Wressle Wellsite

Waste Gas Management Plan

For:-

Wressle site production and testing

ISSUE No.	Description
240429	Draft for Client Review
240501	First Issue for Permit Application

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1. Purpose and Context

This Waste Gas Management Plan forms part of an application to the Environment Agency to authorise the undertaking of specific 'permitted activities' at the Wressle Wellsite. With regards to onshore oil and gas operations, an activity that produces extractive waste is classified as a 'mining waste operation'.

A 'mining waste operation' is considered a 'regulated facility' under The Environmental Permitting (England and Wales) Regulations 2016, as amended [Ref.1] (EPR2016). Throughout the life of the Wressle Wellsite, this Waste Gas Management Plan shall be considered a live 'operating technique' and must be complied with as it forms part of the environmental permit.

This Waste Gas Management Plan has been produced in accordance with EPR2016, which has been transposed, in part, from the Mining Waste Directive [Ref.2] (MWD), the Environment Agency Report: SC170013/R [Ref.3] and follows the principles of the Waste Framework Directive's (WFD) [Ref.4] waste hierarchy.

The purpose of this Waste Gas Management Plan is to demonstrate to the Environment Agency how Egdon Resources U.K. Limited (herein referred to as the 'Operator') established Best Available Technique (BAT) for the management of waste gas associated with long-term production operations and the short-term production testing phase, whilst also providing an explanation into how the BAT assessment was undertaken.

For clarity, domestic legislation derived from European Union legislation such as the MWD and the WFD continues to have an effect in domestic law following the UK's withdrawal from the European Union in accordance with the European Union (Withdrawal) Act 2018 [Ref.5]. The MWD and WFD are therefore still applicable to this Waste Gas Management Plan and activities performed by the 'Operator'.

2. Scope

This Waste Gas Management Plan is applicable to the Wressle Wellsite and all operations conducted therein. It is applicable to the 'Operator', its contractors and subcontractors and may be used in support of an application to the Environment Agency for an environmental permit under EPR2016.

This Waste Gas Management Plan is applicable to the long-term production operations and the short-term production testing phase at the Wressle Wellsite and is specific to the potential for associated (waste) gas produced from the Wressle-1 Well, the Wressle-2 Well and the Wressle-3 Well. For clarity, Table 1 below sets out the scenarios across the different operational phases, in terms of gas produced, its potential use and potential management as a waste product.

Operation	Timeline	Potential gas use	Waste gas
Production from Wressle-1	Before drilling of Wressle-2 and Wressle-3	Gas used to generate electricity for use (e.g. bitcoin mining) via gas engine or turbines	Incinerated via flare; below 10 tonnes/day
	During drilling of Wressle-2 and Wressle-3		
	During testing of Wressle - 2 and Wressle-3	No gas produced	No waste gas
	Post drilling of Wressle-2 and Wressle-3	Gas used to generate electricity for use (e.g. bitcoin mining) via gas engine or turbines	Incinerated via flare; below 10 tonnes/day
Testing of Wressle-2 and Wressle 3	Short-term testing to establish oil and gas rates	No use of gas	Incinerated via flare; above 10 tonnes/day

Operation	Timeline	Potential gas use	Waste gas
Production from Wressle 1, Wressle-2 and Wressle-3	Before gas pipeline installed	Gas used to generate electricity for use (e.g. bitcoin mining) via gas engine or turbines	Incinerated via flare; above 10 tonnes/day
	After gas pipeline installed	Gas supplied to gas network Gas used to generate electricity for use (e.g. bitcoin mining) via gas engine or turbines	Incinerated via flare; above 10 tonnes/day (relief event/start up only)

Table 1: Gas use/waste scenarios

As context, the long-term aim will be to produce gas and export this gas to the main gas network. Once this is achieved, gas will be a usable resource and not waste. However there are operational scenarios that must be considered before this happens, where there may be waste gas that has to be managed. This document therefore covers for the scenarios as set out within Table 1, where waste gas may be produced.

This document (Waste Gas Management Plan, Issue 230215) will supersede the current Waste Gas Management Plan, Issue 230118, once approved.

For clarity, the two Waste Gas Management Plans are summarised as follows

- Issue 230118 – Considers the use of gas management techniques specific to the single Wressle-1 Well and anticipated associated natural gas volumes.
- Issue 230215 (this document) – Considers the use of gas management techniques specific to the Wressle-1 Well (long-term production operations), the Wressle-2 and 3 Wells (short-term production testing phase) and the Wressle-1, 2 and 3 Wells (long-term production phase).

The scenario exists during the life of the wellsite whereby the aggregated natural gas rate across all wells, reduces to the point whereby the gas production operations fall back in scope of the original Waste Gas Management Plan, Issue 230118. Notwithstanding this, the Waste Gas Management Plan will be reviewed in the event of newer technologies or increased availability of existing technologies.

