ensure that all persons who may be affected by their business activities are safe and that any risks are controlled to ALARP, demonstrating compliance with health and safety legislation.

Rathlin consider the transporting, handling and storage of CNG/LNG at an exploratory well site, for introduction into a wellbore for fluid lifting purposes an unnecessary risk. Safer and more cost effective technologies are available to use such as Nitrogen (N_2)/Carbon Dioxide (CO_2) which is an inert/non-hazardous chemical, when compared to flammable and explosive substances.

When comparing the risk of transporting, handling and storing CNG/LNG against the risk of cold venting small quantities of natural gas during the initial stages of Gas Lift as a result of using Nitrogen (N_2)/Carbon Dioxide (CO_2), Rathlin are of the strong opinion that the use of Nitrogen (N_2) / Carbon Dioxide (CO_2) heavily outweighs the benefit of CNG/LNG for exploration operations.

To reduce the amount of cold venting, Nitrogen (N_2)/Carbon Dioxide (CO_2) use is kept to a minimum by using a phased approach. First, where possible the well is made underbalanced by using a light fluid. Secondly where possible Nitrogen (N_2) is displaced into the well from surface to increase the under balance pressure. This keeps the Nitrogen (N_2) and natural gas separate. Lastly Coiled Tubing would be used to circulate Nitrogen (N_2) / Carbon Dioxide (CO_2) around the well. This is used if there are sufficient quantities of fluid that need to be evacuated prior to the gas reaching the wellbore.

To further reduce the amount of cold venting, the Nitrogen (N_2) / Carbon Dioxide (CO_2) will be stopped once sufficient amount of gas has reached the wellbore to lift the fluid in the well. Indications of natural gas are observed by measuring the return gas rate and deducting the Gas Lift rate to verify if this passes the minimum lift capacity. Additional gas gravity sampling can be taken to observe the weight decrease with the presence of natural gas. When the unit starts to lift intermittently the Nitrogen (N_2) can be periodically be shut off to observe if the well flows naturally. Once flowing, the Nitrogen (N_2) / Carbon Dioxide (CO_2) will not be required and the natural gas will be burnt within the combustion unit.

Should it be identified during the Gas lift that there are no hydrocarbons present as part of the gas lift, Nitrogen (N_2) / Carbon Dioxide (CO_2) shall be cold vented via the chosen incineration unit, without propane, for an indefinite period of time until either hydrocarbons are detected or the Nitrogen (N_2) / Carbon Dioxide (CO_2) is depleted. Should hydrocarbons be detected propane will be used as described within section 7.3.3 below.

Although Nitrogen (N_2) would normally be the preferred gas to use in a gas lift due to its environmental impact, Carbon Dioxide (CO_2) would be more suitable in certain instances. Carbon Dioxide (CO_2) is particularly useful in an oil reservoir as it reduces the viscosity to allow freer flow of the oil near wellbore and aids in the removal of debris from near wellbore. The properties of Carbon Dioxide (CO_2) provide for a better result in relation to the removal of near wellbore debris where Nitrogen (N_2), due to not being as rapid in expansion, is more likely to result in compounding the damage rather than remove it.

7.3.3 Use of Propane during Gas Lifting

The main use of support fuel is to assist the combustion process by increasing the temperature and calorific value within the burner to ensure efficient combustion. The use of support fuel to overcome an incombustible mixture of Nitrogen (N_2)/Carbon Dioxide (CO_2) and natural gas is not a well-used process. Whilst it is possible to add propane to the system to achieve efficient combustion, it is unknown whether a fixed amount of propane will ensure complete incineration throughout the operation. During a gas lift the percentage of natural gas will increase throughout the lifting process, as a result the propane introduced to the gas feed will be decreased. The amount of support fuel needed will be ascertained by the flare operator when operating the flare.

It is anticipated that a mixture of 30% burnable gas (propane and/or natural gas) vs 70% non-combustible gas should create a combustible mixture.

