# PERMIT APPLICATION SUPPORTING INFORMATION

## Saltholme North Gas Fired Electricity Generating Facility - EPR/LP3300PZ/A001

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## Appendices

# 1 INTRODUCTION

1.1.1 This document and associated appendices forms, the application for an Environmental Permit (EP) to operate a gas fired generating facility (GFGF) under the Environmental Permitting Regulations 2016 (as amended). The GFGF operation will provide 49.99 MW of electricity for export to the grid, enough to power the equivalent of 50,000 homes.

1.1.2 The proposed facility will consist of 4 x 12.6 MWe spark ignition reciprocating gas engines and will operate to provide additional energy security during periods of peak electricity consumption within the UK. The combined net thermal input of the GFGF is approximately 105 MW. Operation would not be continuous but would run as a flexible back up supply for up to 3,500 hours in any one year.

## 1.2 Site Location

1.2.1 The site is located to the east of Cowpen Bewley Rd, Saltholme, Stockton-on-Tees, Middlesbrough. The approximate post code is TS23 4HS and the site is centred at National Grid Reference NZ 48981 23873.

1.2.2 The site covers approximately 0.7 hectares of arable farmland and includes access from the A1185 and installation of a new access track to a gas connection kiosk.

1.2.3 The area of the site for the GFGF is bounded by open fields on all sides. The proposed access track to the gas connection kiosk lies to the east of the GFGF area.

1.2.4 Circa 400m south east lies an electricity substation and c. 850m north west lies an industrial estate. Saltholme brine reservoirs are c. 750m east of the site boundary. Saltholme nature reserve is c. 325m to the south of the site. The Belasis Beck is present c. 175 m to the south of the site. The closest residential area is Cowpen Lane approximately 1.1 km north west of the site and the built up residential area of Billingham is approximately 2.5 km west of the site.

1.2.5 The closest sensitive ecological receptor to the site is the Teesmouth & Cleveland Coast Ramsar site, Site of Special Scientific Interest (SSSI) and Special Protected Area (SPA) which is located approximately 100 m to the south of the site. An assessment of ecological impacts resulting from operation of the GFGF has been made for the above designated sites.

## 1.3 The Applicant

1.3.1 The applicant and operator is Saltholme North Power Limited and is listed on Companies House with registered number 11504313.

1.3.2 The Directors, and their dates of birth, as listed on Companies House are provided in Appendix H.

## 1.4 Structure of the Permit Application

1.4.1 This section provides an overview of the proposals. This is supplemented by further details in Sections 2 – 5 as follows:

- Section 2 details the proposed management practices which will be in place at the plant, with specific detail covering:
  - Accident management;
  - Energy efficiency;
  - Efficient use of raw materials and water; and
  - Avoidance, recovery and disposal of wastes.

- Section 3 addresses the operational measures which will be in place to prevent and/or control the environmental effects of the proposal.
- Section 4 identifies the nature of emissions from the GFGF and details the monitoring systems that will be in place.
- Section 5 summarises the conclusions from the detailed assessments undertaken to predict the environmental effects from the GFGF.
- Section 6 summarises the outcome of the detailed assessments of Best Available Techniques (BAT) for the key plant and abatement systems proposed.

1.4.2 The information provided within this application has been set out with due regard to the BAT guidance provided within Sector Guidance Note - EPR 1.1[1]. Supporting documents, assessments and application forms are provided within the appendices list as set out in the contents page.

[1] Environment Agency (2009): Combustion Activities (EPR1.01).

# 2 MANAGEMENT OF ACTIVITIES

## 2.1 General

2.1.1 An environmental management system (EMS) will be established on site and will cover those elements requiring environmental permitting. The EMS will be set up in accordance with the BAT conclusions for large combustion plants (LCP BAT-C)[2] and will follow the key requirements of ISO14001.

2.1.2 The EMS will be underpinned by an environmental policy. All staff and external contractors will be made aware of the environmental policy as part of the induction training and a copy will be made available on site.

2.1.3 A system of keeping all relevant records including, but not limited to, the following will be developed and implemented prior to commissioning:

- Records of incidents, accidents and emergencies including details of follow-up;
- Monitoring records, including those required by the environmental permit; and
- Any other record to be kept as part of the permit.

2.1.4 Systems will be developed and implemented for undertaking audits, reporting of environmental performance, objectives, targets and programmes for future improvements.

2.1.5 Prior to commencing commissioning of the GFGF, all key EMS systems will be in place.

## 2.2 Operations and Maintenance

2.2.1 Management systems will be put in place to ensure that those operations which have the potential to give rise to significant environmental effects are controlled. These systems will not only cover normal running but will also address abnormal operation and start-up and shutdown of the GFGF.

2.2.2 Planned maintenance routines will be established to ensure all key plant components which have the potential to affect the environmental performance of the facility remain in good working order. Maintenance routines will draw on manufacturer's recommendations, modified as appropriate by operational experience during the lifetime of the GFGF. Maintenance will be carried out by contractors in accordance with the operator's maintenance requirements.

## 2.3 Competence and Training

2.3.1 All subcontractors working on the site will be subject to a competency assessment carried out by a third party consultancy under the supervision of the operator. In addition, where any subcontractor has any operational input to the site, they must fulfil any relevant obligations under the EMS.

2.3.2 Training shall be provided to the subcontractor at the beginning of their contract term in the form of the site induction process; the subcontractor is in turn responsible for training their own personnel and providing records of such training back to the operator. This will include all maintenance staff carrying out routine maintenance at the facility.

2.3.3 Training will ensure that all staff are aware of relevant elements of the EMS including relevant operational procedures and the requirements of the environmental permit when issued. Induction

[2] European Commission (2017), Best Available Techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D1442&from=EN

procedures will be established for the identification and provision of training and updated knowledge for all personnel engaged in activities affecting environmental performance.

2.3.4 Records of training will be stored and maintained. As a minimum, records will include details relating to the date, type of training and training provider.

## 2.4 Organisation

2.4.1 A draft organogram for the GFGF is provided in Appendix B to this document and indicates the main lines of responsibility. Roles and responsibilities will be clearly defined within the management system.

2.4.2 The plant will be remotely operated but at least one maintenance engineer will attend the site daily to carry out routine checks and inspections. Attendance will be for at least one hour between 7 am and 7 pm. The plant will be available for 24 hours a day, 365 days per year, subject to the limit on operating hours to 3,500 hours in any one year.

2.4.3 Further details on specific aspects of the management systems for the facility are provided in the following sections.

## 2.5 Accident Management

2.5.1 An Accident Management Plan (AMP) will be established prior to commencing operation of the proposed GFGF. The AMP will detail those actions required in the event of an emergency or accident/incident. This will include small incidents such as minor spills and leaks and complaints, as well as major incidents such as fire. In particular, a system for recording and allocating appropriate follow-up for accidents, incidents and non-conformances will be established prior to operation.

2.5.2 The site is remotely controlled and under normal day to day operation will be controlled via feedback from the automatic control system and visual monitoring of the site via the CCTV camera system. In addition at least one engineer will attend the site daily in order to carry out routine inspections and maintenance. An engineer will be on site for at least one hour, between 7 am and 7 pm.

2.5.3 A fire detection and suppression system, including smoke detectors and gas isolation, will be installed in each power house. These systems will link to the main control room (offsite) to alert the local engineer of an issue, who will respond directly and will then call the Fire and Rescue Service to attend if necessary.