3. Abbreviations and Definitions

BAT:	Best Available Technique
CAPEX:	Capital Expenditure
CO_2:	Carbon Dioxide
DNO:	District Network Operator
EPR2016:	The Environmental Permitting (England and Wales) Regulations 2016
Extractive Waste:	Has the meaning given within Regulation 2 of EPR2016
Groundwater Activity:	Has the meaning given within Regulation 2 of EPR2016
GEU:	Grid Entry Unit
Installation Activity:	Has the meaning given within Regulation 2 of EPR2016
km:	Kilometre
kWe:	Kilowatt Electric
m:	Metre
Mining Waste Operation:	Has the meaning given within Regulation 2 of EPR2016
Mining Waste Facility:	Has the meaning given within Regulation 2 of EPR2016
MWD:	Mining Waste Directive
MWe:	Megawatt Electric
NORM	Naturally Occurring Radioactive Material
OPEX	Operating Expenditure:
Operating Technique:	Documents approved by the regulator to ensure compliance with the issued permit.
Operator:	Has the meaning given within Regulation 7 of EPR2016
PDC:	Pollution Damage Cost
Permitted Activities:	Any activity or operation defined within Schedule 1 to 29 of EPR2016
Regulated Facility:	Has the meaning given within Regulation 8 of EPR2016
Radioactive Substances Activity:	Has the meaning given within Regulation 2 of EPR2016
Sm^3:	Standard Metres Cubed
UK:	United Kingdom
Water Discharge Activity:	Has the meaning given within Regulation 2 of EPR2016
WFD:	Waste Framework Directive

Table 2: Abbreviations and Definitions

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4. ENVIRONMENTAL PERMITTING (ENGLAND AND WALES) REGULATIONS 2016

The Wressle Wellsite has historically been the subject of a number of permit applications and variations. Table 3 provides a summary of the 'permitted activities' currently permitted at the wellsite.

Permitted Activities				
Permit	**Ref.**	**Description**	**Activity**	**EPR2016**
EPR/AB3609XX	A1	Loading, unloading, handling or storage of crude oil.	Installation	Schedule 1
	A2	Non-hazardous mining waste operation	Mining Waste	Schedule 20
	A3	Non-hazardous mining waste facility		
	A4	Groundwater activity for a single injection.	Groundwater	Schedule 22
	A5	Discharge of rainfall run off water to Ella Beck	Water Discharge	Schedule 21
	A6	Operate a Medium Combustion Plant up to 2MWth.	MCP and SG	Schedule 25
EPR/HB3295DH	A1	Accumulation of radioactive waste on the premises.	Radioactive Substances	Schedule 23
	A2	Disposal of radioactive waste on or from the premises.		

Table 3: List of Activities Currently Permitted

4.1 Current Operational Status (Pre-Application)

The Wressle Wellsite is currently producing oil and natural gas from a single well. The wellsite is in its infancy with regards to production and as such, activity A6 has yet to commence.

The site is currently producing and storing crude oil in accordance with Activity A1 of permit EPR/AB3609XX, whereby the volume of oil is less than 500 tonnes. This activity is considered an 'installation activity'.

As the Wressle Wellsite is in a phase of production, it is currently operating as a 'mining waste operation' (Activity A2 of EPR/AB3609XX), due to the production (or potential production) of extractive waste. Such extractive waste may include formation water, spent acid and proppant throughout the lifetime of the development. The wellsite also holds the necessary permission to operate a 'mining waste facility' (Activity A3) which for clarity is not located at the wellsite itself but within the target formation where proppant fluid remains following a previously permitted proppant squeeze operation.

As previously stated, a proppant squeeze operation was undertaken at the wellsite. The 'groundwater activity' permit was obtained to enable the discharge of a pollutant in circumstances that might lead to an indirect input of that pollutant to groundwater. The residual proppant fluid and proppant remains in the formation from which hydrocarbons are produced.

Due to the wellsite incorporating an impermeable membrane to capture any potential spills or leaks, the site regularly collects rainwater. To negate the need for a road tanker to remove the water from site, a 'water discharge activity' was permitted at the site to enable the discharge of clean rainwater to the adjacent Ella Beck surface watercourse via an oil-water separator. During low risk operations, i.e. production and suspension operations, the outlet remains open. Where workovers and similar operations are being undertaken, the outlet shall be closed.

Due to the production of associated gas at the wellsite, a 'medium combustion plant activity' (which is also considered as a specified generator) was obtained as a means to harness the gas, produce electricity for site use, and potentially export. This activity has yet to commence at the wellsite due to an ongoing evaluation of gas engines, uses for generated electricity, site consumption and variability of gas rates.

The waste natural gas is currently harnessed as much as possible via micro-turbines to meet the sites electrical supply with any remaining gas being incinerated in a flare unit, consented under the 'mining waste operation' as the volumes of incineration are below 10 tonnes per day.

For clarity, the use of the micro-turbines do not fall under EPR2016 due to the aggregated thermal input parameters not meeting the threshold limit detailed within the Medium Combustion Plant Directive [Ref.6] and is therefore not considered a 'permitted activity'.

Production of hydrocarbons together with associated water and natural gas has the potential to produce naturally occurring radioactive material (NORM). At the time of this application, produced water is materialising and initial analysis indicates that NORM is evident. A Radioactive Substances Permit (EPR/HB3295DH) [Ref.7] is in place for the accumulation and disposal of radioactive waste from NORM resulting from the production of oil and gas. This is considered a 'radioactive substances activity'.

Table 4 outlines the operations that are permitted to be undertaken currently in line with the current environmental permitting consents.