The required amount of combustible gas within a gas mixture to achieve combustion is calculated to be 26%. However, it is unlikely that inputting that precise amount of support fuel to the system will ensure efficient combustion due to the mixing of the gas in the system. A single gas lift would use a tubing volume of approximately 21mcf (based on KA depth). If using 30% support fuel for the whole of the gas lift this would equate to 9mcf propane required per gas lift. Therefore, circa 500kg of propane will be in place at the site per gas lift. There will be propane and the necessary equipment located at the site to deliver the required rate of propane to the combustion unit.

There is no means to instantly calculate the make-up of the gas flowing from the well and alter the amount of support fuel being added to achieve combustion. Therefore, the support gas to be added will be regulated by the flare operator during the gas lift in an effort to achieve the maximum combustion possible. However, due to the need to adjust the flow rates in reaction to the flow, there may be times of incomplete combustion or cold venting. If pumping Nitrogen (N_2)/Carbon Dioxide (CO_2) into the well at $11.3m^3$/min a full tubing volume should be displaced in less than an hour so any cold venting within that process will be very short term. The AQIA shows that cold venting this amount of gas shall have negligible impact on the air quality but cold venting may lead to odour being dispensed from the site for a very short period of time.

During the gas lift operations, the SG will be determined by taking a sample of the gas within the separator and analysed in the on-site lab. Once the SG of the gas is determined, the percentage of flammable gas within the sample can be calculated using the following calculation;

% flammable gas = (SG Nitrogen (N_2) – SG measured) / (SG Nitrogen (N_2) – SG reservoir), assumed reservoir SG is 0.616 based on previous samples. A handheld gas analyser will also be used to verify the calculations by taking a sample from the separator. To clarify, neither process gives an immediate reading and is just a sample at that point in time.

It is not possible to justify the use of a pressure regulating device in a temporary well test and for safety reasons the pressure must remain unrestricted and open to atmosphere. Furthermore, the process to alter the propane input isn't automated given the flammability of the gas and must be regulated by the operator. The process to alter the support fuel given the makeup of the gas flowing from the well isn't instantaneous, but adapted as soon as possible.

7.4 Lifting the Well Using Mechanical Lifting Techniques

In the event the well(s) are not able to flow to surface naturally a number of lifting techniques are available to the onshore oil and gas industry, including the aforementioned Nitrogen (N_2)/Carbon Dioxide (CO_2) lift. Another lifting technique is a mechanical lift. The use of mechanical lifting techniques is common place within oil production wells and can take a number of forms.

As a contingency Rathlin may use a mechanical lifting technique known as swabbing to aid in the lifting of wellbore fluids to surface. Swabbing is performed by unloading liquids from the well using a specific tool string incorporating a swab cup assembly that can be run into the wellbore by various means (wireline, coiled tubing or drill pipe).

When the assembly is run, the specially shaped swab cups have a tight tolerance inside the wellbore casing or tubing and allow both lifting of the liquids from the wellbore and temporary removal of the hydrostatic column within the well.

The methods of longer term mechanical lifting include 'Beam Pump'/ 'Rod Pumping Hydraulic Pump Jack' and an 'Electric Submersible Pump. both of which are lifting techniques Rathlin have identified as being suitable for the well(s). The techniques involve running a rod string into the well attached to a downhole pump located in the bottom of the tubing string. The rods are then lifted and lowered into the well by the surface equipment.

If larger quantities of associated gas are expected from the reservoir then the gas will flow up the annulus and be directed straight from the wellhead to the gas incineration unit, whilst the rest of the fluids will be handled as previously described.

In both instances the gas will be separated from produced fluids by physical separation, this does not produce any additional waste streams, and the management of each waste stream will remain the same as currently permitted.

A downhole pump does not work effectively when completing a gas reservoir. Downhole pumps are required to be submerged in liquid to avoid becoming 'gas locked'. Therefore, the operator requires certainty that the reservoir fluids to be lifted are mainly liquids prior to running a completion with a downhole pump.

As it is not possible to be certain of the reservoir fluids that will be encountered in an exploration well, a gas lift may be necessary to evacuate the borehole of wellbore liquids to flow reservoir fluids into the well to ascertain their composition in the first instance.