2.5.4 There will be a link to a local support team in the event of an issue onsite e.g. intruder alarm or an emergency (e.g. fire). Documented procedures will be in place which set out management measures should such an event occur including contacts details for local support.

2.5.5 To support this application, an initial Environmental Risk Assessment (ERA) is provided in Appendix E, which includes an assessment of potential accident risks. This will be reviewed prior to commencing operation and maintained as part of the AMP throughout the operational life of the facility.

2.5.6 As part of the design process, the proposals will be subject to detailed HAZOP/HAZID with a view to minimising safety, health and environmental risks.

## 2.6 Site Security

2.6.1 The site and the adjacent Salthome South GFGF will be surrounded by a combination of security fencing including padlocked manual gates. Additional security will be provided by CCTV and intruder alarms.

## 2.7 Energy Efficiency

2.7.1 The following section provides information on energy consumption and basic energy efficiency measures, for the GFGF. The gas reciprocating engines proposed to be installed will have an electrical efficiency of circa 50% as measured by ISO3046.

2.7.2 The plant has a thermal input greater than 50 MW and consequently the provisions of the LCP BAT-C[2] apply.

### Basic Energy Requirements

2.7.3 Table 2.1 below provides a breakdown of the energy requirements of the GFGF. Start-up and shutdown energy requirements have also been included.

**Table 2.1: Energy Consumption by Source**

| Energy Source | Annual Energy Consumption | |
|---|---|---|
| | Delivered MWh | Primary MWh |
| Natural Gas<br>(usage during normal operation assuming 4 engines operating for 3,500 hours) | 367,500[(1)] | 367,500 |
| Parasitic load | 3,500[(2)] | 3,500 |

(1)Based on data from MAN, total net thermal input 105 MW and 3,500 hours average operation.

(2)Based on data from SEL, maximum parasitic load of 1 MW and 3,500 hours average operation.

2.7.4 The table above provides details on the energy consumption associated with gas delivered to the GFGF for the purpose of generating electricity and therefore is technically not consumed by the facility, it is simply converted to electrical output. A maximum of 1 MW of electricity will be associated with the parasitic load during operation, for start-up and shutdown periods and during non-running hours. Compared to usage associated with natural gas to generate energy the energy consumption of the plant is considered insignificant.

### Operations and Maintenance

2.7.5 Operational procedures will be developed for the GFGF. These procedures will incorporate measures aimed at ensuring the GFGF operates efficiently and safely. Site maintenance and housekeeping systems will be also be developed for the GFGF and relevant plant will be included within a preventative maintenance schedule.

### Energy Management Policy

2.7.6 Energy management will form an integral part of the facility's management systems. Systems will be developed to ensure that measures are in place to minimise energy use as far as possible. Training programmes will be in place to ensure that operational and maintenance staff are aware of relevant procedures for ensuring energy efficiency.

2.7.7 Efficiency parameters will be monitored and energy minimisation features will be applied to all major energy uses where appropriate. Energy efficiency will be monitored in accordance with the LCP BAT-C[2], i.e. a performance test will be carried out, according to EN or equivalent standards, at full load after commissioning and after each modification that could significantly affect the net electrical efficiency, net total fuel utilisation, and/or net mechanical efficiency of the unit. On-site electricity usage will be minimised as far as possible within the constraints of the process optimisation.

## Building Services

2.7.8 Energy requirements for the GFGF will be low with minimal heating and lighting requirements. Energy efficient lighting will be used where possible.

## Efficient Use of Raw Materials

2.7.9 Raw material requirements for the GFGF will be limited in number. The main materials used within the GFGF will include natural gas for fuel, ethylene glycol for the cooling circuits, ammonia or urea for the Selective Catalytic Reduction (SCR) system and lubrication oil. Error! Reference source not found. provides details of raw materials, expected usage, storage and potential environmental effects. After 16,000 operating hours (approximately 4 to 5 years) an additional layer will be added to the SCR catalyst. This will be replaced after 32,000 hours.

2.7.10 The gas engines will combust natural gas only. A typical composition for natural gas is provided within Error! Reference source not found.. Compared to alternative fossil fuels natural gas has the advantage of being clean to handle and burns with no soot or solid residues produced. Furthermore, in terms of environmental benefits there are fewer emissions to air associated with natural gas in comparison with other fossil fuels, and there is a reduced potential for accidents associated with storage. Gas will be supplied by National Grid via the National Transmission System and will be delivered to the gas reception skid, which is shown in Figure 2 of Appendix B.

**Table 2.2: Typical Natural Gas Specification**

| Compound | Typical Mole (per cent) |
|---|---|
| Nitrogen | 2.22 |
| Carbon Dioxide | 0.29 |
| Methane | 93.23 |
| Ethane | 3.24 |
| Propane | 0.67 |
| Butane | 0.26 |
| Pentane | 0.09 |
| Total Sulphur | <0.001 |
| Net Calorific Value | 28 $MJ/m^3$ |
| Gross Calorific Value | 40.1 $MJ/m^3$ |

2.7.11 There will be one common lubrication oil tank for all engines, which will require occasional topping up. Any tanks, valves, pipework and couplings used for filling or emptying the lubrication oil consoles will be located within bunded areas to ensure ease of clean-up should a spillage occur. No other additional chemicals will be stored at the GFGF.

2.7.12 The GFGF will utilise a closed circuit cooling water (CCCW) system which will utilise a water / glycol mix and consequently the area containing the fin fan coolers and CCCW circulating pumps will be bunded.

**Table 2.3: Raw Material Consumption for GFGF**

| Raw Material | Nature | Expected Usage (approx.) | Storage | Fate | Environmental Effects | Alternatives |
|---|---|---|---|---|---|---|
| Natural Gas | Natural Gas | 367,500MWh (38,684,210.5 $m^3$ based on gas LHV of 9.5 KWh/$Nm^3$) | No natural gas will be stored on site. Gas connection will supply plant. | Combusted within gas engines. | Various emissions to air. Potential impacts arise through acidification, vegetation and health effects and global warming. | - |
| Lubricating Oil | Refined hydrocarbon with additives | Low usage. Expected consumption rate is up to circa 3.9 kg/hr per engine | Stored in 8 $m^3$ bunded tanks. Bund will have capacity for 110% of the stored oil volume | Used primarily within gas engines and discharged as waste oil for disposal | Harmful to aquatic organisms. May cause long-term adverse effects in the aquatic environment. Not readily biodegradable. | No practical alternative. There is a choice of supplier but quality is specified by engine manufacturer. |
| Urea solution* | 40% urea solution | 420,000 litres per year | Stored in 50 $m^3$ bunded tank on impermeable surface | Used within secondary abatement (SCR) | Not significantly bio-accumulative. Spillage of urea to water course will promote algae growth which may degrade water quality and taste. | Ammonium hydroxide, which has higher environmental risks associated with storage and handling. |
| Ammonia solution* | 24.5% ammonia solution | 370,000 litres per year | Stored in 50 $m^3$ bunded tank on impermeable surface | Used within secondary abatement (SCR) | | Urea solution, which has a higher global warming potential. |

***** either urea solution or ammonia solution will be used.

### Water Use

2.7.13 As stated in paragraph 2.7.12, a CCCW system will be installed which has no associated process discharge under normal operation. No process waters will be generated by the plant, hence there will be no associated process water releases to surface water or sewer from the GFGF.