Permitted Operations derived from Permitted Activity.		
Permit		**Description**
EPR/AB3609XX	A1	Allows for the storage and handling of crude oil that arise from oil production activities.
	A2	Allows for the management of extractive wastes from side-track drilling, radial drilling and near well-bore treatments (acid-squeeze, hot oil wash, solvent treatment, nitrogen injection) and hydraulic fracturing for conventional oil which will be done only once. An enclosed ground flare will be used to incinerate less than 10 tonnes of waste gas per day.
	A3	Allows for a mining waste facility for the disposal and management of non-hazardous extractive waste and permanent deposit in-situ of fracturing fluids.
	A4	Allows for the discharge (injection) of fracturing fluid into the target formation that might lead to an indirect input of a pollutant to groundwater.
	A5	Allows for the discharge of rainfall runoff treated site surface water to the Ella Beck.
	A6	A medium combustion plant comprising of a natural gas fired engine.
EPR/HB3295DH	A1	Accumulation of radioactive waste including both aqueous and solid material containing NORM on the premises
	A2	Disposal of radioactive waste on or from the premises to an EA permitted facility for treatment and onward disposal.

Table 4: Permitted Operations Derived from the Permitted Activities

4.2 Proposed Activities and Permitted Activities

The next phase of the development will include the drilling of up to two new boreholes from an extended Wressle Wellsite. The second and third boreholes shall be known as the Wressle-2 Well and the Wressle-3 Well respectively and will be drilled with the intention of further evaluating the zones of interest identified by the 'Operator' during the drilling of the Wressle-1 Well.

To facilitate the additional wells at the site the Wressle Wellsite will be extended from the southern boundary. As such, the area classified as the 'regulated facility' will need to be increased and updated on any future permit.

4.2.1 Mining Waste Operation including a Mining Waste Facility

In order to drill, test and undertake well treatments from the proposed Wressle-2 Well and Wressle-3 Well it is necessary to apply for a variation to the mining waste operation (which includes a flare, mining waste facility and a fracture operation). It is necessary to vary the 'mining waste operation' to include the additional extractive waste volumes and streams created as a result of both the drilling process and any subsequent testing, production and well treatment operations. In addition, the 'Operator' is proposing to undertake a proppant squeeze, which will also require a variation to the 'mining waste facility' which permits the permanent storage of waste at the wellsite, which in the case of the proposed development is the permanent disposal of proppant carrier fluid into the target formation.

4.2.2 Incineration of Natural Gas

Schedule 1, Part 2 of EPR2016 transposes the requirements of the Industrial Emissions Directive, which requires an environmental permit to authorise an installation operation for the incineration and co-incineration of waste, as detailed within Section 5.1.

Part A(1)

(a) The incineration of hazardous waste in a waste incineration plant or waste co-incineration plant with a capacity exceeding 10 tonnes per day;

The proposed short-term production testing phase may involve the incineration of natural gas exceeding 10 tonnes per day and therefore Environmental Permit EPR/AB3609XX is being varied to include the Well Clean up (WCU) and Extended Well Test (EWT) activities.

4.2.3 Groundwater Activity

An activity that could involve the discharge of pollutants into groundwater must be notified to the Environment Agency, together with the nature of these pollutants, under EPR2016. The Environment Agency will then determine whether the groundwater activity needs to be permitted.

During the life of the well, as with the current Wressle-1 Well, it may be necessary to undertake near wellbore treatments, including an acid squeeze and solvent treatment, all of which fall within the definition of a 'groundwater activity under Schedule 22 of EPR2016.

Schedule 22 3 (3) of EPR2016 provides that the '*The regulator may determine that a discharge, or an activity that might lead to a discharge, is not a groundwater activity if the input of the pollutant…*

(b) is or would be of a quantity and concentration so small as to obviate any present or future danger of deterioration in the quality of the receiving groundwater.

To assist the regulator in determining whether the proposed activities are/are not considered groundwater activities a description of the operations, together with a technical justification as to why the 'Operator' believes these can be excluded under Schedule 22 paragraph 3 (3) of EPR2016, is included within the Waste Management Plan.

It may be necessary to undertake a proppant squeeze, should it be deemed necessary to enhance production rates. This activity falls within the definition of a 'groundwater activity under Schedule 22 of EPR2016. The proppant squeeze has been designed such that will be confined to the saturated formations, which contain hydrocarbons. The proppant squeeze is a 'groundwater activity', namely the injection of any substance into groundwater to increase the flow of fluids or gas to a well or borehole in connection with the extraction or use of any energy source.

4.2.4 Water Discharge Activity

To enable the drilling of up to two additional wells it is necessary to increase the area of the 'regulated facility'. As such, the containment system (HDPE Impermeable membrane) will also need to be extended to cover the additional site area. The containment ditches on the East and West side of the Wressle Wellsite will be extended further South, with a new southern perimeter ditch also being installed of the same design. The current southern containment ditch will either remain and connect to the eastern and western ditches via a T-Piece connection or be removed and infilled depending on the final configuration of the site design.

The rate of discharge will not alter from the existing permit boundary, nor will the maximum volume of daily discharge. The discharge conditions shall also remain the same and the surface water will be the subject of the same monitoring regime, with surface water only being discharged during production operations or during periods of site inactivity where the likelihood of contamination is far lower. The interceptor and surface water outlet will be locked off during any well operations or wellsite construction operations.

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5. ESTABLISHING BEST AVAILABLE TECHNIQUE FOR WASTE GAS MANAGEMENT

BAT is defined within the Industrial Emissions Directive [Ref.8] 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;

5.1 Current Operations and Identification of Waste Gas Streams

Within the onshore oil and gas industry, there are a number of activities that produce natural gas which require management. For the current Wressle production operations, the long-term production of gas from the current Wressle-1 Well will be a minor contributor to the main source of gas.