Furthermore, if the reservoir liquids are known to have a high concentration of gas, a downhole pump would not be run but a means to evacuate the wellbore of liquids may be required. In this instance a gas lift may be deemed the most effective method.

8. IDENTIFICATION OF SUITABLE WASTE GAS MANAGEMENT PLANT

Having established the BAT for both well testing and production operations, Rathlin have identified suitable plant and equipment which meets the description of each BAT.

8.1 Well Testing - Waste Gas Incineration - Aereon Clean Enclosed Burners

Rathlin have identified a suite of enclosed burners which are capable of meeting the requirements of the well testing phase. Flare units have frequently been used within the onshore oil and gas industry, however the Enclosed Burner (AEREON CEB) unit(s) identified have been designed to achieve a 99.99% combustion efficiency and, unlike flare units, can be relied upon without having external environmental factors such as weather impacting on the units operating performance and combustion efficiency.

In order for the CEB units to facilitate the varying flow rates, a number of units will be required, operating either in sequence or in parallel.

In addition, during the well clean up where Nitrogen (N_2) will be present and propane required to raise the calorific value of the produced natural gas during this phase, the PW Shrouded Flare has also been considered suitable due to its ability to efficiently incinerate natural gas across a varying flow range, something which is likely to occur during the well clean up phase. The PW flare also facilitates the introduction of propane.

A summary of the three (3) CEB units and the PW Shrouded Flare has been provided within Table 8.1 below.

Aereon CEB Unit	Maximum Capacity	Turndown Ratio	Combustion Efficiency	Temperature (°C)
PW Shrouded Flare	2.5mmscfd		99.99%	480-933[5]
CEB350	0.27mmscfd	10:1	99.99%	1,100 - 1,250
CEB1200	0.9mmscfd	10:1	99.99%	900 - 1,200
CEB4500	3.5mmscfd	10:1	99.99%	900 - 1,200

Table 8.1: Summary of Aereon Unit and PW Shroud Technical Performance

The combustion efficiency of a combustion unit is generally based upon the units' ability to incinerate methane, which in turn produces Carbon Dioxide (CO_2) and Water (H_2O). The combustion efficiency of higher hydrocarbons, such as benzene, is generally expected to be lower. Higher combustion efficiency is achieved by increasing the residence time in the combustion chamber, allowing time for the hydrocarbon gas to mix with air, resulting in greater destruction(incineration). The mixture of gas and air within the CEB passes through a knitted metal fibre media separating the flow into numerous small streams which are ignited to form millions of small, surface resident mini-flames, ensuring a more efficient combustion.

A pilot line is present delivering propane from tanks located a safe and sufficient distance from the unit. The pilot line delivers propane from external tanks ensuring a continuously lit flame, providing a reliable and secure means of ignition.

In order to enhance the efficiency of the thermal oxidation reaction, the units operate an air-to-fuel ratio of roughly 15:1. The high excess air ensures that an efficient reaction takes place with a high combustion efficiency. Due to the design of the CEB Units i.e. resulting in an extremely high combustion efficiency, flame height is relatively short. The thermal reaction results in very short, non-luminous blue flames, which is why the CEB unit(s) has a short stack.

When the well is flowing, the well test package is continuously manned and periodic checks of the combustion unit are undertaken, including temperature and flame condition. A dedicated well test operative will be assigned to continuously monitor the combustion unit during testing operations and shall be in full communication with the dedicated choke manifold operator, advising the choke manifold operator of the flame characteristics. Choke adjustments are normally carried out in $^{4}/_{64\ (1/16)}$" increments, with upstream and downstream pressures monitored throughout.

If necessary, due to any safety concerns, the well can be shut in at the choke manifold. The well test package will have an active Emergency Shutdown (ESD) system in operation throughout the well testing operation. All well testing personnel must be trained in its use, including how to shut in the well in the event of an emergency.

[5] Based on stack emissions data.

Data sheets on the Aereon CEB Units have been provided within Appendix 4 with the stack emissions report on the PW Flare provided within Appendix 5.