2.7.14 No fire-fighting water will be stored, details of fire detection and suppression systems are provided in paragraph 2.5.3 and fire management procedures will be included within the AMP.

## 2.8 Avoidance, Recovery and Disposal of Wastes

2.8.1 It is anticipated that waste generation during operation of the GFGF will be low, primarily resulting from maintenance activities. Waste generation will be from the following limited sources: used gas engine air intake filters; separated oil or sludge from oil/water separators; and used lubricating oils.

2.8.2 Disposal of wastes generated will be incorporated within maintenance contracts. All contractors carrying out maintenance on the plant will be responsible for wastes generated from their activities. The operator will be supplied with copies of records of waste removed from the site and associated recovery/disposal routes.

2.8.3 Waste minimisation audits will be carried out in accordance with the permit requirements. The audit will aim to minimise raw material consumption and therefore prevent the generation of waste.

# 3 OPERATIONS

## 3.1 Overview of GFGF Proposals

3.1.1 The proposed facility will consist of 4 x 12.6 MWe spark ignition reciprocating gas engines and will operate to provide additional energy security during periods of peak electricity consumption within the UK. The combined net thermal input of the GFGF is approximately 105 MW. Operation would not be continuous but would run as a flexible back up supply for up to 3,500 hours in any one year.

## 3.2 Multi Operator Installation

3.2.1 The site is within the same fenced off area as the adjacent, identical facility operated by Saltholme South Power Limited (SSPL). Both SNPL and SSPL (the operating companies) are ultimately controlled by Statera Energy Limited. The operating companies are separate corporate entities. The two facilities will be operationally independent. An application for the facility at Saltholme South is being made simultaneously to this application as it is anticipated that these facilities will be permitted as a multi operator installation.

3.2.2 Each operating company will operate four engines in it's own building. Each will have separate O&M contracts and separate water supplies and contracts.

3.2.3 The two facilities will share a number of features which are described below. These common features are not related to the main permitted activity of the sites and therefore are not considered to impact the independence of each operation. Common features include:

- Vehicular access;
- Gas delivery facility;
- Gas pressure compound;
- Electricity substation;
- Site security systems;
- Office and welfare facilities;
- Landscaping.

3.2.4 It is intended that there will be a single shared gas delivery unit and a single shared gas pressure compound to serve both facilities. Within the gas pressure compound there will be a "Fiscal Meter" which will measure all gas consumption by both facilities. A secondary "Allocation Meter" will measure the consumption by the SNPL facility, with the gas usage by the south facility being calculated by netting the two meter readings.

3.2.5 SNPL will own and operate the 132kV substation and connection infrastructure to the DNO. This will be operated as a private network. Both operating companies will own their own 11kV substations within their own generation buildings. Separate cables will feed each facility. Each facility will have separate export meters within its own generation building.

## 3.3 Fuel and Raw Material Supply, Storage and Handling

3.3.1 As described in Section **Error! Reference source not found.** natural gas will be delivered to the GFGF via a gas pipeline. Gas will be provided by the high pressure National Transmission System. Fuel gas will be supplied via on-site reception equipment consisting of safety isolation valves, filters, pressure regulation, metering and distribution piping as required.

3.3.2 Within the GFGF there is a dedicated lubrication oil storage tank located within a bunded containment area. The lubricating oil tank and waste oil tanks will each have 10 $m^3$ capacity and will comply with oil storage regulations[3] and the associated bund will be designed to hold 110% of the tank content. Tanks will only be re-filled whilst a maintenance engineer from the engine Maintenance Contractor is on site to oversee the delivery. All delivery staff and maintenance engineers will be trained and will hold contact details for the remote monitoring centre to alert operatives in the event of an incident. Contact details will also be held local to the filling point.

3.3.3 In the event that the cooling circuit requires a top-up or a spillage is identified, the engine Maintenance Contractor will be responsible for overseeing this and notifying the Operator of any spillage incident and actions taken in accordance with the incident reporting system.

3.3.4 The Grid Maintenance Contractor will be responsible for management of any top-up or spillage within the grid compound.

3.3.5 There will be no other additional raw materials to be used by the GFGF.

## 3.4 Combustion of Fuel and Power Generation from GFGF

3.4.1 Combustion will take place within up to 4 spark ignition reciprocating gas engine generator sets which will be housed within the engine hall.

3.4.2 Each gas engine will have an air intake system, combustion chamber, an exhaust system and an electrical generator, together with common auxiliary plant.

3.4.3 The air intake system will feature filters to remove any contamination present, such as dirt, dust or grit, which could damage or reduce efficiency of the plant.

3.4.4 Within the engines gas and combustion air are ignited by means of a spark plug. As the burning mixture of fuel and air expands, a piston is pushed transferring energy released from combustion to an engine flywheel, from which a connected alternator is used to generate electricity.

3.4.5 Clean combustion technology will be incorporated as detailed in section **Error! Reference source not found.**.

3.4.6 Automatic monitoring and control systems will be in place to control the combustion process to ensure that emissions from combustion are consistent with the limits in place for the engines. The control systems will be able to monitor various aspects of operation including efficiency and fuel use over the full range of ambient and fuel conditions.

3.4.7 The exhaust system for each gas engine will have a silencer and ducting to convey the hot gases from the engines to a dedicated exhaust stack for each engine. The 4 stacks will be designated as release points A1 – A4.

## 3.5 Transformer

3.5.1 The electricity generated will be exported to the Grid via a step up transformer. This oil-filled transformer will be located outside the permit boundary within a bunded compound. Transformer oil shall be of a grade suitable for operating the transformer at the rating under prevailing site conditions.

## 3.6 Cooling Systems within the GFGF

3.6.1 The CCCW system will comprise the main fin fan cooler, CCCW pump, system header tank, associated pipework and valves.

[3] SI 2001/2954. The Control of Pollution (Oil Storage) (England) Regulations 2001.

3.6.2 The CCCW system will be filled with a water/glycol mix and a corrosion inhibitor added. A manually operated dosing facility with mixing tank and injection pump will be in place to ensure cooling water quality.

3.6.3 The number of fans to be operated at one time will be dependent on the ambient weather conditions and the engine operating temperature at the time. This will be controlled to minimise the plant's electrical energy usage.

3.6.4 The noise assessment provided within Appendix D has assessed the potential for noise generation on site, including noise from operation of the fin fan coolers.

## 3.7 Start up and Shut down Procedures

3.7.1 The facility will be capable of rapid start up when generation is required and a controlled shut down after use. The expected definitions of the start-up and shut-down periods are given below:

- "Engine Start-up Period" means the time from receipt of an instruction to start the gas reciprocating engine, synchronisation with the respective electrical network, up to the time when the engine achieves a state of steady electrical load.
- "Engine Shut-down Period" means the time from receipt of an instruction to stop the gas reciprocating engine, rejection of engine load and isolation from the respective electrical network up to the time the gas reciprocating engine ceases to rotate.

## 3.8 Commissioning

3.8.1 A commissioning plan will be developed for the GFGF to outline the commissioning and associated monitoring activities. Commissioning will include the following:

- Tests to ensure that the GFGF output and efficiency meets the guaranteed values;
- Tests to ensure that the GFGF operates safely across the full load range across a range of operating parameters;
- Tests to ensure that the GFGF operates reliably throughout a pre-determined set of handling trials designed to simulate real world operation and dispatch scenarios;
- Tests to ensure that the emissions to air from the GFGF meet the guaranteed values;
- Tests to ensure that the noise emissions from the GFGF meet the guaranteed values; and
- Various other tests of the GFGF equipment to confirm the functionality and safety of the plant.