The associated natural gas is utilised to provide site power by means of either micro-turbines or gas combustion engines with any excess associated natural gas diverted to an enclosed flare unit which has been considered BAT during the well testing stage and the initial phases of production.

5.2 Proposed Operations and Identification of Waste Gas Streams

In addition to the current associated natural gas production from the Wressle-1 Well, the Operator is proposing to drill, test and produce from up to two new wells known as the Wressle-2 Well and the Wressle-3 Well which are intended to be dedicated oil and gas production wells i.e. not associated (waste) gas.

It is intended by the Operator to install a pipeline to the DNO. However, before pipeline export can commence, it is necessary to test the Wressle-2 Well and subsequently the Wressle-3 Well to determine the resource potential in the form of natural gas.

This Waste Gas Management Plan is concerned with establishing BAT for the management of waste gas associated with long-term production operations and the short-term production testing phase.

Due to the production of associated gas at the wellsite, the following scenarios have been identified whereby the associated gas is harnessed for onsite/offsite power generation, exported via pipeline or flared onsite.

Scenario 1

1. Continued production from the Wressle-1 Well:-
    a. Long-term production operations:
        i. No immediate-term use;- gas flared.
        ii. Short term use in gas engine or turbines (e.g. power generation); any surplus gas flared.

Scenario 2

1. After drilling of the Wressle-2 Well and the Wressle-3 Well:-
    a. Long-term production operations:
        i. Wressle-1 continues as detailed within Scenario 1.
    b. Very short-term production testing:
        i. Gas flared from the Wressle-2 Well and the Wressle-3 Well.

Scenario 3

1. Before pipeline installation:-
    a. Long-term production operations:
        i. Wressle-1 continues as detailed within Scenario 1.
        ii. Production from Wressle-2 and Wressle-3:
            1. Gas utilised in a gas engine/turbines; any waste gas flared due to recovery of oil.
    b. No production from Wressle-2 and Wressle-3 (i.e. shut-in) to conserve gas.

Scenario 4

1. After pipeline installation:-
    a. Long-term production operations:
        i. All gas (Wressle-1, Wressle-2 and Wressle-3) exported via pipeline.
        ii. Possible low usage in gas engine or turbines (e.g. bitcoin mining).

Potential scenario for waste gas in the event of relief (i.e. export interruption – albeit would be very short term).

5.3 Initial Screening of BAT

The Environment Agency has identified a "*long list of technologies*" within report: SC170013/R, which has been summarised below by class/type:

- Cold venting;
- Flaring;
- Heat generation;
- Power generation;
- Reinjection to well;
- Recycling through gas processing;
- Mini liquefied natural gas;
- Conversion to fuels;
- Vapour recovery;
- Gas processing and natural gas liquids recovery;
- Compressed natural gas; and
- 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. Full details of the "*long list of technologies*" from the Environment Agency Report can be found within Appendix 2.

Table 5 provides a list of technologies that have been identified with the potential of being considered BAT for the onshore oil and gas industry. This Waste Gas Management Plan has been produced to assess the techniques considered 'best available' for long-term production and the short-term production testing phase.

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 waste gas produced. The "*long list of technologies*" from the Environment Agency Report is provided in Appendix 2.

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.
- The working capacity or specification of the technology did not meet the onshore oil and gas sector requirements.

Techniques for BAT Assessment for Oil Production (Associated Gas)		
Option	**Technology / Process**	**Reason for Consideration**
Collection and Recycling	Export via Pipeline.	Can be considered if pipeline connection economics are not prohibitive and the receiving network can guarantee to take the export gas. This is the most practical solution for recovering and utilising waste gas.
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.
	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)	Used in conjunction with gas turbine.
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.
Incineration	Shrouded Flare	Considered to have a reduced combustion efficiency but able to accommodate variable and unpredictable flow (associated gas) even at low flow.
	Enclosed Flare / Incinerator	Provides the best combustion efficiency and reduced noise and visible flame, but can only operate within a defined range of flow. Struggles with inconsistent volumes.
Cold Venting	Direct Release to atmosphere	Worst environmental impact with Methane being 28 times greater in global warming potential than CO_2. Potential for use in the event of very low gas volume and flowrates.

Table 5: BAT Options - Results of Long List

5.4 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.

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

- Harness natural gas for alternative use;
- Incineration of natural gas by flare; 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 associated (waste) gas with regards to the Wressle-1 Well (long-term production operations), the Wressle-2 Well (short-term production testing phase) and the Wressle-3 Well (short-term production testing phase).

Wressle-1 Production

The actual volume of waste gas (Wressle-1) is anticipated to peak at 203 Sm^3/hour and steadily decline to 0 Sm^3/hour. Production gas (Wressle-2 and Wressle-3) will need to be used to support (eventually replace) the Wressle-1 waste associated gas to provide for the site electrical demand.

Wressle-2 and Wressle-3

It is anticipated that the Wressle-2 Well and the Wressle-3 Well will be only tested for short periods, which may range from a matter of days to weeks for data gathering. In the event that significant oil volumes are encountered from either the Wressle-2 Well or the Wressle-3 Well, there is the potential for natural gas to be produced which will be managed in the intervening time before the gas process installation and pipeline are completed.