8.2 Production Operations - Harnessing Waste Gas

Rathlin have identified a number of gas fuelled electrical generators which can be used as part of the production operations. Whilst the exact make and model has yet to be chosen, Rathlin can confirm that the emissions output for each generator shall comply with the emission limit values, namely <95mg/Nm^3 (15% O_2).

The number of generators to be installed at the WNA wellsite in contingent on the volume of natural gas encountered as part of the production operations. However, the total aggregated thermal input of the WNA wellsite shall not exceed 49.9MWth.

A technical data sheet on the generator(s) has been provided within Appendix 6. The exact make and model may differ, however the emissions performance criteria as set out within EPR2016, as amended shall still be complied with.

9. MEDIUM COMBUSTION PLANT AND SPECIFIED GENERATORS

Operators of 'Medium Combustion Plant' (MCP) and Specified Generators (SG) that are in scope will require an environmental permit under schedule 25A and 25B of EPR2016. A permit to operate both is determined by the capacity, emissions and operating hours of the plant.

MCP applies to combustion plants with a rated thermal input (th) equal to or greater than 1MW (Megawatt) and less than 50MW regardless of the fuel type. Specified Generators are combustion plants which are used to generate electricity and are on a site with an aggregate thermal input of less than 50MWth (Megawatt Thermal).

Rathlin is proposing to harness the associated natural gas as a fuel to provide electrical energy for the site with surplus being exported as dictated by grid capacity.

The BAT Assessment has concluded that the harnessing of natural gas, by means of electricity generation through gas fuelled generators, is BAT for the proposed WNA Wellsite development.

9.1 Combined Heat and Power

As the proposed production operations includes the harnessing of waste gas using a medium combustion plant there are certain criteria the operator needs to consider with regards to suitability and compliance with Schedule 24 of EPR2016 - Efficiency in heating and cooling energy: Energy Efficiency Directive, namely the feasibility of harnessing Combine Heat and Power (CHP) / cogeneration. The Best Available Technique Reference Document (BREF) for Energy Efficiency concludes that:

Cogeneration is as likely to depend as much on economic conditions as ENE optimisation. Cogeneration opportunities should be sought on the identification of possibilities, on investment either on the generator's side or potential customer's side, identification of potential partners or by changes in economic circumstances (heat, fuel prices, etc.).

In general, cogeneration can be considered when:

- *the demands for heat and power are concurrent*
- *the heat demand (on-site and/or off-site), in terms of quantity (operating times during year), temperature, etc. can be met using heat from the CHP plant, and no significant heat demand reductions can be expected.*

The Environment Agency's guidance document 'CHP Ready Guidance for Combustion and Energy from Waste Power Plants V1.0 February 2013 provides the framework for which operators of new combustion power plants or Energy from Waste (EfW) plants, although the guidance pre-dates that of the EPR2016, as amended, it still remains applicable to medium combustion plants which are now considered under Schedule 24.

The Environment Agency requires that all applications for Environmental Permits for new installations regulated under the EPR2016 demonstrate the use of Best Available Techniques (BAT) for a number of criteria, including energy efficiency. One of the principal ways in which energy efficiency can be improved is through the use of Combined Heat and Power. There are three BAT tests which should be applied. These are as follows in order of preference:

1. Use of CHP in circumstances where there are technically and economically viable opportunities for the supply of heat from the outset;
2. In cases where there are no immediate opportunities for the supply of heat from the outset, then BAT is to build the plant to be CHP-Ready (CHP-R) to a degree which is dictated by the likely future opportunities which are technically viable and which may, in time, also become economically viable.
3. Once an Environmental Permit has been issued for a new CHP-R plant, the operator should carry out periodic reviews of opportunities for the supply of heat to realise CHP

Given the nature of the proposed operations Rathlin has determined that there are no immediate opportunities to harness the heat created from the combustion plants. The proposed site is predominantly outside, with an internal control room. The electricity from the waste natural gas is already being utilised to provide electricity for/from the site. Furthermore, the rural location of the proposed development means that any heat generated at the wellsite is unable to be exported and harnessed by neighbouring businesses or residential areas.