# 4 EMISSIONS AND MONITORING

## 4.1 Emissions to Air

4.1.1 Emissions to air from the GFGF will result from exhaust gases generated from combustion of natural gas within the gas engines. Natural gas is considered to be a clean fuel compared to alternatives and the primary air pollutants of concern from the gas engines with the potential to impact on human health are $NO_x$ and CO. The effects from $NO_x$ emissions to air also need to be considered in relation to potential impacts at ecological sites including effects from deposition.

4.1.2 Each of the 4 engines will require its own stack. The footprint of the plant is such that there is insufficient space to accommodate a combined stack structure in one location. Furthermore, for plant maintenance there are operational and safety advantages in providing separate stacks as maintenance on one engine will not prevent the operation of the remaining engines. This will allow electricity generation at any time, a significant advantage for a plant designed to provide peaking power at short notice.

4.1.3 The engines will each have a net thermal input above 15 $MW_{th}$ and in total the combined thermal input of all 4 engines is greater than 50MW. On this basis the relevant emission performance for the engines is set out within the Industrial Emissions Directive (IED) and in the LCP BAT-C[2].

4.1.4 Combustion technology will be utilised to minimise generation of pollutants, with the use of secondary abatement technology and control systems in place to ensure that emissions are within the emission limits stated for the GFGF.

4.1.5 Secondary abatement measures such as selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR) are available. SNCR is not considered viable for gas engines and so SCR will be used for this facility.

4.1.6 An SCR system will be installed using either 40% urea solution or 24.5% ammonia as the reduction reagent. This system will inject the relevant solution into the flue gases, which then enter the catalyst chamber where the catalyst promotes the reduction of $NO_x$ in the flue gases before they are released from the stack. The 40% urea or 24.5% ammonia solution will be stored in a 50 $m^3$ tank bunded to 110% of the capacity and located on an impermeable surface.

4.1.7 With the SCR system the $NO_x$ emissions will be reduced to 20 $mg/Nm^3$.

4.1.8 Each of the 4 exhaust stacks will be 15 m in height. The locations of these emissions points are illustrated on Figure 3. The stacks are designated release points A1 – A4.

## 4.2 Emissions to Land

4.2.1 There will be no emissions to land associated with operation of the GFGF.

## 4.3 Emissions to Surface Waters and Sewer

4.3.1 No process waters will be generated by operation of the GFGF; hence there will be no associated process water discharge to surface water or foul sewer from the GFGF. In terms of surface water drainage any surface water run-off from the GFGF (roofs, roads, hard standing, etc.) or from washing of equipment will either be collected within a drainage system or within a bund and pumped out to a tanker or drainage system. This drainage system will incorporate a class 1 oil interceptor featuring high oil level and oil carryover alarms. Water will discharge via an attenuation pond within the installation. A manually operated penstock valve may also be utilised to isolate waters from the peaking plant drainage system before they enter the site drainage system. The surface water drainage system discharges to the Belasis Beck.

## 4.4 Emissions to Groundwater

4.4.1 The GFGF will not include any point source emissions to ground or groundwater.

## 4.5 Fugitive Emissions to Air

4.5.1 Management systems will be in place at the GFGF to ensure that the risk from fugitive emissions to air is minimised, for example through regular inspection and maintenance of plant. Protection systems will include automatically triggered safe plant start-up and emergency shut-down in the event of major faults in equipment. Scheduled maintenance of natural gas containment systems will be extended to incorporate the GFGF, to minimise the risk of fugitive emissions of gas to air.

4.5.2 It is anticipated that fugitive emissions of odour will not be significant for the GFGF. The site uses unodourised natural gas which means there is no potential for odour from this source.

## 4.6 Fugitive Emissions to Surface Water or Sewer

4.6.1 The only process waters associated with operation of the peaking plant relate to the CCCW system. The area containing the fin fan coolers and CCCW circulating pumps will be bunded so the risk of accidental discharge of process waters to controlled waters is minimised.

4.6.2 In terms of potential contamination from oils stored on site, the lubrication oil storage tank will be bunded to ensure that should an accidental spillage occur, the oil remains isolated from drainage systems prior to clean up.

## 4.7 Noise and Vibration

4.7.1 An assessment of the noise effects from the peaking plant has been included within Appendix D and a summary of its conclusions is provided in Section Error! Reference source not found. of this document.

4.7.2 The main sources of noise from the peaking plant would be those associated with combustion, including the gas engines, exhaust stacks and fin fan coolers. No significant vibration effects are anticipated to result from operation of the GFGF.

4.7.3 The gas engine exhaust stacks will be fitted with silencers, the engines will be installed within an engine hall with acoustic cladding and ceilings and the use of low noise fin fan coolers is also being considered.

4.7.4 At present, a decision regarding the exact equipment has not been made, therefore the noise assessment supporting this application (which can be found within Appendix D) has been carried out on a conservative basis.

4.7.5 The results of the noise assessment carried out for the facility can be summarised as follows:

- The design of the facility will incorporate in design mitigation measures to minimise noise levels to the lowest reasonably practicable level.
- The BS 4142:2014 assessment indicates that no adverse impact is likely during the daytime or evening, but that there is the potential that an adverse impact could occur at night, in the unlikely event that the plant is required to operate at that time.
- Noise from the plant will be well below the noise standards contained in WHO guidelines for avoidance of annoyance during the daytime.
- Whilst the ambient noise level at night is above the noise standards contained in WHO guidelines for avoidance of annoyance sleep disturbance at night the increase in noise level from the GFGF is only 2 dB and therefore the impact on sleep disturbance would be low.

- Ambient noise levels will increase slightly at residential receptors. However, it is unlikely that small changes in ambient noise will be noticeable during the daytime and will be only just noticeable during the night-time, if the facility is called to operate at this time. When the changes are considered alongside the absolute noise levels, it is considered that ambient noise level increases will not yield any adverse impacts.

# 4.8 Monitoring and Reporting of Emissions

## Emissions to Air

4.8.1 The gas engine stacks will incorporate suitable sampling ports for monitoring of emissions which will be designed in accordance with EA Technical Guidance Note M1[4]. Continuous monitoring of $NO_x$ will be undertaken in accordance with methodologies for continuous sampling as set out in EA Technical Guidance Note M2[5], as appropriate. Monitoring will involve reporting of operational hours of the peaking plant which will be employed to derive mass emission data for the plant. Some periodic monitoring will also be carried out for compliance purposes on a rolling programme to ensure compliance with emission limits.

4.8.2 Records will be kept of all emissions testing results and instrumentation calibration or testing documentation. Monitoring of releases to air will be controlled as part of the EMS.

4.8.3 The following emissions monitoring for releases to air will be undertaken:

**Table 4.1: Summary of Monitoring of Emissions to Air**

| Pollutant | Emission Point | Monitoring Method | Monitoring Frequency | MCERTS certified? |
|---|---|---|---|---|
| $NO_x$ | A1-4 | BS EN 14792 / ISO 8178 | Continuous | Yes |
| CO | A1-4 | BS EN 15058 | Continuous | Yes |
| $NH_3$ | A1-4 | Generic EN standards | Periodic – quarterly | Yes |
| Oxygen | A1-4 | BS EN 14789 / ISO 8178 | Continuous | Yes |
| Water vapour | A1-4 | BS EN 14790 | Continuous | Yes |
| $CH_4$ | A1-4 | BS EN 12619 | Periodic – once every year | Yes |

4.8.4 Monitoring results will be corrected to standard references conditions and reported to the EA, as required by the permit.