It is anticipated over the production testing phase of the Wressle-2 and Wressle-3 wells that the aggregated volume of natural gas produced from both wells will peak at 3,450 Sm^3/hour.

Harness Natural Gas for Alternative Use

The preferred method for waste gas management is to harness the associated gas to produce energy i.e. electrical or heat potentially reducing the running cost of the site, or to pipe the gas or electricity away for consumer use. Following the initial screening process, a number of options have been assessed further for the harnessing of associated gas.

5.4.1.1 Export of Natural Gas via Pipeline

The 'Operator' is proposing to install a dedicated pipeline to an offtaker as part of the proposed development works with the purpose of transporting the production gas from the Wressle-2 Well, the Wressle-2 Well and the Wressle-3 Well. However, before this can be commissioned it is necessary for the 'Operator' to test the Wressle-2 Well and subsequently the Wressle-3 Well for their commercial viability.

For clarity, this is not intended to be a proposed waste gas management technique, but rather a commercial led decision.

Nevertheless, the presence of a dedicated gas pipeline for export must be considered with regards to the management of associated gas from the wellsite, as comingling the Wressle-1 Well gas with the gas from the Wressle-2 Well and the Wressle-3 Well is technically available.

The harnessing of natural gas by means of gas export is being considered further as part of the long-term production operations.

5.4.1.2 Onsite Power Generation (Spark Engines or Turbines and Power Export (Gas to Wire))

Gas Turbines

The potential for gas engines is only feasible should there be sufficient demand for the electricity. Gas turbines are able to accommodate lower flow rates and produce small volumes of electricity for site use and can be scaled up and down to facilitate variable electrical loads at the wellsite throughout its life. Micro-turbines are currently considered BAT for the current site configuration (Waste Gas Management Plan, Issue 230118), when coupled with an enclosed flare unit.

The harnessing of natural gas for the purpose of providing electricity for use has been considered with regards to micro-turbines, as it is an option to utilise a micro-turbine to generate electricity for third-party use (on or off site e.g. bitcoin mining, local farm project etc.) as part of the long-term production operations.

Spark Engines

The potential for gas engines is only feasible should there be sufficient demand for the electricity. Generally, gas engines are only suitable where there is sufficient gas volumes (as is the case at the Wressle Wellsite) and where there is sufficient offtake capacity on or off site e.g. bitcoin mining, local farm project etc. Whilst there is a large volume of natural gas available, sizing a dedicated engine, which is able to facilitate variable electrical loads at the wellsite throughout its life is possible. A mains electricity supply may be progressed to cater for site needs.

The harnessing of natural gas for the purpose of providing electricity for use has been considered with regards to gas engines as it is an option to utilise a gas engine to generate electricity for third-party use (on or off site e.g. bitcoin mining, local farm project etc.) as part of the long-term production operations.

Power Export (Gas to Wire)

The Operator has been in discussions with the DNO for the export of site electricity although the Operator has been informed by the national grid that export feed capacity is limited.

The DNO has confirmed that there is very limited capacity of only 190kW. It is possible to significantly increase export, but there would need to be significant infrastructure investment (c£6m) and would take 5-7 years to achieve

Additional micro-turbines used in sequence could be considered to provide site power and export, though a significant number would be required to match the equivalent output of a gas engine, they are also typically less efficient than a gas engine. For context, to facilitate 2 MW using micro-turbine technology would require up to 10 units as a 1 MW singular unit or larger could not be identified for UK distribution.

With the potential for a demand of 2 MWe, the 'Operator' is confident that a suitable gas engine can be identified given the increase in site load and export potential.

The harnessing of natural gas for the purpose of providing electricity for internal site use and exportation has been considered further with regards to micro-turbines on the basis that the technology is available, granted it will have a significant capital expenditure and larger site footprint.

The harnessing of natural gas for the purpose of providing electricity for internal site use and exportation has been considered further with regards to gas engines as the technology is available.

5.4.1.3 Heat Generation

The wellsite will require the intermittent production of heat for very short periods for a well treatment known as hot water washing. There is no permanent requirement for a heat source and as such, heat generation is not considered feasible.

No further use for heat has been identified within the site internally or externally.

The harnessing of natural gas for the purpose of providing heat generation for either internal or export use has not been considered further as part of the production operations.

5.4.2 Incineration of Natural Gas

Methane has a Global Warming Potential 28 times greater than CO_2, based on a 100-year time horizon, therefore, the incineration of unburnt hydrocarbons represents a decrease in the environmental impact over the venting of natural gas. In addition, the incineration of large volumes of hydrocarbons presents a decreased risk of fire and/or explosion.

5.4.2.1 Enclosed Flare

Enclosed flares, such as those used in landfill, are designed with either a single or a multiple burner, to incinerate natural gas with lower methane contents, typically around 56% methane and 31% carbon dioxide. 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 known, as is the case with the current status of the Wressle Wellsite with a methane content of c70% and a suitable pressure and flow rate. The incineration of natural gas using an enclosed flare was previously BAT during the early stages of production and well testing.

The incineration of natural gas by means of an enclosed flare is being considered further as part of the short-term production/testing phases. It is anticipated that in the absence of a gas export pipeline, coupled with a limited offtake capacity, there will be some natural gas that will need to be incinerated for disposal to ensure a suitable and sufficient testing phase is achieved.

The incineration of natural gas by means of an enclosed flare is not being considered further as part of the long-term production operations. However, it is important to recognise that an enclosed flare will remain at the site as a safety flare and to facilitate both planned and unplanned maintenance schedules.