Having identified that there are no immediate opportunities for the supply of heat, Rathlin are committed, so far as reasonably practicable, to ensuring that the proposed development will be CHP-R by the selecting appropriate medium combustion plant. Rathlin shall periodically assess the potential to harness any heat generated by the medium combustion plant.

10. ENVIRONMENTAL MANAGEMENT AND MONITORING

The WNA Wellsite will be managed to ensure that all operations will be undertaken in such a way as to minimise environmental impact. Management and monitoring regimes will be implemented at the wellsite by Rathlin which contractors and subcontractors much adhere to.

10.1 Odour

An Odour Management Plan (OMP) is currently in place for the WNA Wellsite. Forthcoming operations relating to well testing will be the subject of the OMP which will be in place for operations conducted at the WNA wellsite. The OMP will be the subject of review by the Environment Agency.

The OMP has identified a number of potential sources of odour together with the mitigation measures that will be used to ensure that odour is eliminated so far as reasonably practicable. The OMP also details monitoring techniques such as sniff testing, emissions monitoring and grab sampling.

10.2 Air Monitoring

Prior to the commencement of operations, baseline air quality samples will be collected at the WNA Wellsite. The main source of air emissions from the operations will be the incineration of natural gas during the well testing and production operation.

The scheme of monitoring will be consistent with the requirements and methodologies previously approved by the Environment Agency.

The required samples will be analysed and the findings issued to the Environment Agency in accordance with the requirements of the WNA environmental permit.

10.3 Emissions Calculation

Previous operations at the WNA wellsite required a method to calculate the point source emissions to air from the combustion unit. The previously agreed calculation method remains relevant and will be used to establish the emissions to air as a result of natural gas being combusted during the proposed operations.

11. Emergency Response Procedures

In the event of an incident occurring, the Wellsite Supervisor is to comply with the Wellsite Emergency Response Plan ensuring, if safe to do so, immediate action is undertaken to isolate, contain and prevent an incident.

In addition, Rathlin will inform Emergency Services of the location of the wellsite and of circumstances in which they may be called to attend. This will aid the emergency services developing an emergency response plan of their own specifically for the operations and wellsite.

11.1 Spillages

Spillages of crude oil during the transfer or over filling of vessels will result in associated vapour being dispersed to the local environment.

Spillages occurring during the transfer of crude oil are not to be hosed down or detergents used to remediate the spillage. Remediation of the spillage is to be undertaken and the contaminated stone is to be removed, segregated and disposed of to an Environment Agency licensed facility as hazardous waste.

Spillage response equipment is located onsite. During site inductions, personnel will be shown the location of spillage equipment, how to use the equipment correctly and how to store and use materials safely.

Spillage equipment is to be labelled and checked on a regular basis by the Wellsite Supervisor and unserviceable items quarantined and replaced.

11.2 Well Shut In

The Borehole Sites and Operations Regulations 1995 requires that a site specific health and safety document is produced for wellsite operations and requires a plan for the prevention of fire and explosions including particular provisions for preventing uncontrolled escape of flammable gasses.

In the unlikely event of an emergency situation arising during the well testing operation, for example a failed component or exceedance in pressure leading to one of a number of pressure relief valves within the well test package being activated, the well will be shut in with any residual gas remaining within pipework incinerated.

Primary well control during a well testing is the choke manifold, which must be fully certified and pressure tested to ensure it is sufficient to withstand the anticipated well pressures.

Depending on the nature of the emergency situation, the well will be shut in at the choke if there is any visual indicator of a potential emergency situation starting to occur. If the emergency situation is not so obvious, such as pressure build-up within the well test package, high pressure sensors located at the choke and possibly, at the three (3) phase separator, will send an electronic signal to the SSV, which will close, isolating the well from the well testing package.

APPENDIX 1 - SITE LAYOUT PLANS

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APPENDIX 2 - AIR QUALITY IMPACT ASSESSMENT

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APPENDIX 3 - COST BENEFIT ANALYSIS

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APPENDIX 4 - AEREON CEB UNIT TECHNICAL DATA

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APPENDIX 5 - PW STACK EMISSIONS REPORT

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APPENDIX 6 - JENBACHER - JMS 624 GS-N.L

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