4.8.5 An annual periodic stack test will also be undertaken by an MCERTS certified body to confirm the performance of the continuous emissions monitoring. Further, the continuous emissions monitoring system (CEMS) will be calibrated by means of parallel measurements with the reference methods at least every three years.

4.8.6 The precise location of the sampling and measurement points will be determined at the detailed design stage and details will be submitted to the Environment Agency for approval. This submission will also include an assessment of the sampling points in accordance with the M1 guidance.

4.8.7 Emission limits to air will be regarded as having been complied with where monitoring data confirms that emission values are below the limits specified in the IED, over the corresponding monitoring period.

[4] Environment Agency (2017), Technical Guidance Note (Monitoring) M1, Sampling requirements for stack emission monitoring, version 8, August 2017

[5] Environment Agency (2017), Technical Guidance Note (Monitoring) M2, Monitoring of stack emissions to air, version 12, August 2017

4.8.8 At the emission limit value level, the value of the 95% confidence intervals of a single measured result shall not exceed the following percentages of the emission limit values:

- carbon monoxide 10%
- nitrogen oxides 20%

4.8.9 Whilst LCP BAT-C requires $SO_3$ to be monitored it is considered unnecessary where the fuel to be burned is natural gas. Where sulphur is present this will be de minimus.

4.8.10 The LCP BATC states in BAT 4 that BAT for monitoring of ammonia when SCR is used is continuous monitoring. However, it is noted below the table that the minimum monitoring frequency can be reduced to at least once every year, "if the emissions levels are proven to be sufficiently stable".

4.8.11 A calculation-based method has been demonstrated as a viable alternative for monitoring ammonia slip[6]. This relies on the association between reacted ammonia and reduced $NO_x$, using the equation below:

$NH_3$ slip = $NH_3$ fed – ($NO_x$ in – $NO_x$ out)

4.8.12 Therefore, the levels of ammonia emissions can be proven to be "sufficiently stable" via the $NO_x$ levels which will be measured continuously.

4.8.13 Measured emissions data from a similar site at Creyke Beck[7,8], demonstrate that the $NO_x$ levels remain stable across all 11 engines measured. Table 4.2 below shows that the standard deviations for each engine generally range from approx. 0.5 – 3.5. with one at 6.75 for Engine 9 Bank A. This demonstrates very low variation about the mean for each engine, and the $NO_x$ emissions from these engines can therefore be considered stable enough to calculate the ammonia slip from the continuously measured $NO_x$ emissions. Where $NO_x$ emissions are relatively stable the associated ammonia dosing and reaction chemistry would similarly be expected to be stable with a consequence of a consistent ammonia slip.

**Table 4.2: Summary of $NO_x$ Emissions as Measured at Creyke Beck Peaking Plant**

| Engine | Bank | Max NOx (mg/m$^3$) | Min NOx (mg/m$^3$) | Standard Deviation |
|---|---|---|---|---|
| 1 | A | 160.1 | 140.9 | 2.66 |
| | B | 164.1 | 150.1 | 2.34 |
| 2 | A | 154.1 | 141 | 2.24 |
| | B | 157.3 | 147.4 | 2.03 |
| 3 | A | 176.6 | 157.9 | 3.76 |
| | B | 176.8 | 164.3 | 3.12 |
| 4 | A | 166.1 | 150.1 | 2.51 |
| | B | 176.4 | 164.3 | 1.98 |
| 5 | A | 182.0 | 167.9 | 2.87 |
| | B | 165.1 | 154.4 | 2.09 |
| 6 | | 168.4 | 149.5 | 3.21 |
| 7 | A | 139.1 | 133.2 | 1.52 |
| | B | 126.9 | 118.9 | 1.56 |

[6] Anderson, C. M. and Billings, J. A. (1990). Calculating $NH_3$ Slip for SCR Equipped Cogeneration Units, The American Society of Mechanical Engineers.

[7] EnviroDAT (2018). Report for the Periodic Monitoring of Emissions to Air from a Gas Engine Located at Creyke Beck Peaking Plant.

[8] EnviroDAT (2018). Report for the Periodic Monitoring of Emissions to Air from 10 Gas Engines Located at Creyke Beck Peaking Plant.

| Engine | Bank | Max NOx (mg/m$^3$) | Min NOx (mg/m$^3$) | Standard Deviation |
|---|---|---|---|---|
| 8 | A | 151.7 | 138.4 | 2.00 |
| | B | 145.6 | 140.3 | 1.30 |
| 9 | A | 168.8 | 123.5 | 6.75 |
| | B | 157.7 | 132 | 3.67 |
| 10 | A | 116.3 | 110.3 | 1.51 |
| | B | 115.4 | 109.7 | 1.08 |
| 11 | A | 98.9 | 91.6 | 1.07 |
| | B | 104.5 | 102.1 | 0.47 |

4.8.14 On this basis it is proposed to undertake only periodic monitoring of ammonia as set out in Table 4.1.

### Emissions to water and land

4.8.15 Water discharges will result from rain water surface run-off from roofs, roads and hard-standing, but there will be no process water discharges associated with the GFGF. Rain water collected in bunds will be tested for glycol to drinking water standards. If drinking water standards are met the water will be released to the Belasis Beck, if not the water will be removed from site to a waste processing centre.

4.8.16 There will be no discharges to land from the GFGF.

### Process Monitoring

4.8.17 Key process monitoring will be carried out to monitor the plant performance including water usage, energy consumption (natural gas and electricity), hours of operation and power generated. These performance parameters will be reported on an annual basis, in keeping with the permit.

4.8.18 The plant performance and equipment will be continually monitored and a system will be in place to optimise performance.

# 5 IMPACTS

5.1.1 To support this application a number of environmental assessments have been performed. The full details of these assessments are appended to this application and a reference to the full assessment is given where relevant for the environmental issues detailed below.

## 5.2 Emissions to Air

5.2.1 An air quality assessment has been undertaken to support this application and full details of the assessment are reported in Appendix C – Air Quality Assessment.

5.2.2 The approach to the assessment of emissions from the exhaust stacks has involved the following key elements:

- Establishing the background Ambient Concentration (AC) from consideration of Air Quality Review & Assessment findings and assessment of existing local air quality through a review of available air quality monitoring and Defra background map data in the vicinity of the proposed site.
- Quantitative assessment of the operational effects on local air quality from the proposed stack emissions utilising a "new generation" Gaussian dispersion model, ADMS 5.
- Assessment of Process Contributions (PC) from the GFGF, and assessment of resultant Predicted Environmental Concentrations (PEC), taking into account cumulative impacts through incorporation of the AC.

5.2.3 Dispersion modelling was undertaken using ADMS 5, a version of the ADMS (Atmospheric Dispersion Modelling System) developed by Cambridge Environmental Research Consultants, (CERC) which calculates the mean concentration over flat terrain, whilst allowing for the effect of plume rise, structures, complex terrain and deposition.