5.4.2.2 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 well clean up, where the gas composition, pressure and flow rates are unknown.

Whilst having lower combustion efficiency when compared against an enclosed flare (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 incineration of natural gas by means of a shrouded flare is not being considered further as part of the production operations due to better technologies in the form of an enclosed flare being available.

5.4.3 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 support that the cost of installing a flare for this activity would be disproportionate to the environmental benefit and subject also 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 filtration unit, which in turn reduces both environmental impact and safety risks.

The cold venting of associated natural gas is not being considered further due to the volume of gas and the impact on both the environment and the associated safety concerns.

5.5 Initial Conclusion on Potential Techniques

Table 6 provides a summary of the short list of technologies.

Option	Technology	Considered	Reason
Harness Gas	Pipeline Export	Yes	There is potential within the locality of the site to connect / set up to a pipeline for export to the DNO.
	Onsite Power Generation (Micro-turbines)	Yes	Onsite power generation can be considered in the form of Micro-turbines although it will have a significant capital expenditure and larger site footprint.
	Onsite Power Generation (Gas Engines)	Yes	Option to utilise a gas engine to generate electricity for third-party use.
	Export (Gas to Wire)	Yes	Onsite power generation with export can be considered in the form of gas engines as the site load and export capacity is sufficient. Micro-turbines whilst available would require a significant volume in the UK and have lower efficiencies.
	Heat Generation	No	Heat generation can be considered in the form of hot water tank heating requirements.
Incinerate	Enclosed Flares	Yes	Given there will be gas needed to provide a sufficient well test, it is likely an enclosed flare will also be required to facilitate this.
	Shrouded Flares	No	Gas volumes are well known and established. Enclosed flares should be used to guarantee greater combustion efficiency.
Vent	-	No	Potential for significant global warming emissions (Methane), unless the gas volumes are considerably low.

Table 6: BAT Options - Result of Short List

Section 5.4 has provided a number of technologies considered by the 'Operator' as potentially being considered BAT for the production operations. These are:

1. Gas export – Pipeline.
2. Onsite Power Generation with Power Export – Micro-turbines / Gas Engines.
3. Enclosed Ground Flare for Incineration.
4. A combination of any of the above.

Whilst there is the availability of numerous gas harnessing techniques, the 'Operator' considers the disposal of natural gas via incineration (enclosed flare) to be necessary to, either in part or fully manage, the waste gas as a result of the Wressle-2 (and possibly Wressle-3) short-term production testing phase and Wressle-1 production.

5.6 Quantitative BAT Assessment

The 'Operator' has calculated that the waste gas, as volumes decline, from the Wressle-1 Well will not be able to support the required site electrical load. All remaining quantities of production gas will need to be managed by an enclosed flare for disposal.

The Quantitative BAT Assessment has been simplified to assess the CAPEX, OPEX and Pollution Damage Cost (PDC) of both a micro-turbine and a comparable gas engine, both with the aim of supplying up to 1.4 MWe. The maximum site load will be 0.65 MWe with any surplus (0.75 MWe) being exported by private wire.

The costs associated with the installation of an electricity export connection or the exportation pipeline is not applicable as this is again being proposed by the 'Operator' as part of the overall Wressle production development.

The cost benefit analysis has been provided within Appendix 3.

The results of the quantitative assessment (cost benefit analysis) concluded that the CAPEX for the gas engine is significantly less than that of a micro-turbine, and marginally less in relation to OPEX also. Whilst the turbines do result in less NOx being produced, the gas engine, with its increased efficiency results in less CO^2 overall which, coupled with the financial comparison, results in the gas engine being considered BAT for this quantitative assessment.

Due to the 'Operator' requiring a minimum volume of natural gas to be flowed to achieve an informative well test, it is likely surplus gas will be produced which cannot be taken up by electricity export technologies. As such, the impact of using an enclosed flare has also been included, though in reality will be used in parallel with any electricity producing technologies.

5.7 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.

5.7.1 Considerations of the Assessment

The Wressle Wellsite is located within countryside in the county of North Lincolnshire. The wellsite is located approximately 350 m east of Lodge Farm and is bound to the north by Ella Beck with agricultural land beyond and to the west with a wood approximately 70 m to the west. The village of Wressle is located 1.6 km south of the wellsite. Decoy Cottage is located approximately 580 m to the south of the wellsite.

A 2 km radius was established from the site boundary and a study was undertaken to identify how many district wards were present within the 2 km radius. The district wards were then checked against the Office for National Statistics estimated population data census data available for each district ward was used to estimate the local population within 2 km radius, these are presented below.

- Appleby Civil Parish with a population of 590.
- Bonby Civil Parish with a population of 529.
- Broughton Civil Parish with a population of 5,554.
- Worlaby Civil Parish with a population of 530.

It is acknowledged that both Bonby Civil Parish and Worlaby Civil Parish, whilst partially within the 2 km wellsite radius do not have any properties within the radius itself, therefore the population of each for the purpose of this qualitative assessment is zero.

Appleby Civil Parish is extensively placed within the 2 km wellsite boundary. However, the village of Appleby is located outside of the 2 km radius and as a result the population is likely to be much less.

Broughton Civil Parish is extensively placed within the 2 km wellsite boundary. However, the town of Broughton is, for the most part, located outside of the 2 km radius and as a result the population is likely to be much less.