5.2.4 Several meteorological parameters were required for the dispersion modelling, including; wind speed, wind direction, cloud cover and temperature. Dispersion model simulations have been performed using three years of data from Durham Tees Valley Airport, between 2013 and 2015.

5.2.5 The effect of terrain and wake effects from surrounding structures has been incorporated into the dispersion model. Surface roughness of terrain has also been incorporated with a surface roughness length of 0.5 m assigned to represent the average surface characteristics across the study area.

5.2.6 Dispersion modelling has been undertaken for a worst case scenario assuming that the gas engines operate for 3,500 hours per year which represents the largest total number of operational hours considered as part of this assessment. It was also assumed that emissions of $NO_x$ would be 30 $mg/Nm^3$, this can be considered conservative as stated above, with the SCR system the emissions will be 20 $mg/Nm^3$. Modelling of point source impacts was undertaken using a fine grid of 3 km by 3 km, with a grid spacing of 30 m. Modelling was carried out at the façades of existing local receptors using a height of 1.5 m, to determine the effect on air quality for sensitive human receptors and at the closest ecological sites.

5.2.7 Emissions from the GFGF have been assessed against relevant Air Quality Assessment Levels (AQALs). Long-term (annual-mean) $NO_2$ has been modelled for comparison with the relevant annual mean objective of 40 $\mu g/m^3$. For short-term $NO_2$, the objective is for the hourly-mean concentration to not exceed 200 $\mu g/m^3$ more than 18 times per calendar year, equivalent to the 99.79th percentile of hourly $NO_2$.

5.2.8 Modelling has assumed a 70% conversion of NO to $NO_2$ for annual average $NO_2$ concentrations. Justification of the conversion factors is provided within the Air Quality Assessment.

## Stack Height Determination

5.2.9 The stack height selected for the optimum dispersion of pollutants from the exhaust stacks is determined to be 15 m, based on the Stack Height Determination. This height has been identified as the height at which the wake effect of nearby structures is overcome.

## Dispersion Modelling Assessment Results

5.2.10 The results show that the maximum short-term PC anywhere across the modelling grid is 22% of the relevant air Quality Assessment Level (AQAL). The maximum short-term PEC is below the AQAL. As such, the short-term $NO_2$ impacts based on modelling across the grid are not considered to be significant.

5.2.11 The results show that the highest PC as a percentage of the AQAL at any discrete receptor is 1%. As the PC is less than 10% of the AQAL, the impacts are considered not significant. Furthermore, when the PC is added to the AC, the maximum PEC is 30.0 µg/m$^3$, approximately 15% of the AQAL. This indicates that there is considerable head-room between the PEC and the AQAL.

5.2.12 The maximum long-term PC is more than 1% of the AQAL and the impacts are considered to be potentially significant. The maximum long-term PEC is well below the AQAL. As such, the long-term $NO_2$ impacts based on modelling across the grid are not considered to be significant. The highest predicted concentration is not at a location where the public would be exposed.

5.2.13 The predicted process contributions is less than 1% of the annual-mean limit value of 40 µg/m$^3$ at all of the discrete receptors. On this basis, the long-term impacts are not considered to be significant.

5.2.14 Using professional judgement and experience of similar projects, the resulting air quality effect of the proposed development is considered to be ‘not significant’ overall.

# 5.3 Assessment of Impacts at Ecological Receptors

5.3.1 An assessment of air quality impacts for nearby ecological receptors has been made and can be found within the Air Quality Assessment within Appendix C.

5.3.2 In line with EA guidance for air impact screening for conservation areas[9], the assessment has considered the impacts from the installation in terms of $NO_x$ concentrations, nutrient nitrogen deposition and acid deposition for the following sites:

- Teesmouth & Cleveland Coast SPA, Ramsar, SSSI & pSPA;
- Northumbria Coast SPA & Ramsar site;
- North York Moors SPA;
- Durham Coast SAC; and
- North York Moors SPA.

5.3.3 The assessment has determined the Critical Loads for both Nutrient Nitrogen Deposition and Acidification and compared these to the PC resulting from the operation of the installation following variation. Critical Loads are the quantity of pollutant deposited below which significant harmful effects on sensitive elements of the environment do not occur.

5.3.4 The maximum PC and PEC of $NO_x$ and N/acid deposition are compared to the relevant EQS for the relevant habitat type. Where the PC is less than 1% of the relevant EQS for European

[9] Environment Agency (2016), Screening for protected conservation areas. Available at: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#screening-for-protected-conservation-areas

designated sites, or less than 100% for LNR/NNR the effect is considered not significant. Likewise for European and SSSI sites where the PC is greater than 1% but the PEC is less than 70% then the effects are considered insignificant. Where the PC exceeds 1% and the PEC exceeds 70% the effects are considered potentially significant and hence would require further detailed assessment.

5.3.5 The assessment has concluded that:

- The maximum annual-mean $NO_x$ PC is above 1% of the critical level at three habitat sites. However, the PECs are below the critical level. As such, the emissions are not considered to be significant.
- The maximum daily-mean $NO_x$ PC is above 10% of the critical level at Teesmouth & Cleveland Cost SPA / Ramsar site, SSSI And pSPA. The PECs across parts of these sites exceeds the critical level of 75 $\mu g.m^{-3}$ and the emissions are considered to be potentially significant. Consequently, these impacts have been assessed by an ecologist and an assessment report can be found at Appendix I. This concludes that with regards to how these threshold exceedances may affect the habitats, and hence species, associated with the Teesmouth and Cleveland Coast SPA/pSPA it is concluded that they are either located far enough away to be affected, are not susceptible to the effects of increased nutrient delivery or the contributions from the proposed facility would be infinitesimal compared to the natural inputs which the associated habitats currently receive from the surrounding environment (e.g. riverine, tidal and fertilisation inputs).
- The maximum nitrogen deposition PC exceeds 1% of the critical load range at the Teesmouth & Cleveland Coast SPA / Ramsar site, SSSI and pSPA. The PECs across parts of these sites exceed the minimum critical load for some interest features and the emissions are considered to be potentially significant. Consequently, these impacts have been assessed by an ecologist and an assessment report can be found at Appendix I. This concludes that with regards to how these threshold exceedances may affect the habitats, and hence species, associated with the Teesmouth and Cleveland Coast SPA/pSPA it is concluded that they are either located far enough away to be affected, are not susceptible to the effects of increased nutrient delivery or the contributions from the proposed facility would be infinitesimal compared to the natural inputs which the associated habitats currently receive from the surrounding environment (e.g. riverine, tidal and fertilisation inputs).
- The maximum acid deposition PC exceeds 1% of the Critical Load Function at the Teesmouth & Cleveland Coast SSSI and pSPA. However, the PECs at these sites do not exceed the minimum critical loads. On that basis, the impacts are not considered to be significant.

## 5.4 Emissions to Water and Sewer

5.4.1 The GFGF will not result in any process water discharges to surface waters or foul sewer. The only discharges anticipated will arise from rainwaters and their subsequent run-off from roads, rooftops and hardstanding.

5.4.2 Surface waters consisting of clean rainwater from the GFGF will enter the surface water drainage system before being discharged to Belasis Beck. Water will flow through an oil/water interceptor to remove any oil and grease. For this reason, emissions to water and sewer do not require further assessment.

## 5.5 Noise and Vibration

5.5.1 Appendix D – Noise Assessment to this application provides details of the assessment of noise effects from the operation of the facility. Significant vibration effects are not expected from operation of the GFGF.

5.5.2 Noise levels arising from the operational activities were predicted using SoundPLAN 7.4 environmental noise prediction software, implementing the methodology within ISO 9613-2:1996. The model has predicted noise levels under light down-wind conditions, as well as other conditions based on the procedures detailed in ISO 9613, and as outlined within the Noise Assessment. The significance of the operational effects of noise at residential receptors has been assessed using the methodology contained within BS 4142.

5.5.3 Noise emissions from the GFGF and associated ancillary equipment are expected to be broadband and steady in nature and will not contain other readily distinctive characteristics, hence no acoustic feature correction has been applied.

5.5.4 The noise assessment was based on a combination of long-term and attended short-term surveys to obtain values of the background ($LA_{90}$), residual ($LA_{eq}$) and maximum ($LA_{max}$) sound levels for both day-time and night-time at six locations.

5.5.5 Although some residents living in close proximity to the proposed GFGF could experience higher noise levels during the quietest period of the night compared to what they are used to, it is the daytime and evening periods that are of greatest concern with respect to the impact on quality of life (amenity, enjoyment of property etc.). This is because people will tend to be indoors or asleep during the night, whereas during the day and evening they are more likely to be using outdoor spaces for amenity purposes.

5.5.6 It has been established that the GFGF will result in, at most, a 1 dB increase in ambient noise during the daytime and evening and a 2 dB increase during the night. This change in noise level is unlikely to be noticeable during the daytime or evening. It is therefore only considered that specific sound will not give rise to any adverse impacts during the daytime and evening.

5.5.7 In terms of the absolute noise level assessment, noise from the proposed GFGF will be significantly less than the 55 dB $L_{Aeq}$ noise level specified in WHO guidance for the onset of annoyance during the daytime. Thus, taking both the change in noise level and the absolute noise level assessment into consideration, the facility will not result in an adverse impact on quality of life.

5.5.8 The level for the onset of sleep disturbance during the night-time contained in the WHO Guidance is 45 dB $L_{Aeq}$. Baseline residual sound levels, in the absence of the GFGF, exceed this threshold level at all receptors by up to 8 dB.

5.5.9 At dwellings on Cowpen Bewley Road (the most affected noise sensitive receptors (NSRs)) total ambient night-time sound levels with the GFGF in operation would be 3 dB above the WHO threshold level for sleep disturbance. Existing ambient night-time baseline sound levels at this location currently exceed the WHO threshold level by 1 dB. It is therefore considered that despite the +2 dB ambient noise change as a result of the operation of the GFGF during the night, the impact on sleep disturbance at the most affected NSR would be low.

5.5.10 The BS 4142:2014 assessment indicates that noise from the facility is unlikely to result in an adverse impact during the daytime and evening when the plant is most likely to operate and is therefore of low significance during this period. There is a possibility that a slight adverse impact could occur during the night in the unlikely event (as demand is low) that the plant is required to operate in that period. In accordance with the Government's noise policy aims there is therefore a requirement to ensure that the noise impacts have been reduced through use of appropriate mitigation. In this respect, the operator will install appropriate mitigation measures in order to reduce noise by use of industry good practice. Examples of some of the types of mitigation that could be employed, depending on the site design and equipment chosen, are described in Section 5 of the noise report.

5.5.11 Taking the above factors into consideration, it is concluded that noise from the GFGF will not result in a significant adverse impact at any of the nearby noise sensitive receptors and that the noise from site has been mitigated and appropriately controlled.

## 5.6 Global Warming Potential

5.6.1 Global warming effects have been considered within the Environmental Risk Assessment (ERA) in Appendix E.

5.6.2 The global warming potential (GWP) score of 69,825 represents the effect from gas burned within the engines. It should be noted that energy will be required for non-running times and for start-up and shutdown but this consumption is likely to be very small.

## 5.7 Photochemical Ozone Creation Potential

5.7.1 $NO_2$ emissions from the installation contribute to photochemical ozone creation. The total photochemical ozone creation potential (POCP) for the GFGF facility is 88.44.

5.7.2 Releases of $NO_2$ are discussed in further detail within the ERA in Appendix E and in Section **Error! Reference source not found.** of this report in support of the selection of the abatement plant for controlling the releases.

# 6 BAT ASSESSMENT

6.1.1 The following section provides supporting information for the selection of the following:

- Combustion technique and operating hours (this includes consideration of NOx performance, ammonia and global warming potential (GWP));
- Stack configuration;
- Control of emissions to air (not included in the assessment of combustion technology above); and
- Cooling system.

## 6.2 Selection of Combustion Technique and Operating Hours

6.2.1 The proposed plant is being installed to provide fast response electricity to the grid during periods of peak demand. The need for flexible generation will become increasingly important as times of system imbalance become more difficult to predict. Over and above the intermittency of wind, coupled with the seasonal and diurnal availability of solar, the mass electrification of transport could introduce massive swings in demand and there is the potential for negative repercussions on imported renewable energy from Brexit, if this is not well managed. The greater the ability of a plant to ramp up and down, the more efficient it is in the balancing system, which reduces costs to the consumer and the economy[10].

6.2.2 The current method for balancing the power market in the UK is to bring a new power station online at half capacity and to back another down, also to half capacity. The upside available margin created at the two power stations is then used to fill any requirements for increased generation in the market during peak hours[11].

6.2.3 This can be successful in terms of balancing the market but produces higher carbon emissions on start-up until the plants are operating at full load and is costly. It can take several hours to start a combined cycle gas turbine (CCGT) up from cold and up to two hours to start up from warm. These higher emissions are produced even when no additional balancing is required (which occurs frequently). This type of balancing is clearly inefficient, and this is particularly true for the aging fleet of CCGT power stations that now operate in the UK market.

6.2.4 Available technologies considered within this section are gas turbines and gas engines. An alternative option is use of diesel compression ignition engines; however, implementation of this combustion method would result in a wider range of pollutants generated from combustion including $SO_2$ and particulates and greater emissions of $NO_x$. Spark ignition engine combustion temperatures are low compared to other reciprocating engines, this means these engines result in lower $NO_x$ production. Furthermore, there would be additional requirements for diesel storage (and associated increased potential for accidents), as well as a greater number of vehicle movements on site for fuel delivery. As such implementation of diesel compression ignition engines has been ruled out from further consideration. Selection of the fuel to be burned and the selection of natural gas over other fuels for power generation have previously been discussed in section 2.

6.2.5 The primary BAT issues associated with combustion plant and specifically GFGF are their ability to meet peak demand, emissions to air and energy efficiency. Emissions to water and land, noise, odour and accident potential for these options would be expected to be similar and therefore consideration of these issues has been excluded from the comparison of options.

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[10] RPS (2018). DEFRA Clean Air Strategy Consultation Response, August 2018.

[11] EnAppSys (2017). Email from P Verrill, EnAppSys and A Troup, Statera Energy, 05 December 2017.

6.2.6 Combustion technologies considered in this assessment include:

- CCGTs – a range of CCGTs were considered, comparing performance as per the Large Combustion Plant (LCP) BAT conclusion (BATC) ranges, rapid start and high efficiency H-Class CCGTs.
- Open cycle gas turbine (OCGT) – OCGT options were considered comparing the performance as specified in BATC.
- Gas reciprocating engines – two options were considered here, the selected option using high efficiency larger gas reciprocating engines with SCR and a smaller engine design of a size subject to medium combustion plant requirements.