5.7.2 Impact and Receptors

The following matrices and calculation of magnitude of risk have been developed with consideration of the Environment Agency Report: SC170013/R. The scale of an impact has been determined by considering the size of the relative benefit or risk against the number of people likely to be affected. This allows a scale value to be determined for each factor being considered. For the purpose of this qualitative assessment, the 'Operator' has considered that enclosed flaring should be considered as the base case.

The development is considered to fall within a general population of 1,001-10,000 based on a 2 km radius from the wellsite. However, the actual number of people affected is expected to be much lower largely due to the location of the site and the natural screening around the perimeter. Therefore, the 'Operator' considers the number of people likely to be impacted to be in the region of 101 - 1,000.

Increase / Decrease of Risk / Benefit	Number of People Likely to be Impacted				
	General Population				
	1-10	11-100	101-1000	1001-10k	>10k
	Disadvantaged Groups				
	NA	NA	10-100	101-1000	>1000
No Consequence (NC)	NC	NC	NC	NC	NC
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 7: Scale of Impact Matrix

5.7.3 Magnitude of Impact

The results obtained from Table 7, i.e. population data, has informed Table 9 with regards to the scoring criteria and have been carried forward into Table 8 below to assess the magnitude of each impact. The purpose of Table 8 is to determine the severity of the impact by assessing the duration and scale of an effect.

Duration of Effect	Impact Based on Population					
	No Consequence	Very Small	Small	Medium	Large	Very Large
Days / One Off Event	NC	VS	VS	VS	S	M
Weeks / Months - Repeat Event	NC	VS	VS	S	M	L
Up to 1 Year	NC	VS	S	M	L	VL
1 - 3 Years	NC	VS	S	M	L	VL
4 - 6 Years	NC	VS	M	L	L	VL
Over 6 Years	NC	VS	M	L	VL	VL

Table 8: Magnitude of Risk Matrix

Whilst it is the intention of the 'Operator' to install a gas export pipeline within a reasonable time period, it is likely to take over a year to be fully commissioned from the start date of the production testing phase, as such a worst case of up to three years has been selected for the magnitude of risk score.

For simplicity, the score of each factor will be converted using a numerical score to provide easy comparison (Table 9). As an example, the magnitude of an impact has been rated from 'Very Small' to 'Very Large'. Depending on the BAT

being considered the impact may be positive (reduction in noise) or negative (increase in noise). Each BAT option may bring with it both positive and negative impacts, when compared to that of the base case.

Magnitude Output	Ranking 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 9: Magnitude Score

5.7.4 Assessment of Short Listed Options

The short listed options as identified within Table 6 have been assessed using the methodology presented within Section 5.7.2 and Section 5.7.3. The results are presented within Table 10. For clarity, the assessed impacts include visual impact, noise impact, land take, smoke (combustion history) and commodity production.

The base case for the proposed production operations will be the operation of micro-turbines providing site power, with any surplus gas being incinerated by an enclosed flare.

Impact Factor	Table 7	Table 8	Table 9	Total Impact Score
	Scale of Impact	Magnitude of Impact	Magnitude Score	
Base Case – Micro-turbines Only for Site Power (With Enclosed Flare)				
Visual	NC	NC	Neutral	0
Noise	NC	NC	Neutral	
Land Take	NC	NC	Neutral	
Smoke / Efficiency	NC	NC	Neutral	
Commodity Production	NC	NC	Neutral	
Onsite Power Generation and Power Export – Micro-turbines				
Visual	NC	NC	Neutral	+8
Noise	NC	NC	Neutral	
Land Take	NC	NC	Neutral	
Smoke / Efficiency	S (+)	S (+)	S (+4)	
Commodity Production	S (+)	S (+)	S (+4)	

Impact Factor	Table 7	Table 8	Table 9	Total Impact Score
	Scale of Impact	Magnitude of Impact	Magnitude Score	
Onsite Power Generation and Power Export - Gas Engines				
Visual	NC	NC	Neutral	+8
Noise	NC	NC	Neutral	
Land Take	NC	NC	Neutral	
Smoke / Efficiency	S (+)	S (+)	S (+4)	
Commodity Production	S (+)	S (+)	S (+4)	
Onsite Power Generation and Power Export – Micro-turbines and Enclosed Flare Disposal				
Visual	NC	NC	Neutral	+4
Noise	NC	NC	Neutral	
Land Take	NC	NC	Neutral	
Smoke / Efficiency	S (+)	S (+)	S (+2)	
Commodity Production	S (+)	S (+)	S (+2)	
Onsite Power Generation and Power Export - Gas Engines and Enclosed Flare Disposal				
Visual	NC	NC	Neutral	+4
Noise	NC	NC	Neutral	
Land Take	NC	NC	Neutral	
Smoke / Efficiency	S (+)	S (+)	S (+2)	
Commodity Production	S (+)	S (+)	S (+2)	

Table 10: Impact of Proposals

5.8 Results of the Qualitative Assessment

It is the intention of the 'Operator' to construct a pipeline for the export of production gas from the Wressle-2 Well and the Wressle-3 Well. However, before construction it is necessary to evaluate the commercial viability of both wells to ensure that it makes commercial sense to install the proposed pipework to facilitate gas export. The qualitative assessment relates to both the Wressle-1 Well (long-term production operations), the Wressle-2 Well and the Wressle-3 Well (short-term production testing phase) with the short-term production testing the critical factor in determining the viability of any pipeline installation. Therefore, no pipeline option is being considered as part of this qualitative assessment.

The base case for the qualitative assessment was the use of micro-turbines to provide power to the wellsite only with surplus waste gas being incinerated through an enclosed flare system.

When benchmarked against the base case, the gas harnessing techniques for long-term production operations will result in a benefit.

There was a small positive when using the micro-turbines and gas engines for onsite power generation and power export with any waste gas incinerated via the enclosed ground flare. The micro-turbines and gas engines would be able to consume more natural gas and significantly reduce the volume of natural gas incinerated by the flare unit, though some smoke would be produced from the site as part of the micro-turbines and gas engines exhaust.

There was a large positive when using the micro-turbines and gas engines for onsite power generation and power export. The micro-turbines and gas engines would be able to consume the natural gas produced negating the requirement to incineration any waste gas by the flare unit, though some smoke would be produced from the site as part of the micro-turbines and gas engines exhaust.

No other impacts either negative or positive were identified, not least due to the size of the micro-turbines and gas engines which result in little noise, visual or land take impact, which would not impact any receptors.

Overall the option which provided the most benefit to the surrounding area was the harnessing of the associated (waste) gas for onsite power generation and power export using either micro-turbines or a gas engine.

It was also considered, given the flare unit is already in place and being utilised, that there were no impacts as a result of incinerating surplus gas, which is unable to be utilised.

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6. 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. It 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'.

The main commodity from the Wressle-1 Well is oil with associated natural gas, whereas the Wressle-2 Well and Wressle-3 Wells' main commodity is both oil and natural gas. However, it is necessary to perform a production test on both of the new wells to determine commercial viability of installing a pipeline for the long-term production phase. As such, this Waste Gas Management Plan is applicable to the associated waste gas produced as part of the Wressle-1 Well (long-term production operations) and the Wressle-2 Well and Wressle-3 Well (short-term production testing phase).

The next phase of development includes the drilling, testing and production of the Wressle-2 and Wressle 3 Wells and with that brings in the potential for the BAT to alter for the Wressle-1 Well associated (waste) gas.

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 (Appendix 2) 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.

Any available technologies that were not screened out were considered further for a more detailed assessment to establish whether they can be considered BAT. The available technologies which were the subject of further assessment were placed onto a short list (Table 6). Each technology was then assessed for compatibility against the proposed operations.

It was considered that gas harnessing techniques would be carried forward as part of the assessment and would likely be the techniques adopted for gas utilisation, though an enclosed flare would also be considered to facilitate the safe disposal of natural gas that cannot be utilised due to technological constraints i.e. power export limitations. The gas harnessing techniques did not include gas export via pipeline, as the purpose of the Wressle-2 and Wressle-3 well testing phase is to determine whether a pipeline can be considered for the longer-term production phase.

It was clear that the gas volume anticipated for the Wressle-1 associated gas would not be of sufficient volume to meet the site electrical demand and therefore would need to be topped up with Wressle-2 and/or Wressle-3 production test gas.

In the event that the Wressle-2 and/or Wressle-3 are predominantly oil producing wells, a decision would be taken to determine if oil production would continue to recover any oil which would result in any associated gas being used for onsite power generation with any remaining associated gas being incinerated.

A cost-benefit analysis was carried out to determine the best means to produce electricity for site consumption and considered both gas engines and micro-turbines. When considering CAPEX, OPEX and PDC the gas engine was considered BAT for the quantitative assessment, largely down to the high purchase price of the micro-turbines.

A qualitative assessment was also carried out to determine the likely impact either gas management option would have on the surrounding areas. The assessment demonstrated that the use of a gas engine or micro-turbines would provide a large positive output.

The operation of an enclosed flare was also considered as part of the assessment to manage the excess associated gas from the production testing phase. The use of the enclosed flare did not alter the findings of either the quantitative or the qualitative assessment when the flare was operated at a maximum limit of circa 600 Sm^3/hour (10 tonnes).

During the short-term production testing phase of the Wressle-2 Well and the Wressle-3 Well, there is the potential for the flare to be required to operate above circa 600 Sm^3/hour (10 tonnes). This will be required to ensure that data from the testing phase can be obtained to evaluate and model gas resources, flows, longevity etc.

In the event that the Wressle-2 and/or Wressle-3 are predominantly oil producing wells, a decision would be taken to determine if oil production would continue to recover any oil which would result in any associated gas being used for onsite power generation with any remaining associated gas being incinerated.

To conclude, this Waste Gas Management Plan has identified harnessing of the waste gas in a gas engine or micro-turbines to provide power to the wellsite, or for use by a third-party (either onsite or offsite) with any surplus being incinerated by means of an enclosed ground flare as being the best available techniques with regards to the management of the associated natural gas from the Wressle-1 Well (long-term production operations) and the Wressle-2 Well and the Wressle-3 Well (long-term production).

REFERENCES

1. The Environmental Permitting (England and Wales) Regulations 2016

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7. Radioactive Substances Permit (EPR/HB3295DH)

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APPENDIX 1 - POINT SOURCE EMISSIONS PLAN

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APPENDIX 2 - LONG LIST OF TECHNOLOGIES

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APPENDIX 3 – COST BENEFIT ANALYSIS (ENGINE VS TURBINE)

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APPENDIX 4 – GAS SAMPLE ANALYSIS (OCTOBER 2021)

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