6.2.7 The comparison looked at the performance of these technologies in delivering five different operating regimes. The options considered were agreed during a meeting with the EA[12], as follows:

- Scenario 1 – Baseload operation, assuming continuous operation at full load for 8,760 hours per annum.
- Scenario 2 – Peaking 2 Shift, plant operate twice daily for 4 hours each run, total hours operation per annum 2,920 hours.
- Scenario 2a – Peaking 2 shift, plant operates twice daily for 4 hours each run but limited to 1,500 hours per annum.
- Scenario 3 – Super peaking, plant operates for a single 12 hour run daily, total hours operation per annum 4,380 hours.
- Scenario 4 – 3 x 2 hour runs daily, total hours operation per annum 2,190 hours.

6.2.8 The analysis has included start-up emissions. As the data has been gathered for combustion plant of various sizes emissions performance has been presented as specific emissions per MWh electrical output. Data to inform the assessment has been gathered from various sources as described below:

## CCGT Data

6.2.9 Data for the CCGT options is summarised in **Table 6.1** below. $NO_x$ emissions data has been taken from the LCP BATC[13]; BATC low data reflects the lower end of the BATC emissions performance and the BATC high data reflects the higher emissions performance. Similarly the BATC EEALs have been presented considering the energy efficiency performance range set out in the LCP BATCs. Exceptions to this are the H-Class CCGT option which has assumed the high level of energy efficiency performance presented in manufacturers' data[14] and the rapid start option for which data could only be obtained for an existing CCGT option with an efficiency of 50%[15]. Start-up emissions data were provided for a new CCGT (650 MWe), mid merit CCGT (390 MWe) and rapid start CCGT option (650 MWe)[15]. All CCGT options considered other than the rapid start and mid merit CCGT options have assumed the new CCGT start up emissions performance.

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[12] Meeting between Statera, RPS and John Henderson and Richard Chase of the EA 09/01/2019

[13] European Commission (2017), Best Available Techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D1442&from=EN

[14] https://www.ge.com/power/gas/gas-turbines/h-class

[15] Data from a confidential source.

6.2.10 In order to calculate mass emissions, exhaust gas flow rates have been taken from publicly available air quality assessments. The H-Class turbine data is based on data for the Eggborough facility which was based on an H-Class turbine design (total electrical output of 2,500 MW from 3 units = 833 MWe per unit). All other CCGT options have used data for the Seabank 3 facility although this was scaled from a 700 MWe to a 650 MWe to align with start-up data which had been provided for a 650 MWe facility. For the mid merit option exhaust gas flow data was scaled from 390 MWe to align with the start-up data that was provided for this size of plant.

6.2.11 To achieve the lower NOx emissions set out in BATC, SCR would need to be applied which can give rise to ammonia slippage. The comparison of ammonia emissions is based on ammonia slippage as set out in the BATC which provides a range of 3-10 $mg/Nm^3$.

6.2.12 The thermal input of each option has been calculated from the stated electrical input and the stated efficiency for each option.

6.2.13 The global warming potential (GWP) has been assessed using data provided by AECOM on start-up emissions from a 50 MWe CCGT. Continuous operation emissions have been calculated on the basis of the plant thermal input which has been derived for a 50 MWe facility using the efficiencies presented in **Table 6.1** and DEFRA $CO_2$ factors[16] applied to the thermal input.

[16] $CO_2$ factor of 0.2039 kg $CO_2$/KWh (net) source DEFRA Greenhouse reporting 2019, https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

**Table 6.1. Summary of CCGT data inputs**

| Technology | | | CCGT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | H-Class | | BREF New CCGT | | BREF Existing | | Rapid Start | Mid Merit | |
| | | | BATC low | BATC high | BATC low | BATC high | BATC low | BATC high | BATC low | BATC low | BATC high |
| Thermal Input | MW per unit | | 1,302 | 1,302 | 1,111 | 1,226 | 1,204 | 1,413 | 1,300 | 667 | 780 |
| Start-up Time | min | Cold | 190 | 190 | 190 | 190 | 190 | 190 | 55 | 280 | 280 |
| | | Warm | 105 | 105 | 105 | 105 | 105 | 105 | 40 | 155 | 155 |
| | | Hot | 55 | 55 | 55 | 55 | 55 | 55 | 20 | 85 | 85 |
| Net Efficiency | % | | 64 | 64 | 58.5 | 53 | 54 | 46 | 50 | 58.5 | 50 |
| NOx Concentration | mg/Nm$^3$ @15% $O_2$ | Max | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| | | Min | 10 | 30 | 10 | 30 | 10 | 45 | 10 | 10 | 45 |
| NOx Mass Emission | kg/event | Cold | 422 | 422 | 422 | 422 | 422 | 422 | 136 | 376 | 376 |
| | | Warm | 236 | 236 | 236 | 236 | 236 | 236 | 73 | 209 | 209 |
| | | Hot | 118 | 118 | 118 | 118 | 118 | 118 | 32 | 109 | 109 |
| Vol Flowrate | Nm$^3$/s | | 1,150 | 1,150 | 893 | 893 | 893 | 893 | 893 | 536 | 536 |
| | Nm$^3$/hr | | 4,140,000 | 4,140,000 | 3,214,714 | 3,214,714 | 3,214,714 | 3,214,714 | 3,214,714 | 1,928,829 | 1,928,829 |
| Electrical Output | MW per unit | | 833 | 833 | 650 | 650 | 650 | 650 | 650 | 390 | 390 |

## OCGT Data

6.2.14 Data for the OCGT options is summarised in **Error! Reference source not found.** below.

6.2.15 $NO_x$ emissions data has been taken from the LCP BATC[2], BATC low data reflects the lower end of the BATC emissions performance and the BATC high data reflects the higher emissions performance. Similarly, the BATC EEALs have been presented considering the energy efficiency performance range set out in the LCP BATCs. Start-up emissions data have been taken from published data[17]. This data has been applied to all OCGT options.

6.2.16 In order to calculate mass emissions, exhaust gas flow rates have been taken from publicly available air quality assessments. The data used in this comparison has come from the Eggborough AQ assessment for a 299 MWe F-Class OCGT.

6.2.17 To achieve the lower NOx emissions set out in BATC SCR would need to be applied which can give rise to ammonia slippage. The comparison of ammonia emissions is based on ammonia slippage as set out in the BATC which provides a range of 3-10 mg/Nm$^3$.

6.2.18 The thermal input of the OCGT options has been calculated for a 299 MWe unit with BATC EEAL performances as indicated in **Error! Reference source not found.**.

**Table 6.2. Summary of OCGT data inputs**

| Technology | | | OCGT | | | |
|---|---|---|---|---|---|---|
| | | | New | | Existing | |
| | | | BATC low | BATC high | BATC low | BATC high |
| Thermal Input | MW per unit | | 720 | 831 | 720 | 906 |
| Start-up Time | min | Cold | 60 | 60 | 60 | 60 |
| | | Warm | 30 | 30 | 30 | 30 |
| | | Hot | 10 | 10 | 10 | 10 |
| Net Efficiency | % | | 41.5 | 36 | 41.5 | 33 |
| NOx Concentration | mg/Nm$^3$ @15% $O_2$ | Max | 50 | 50 | 50 | 50 |
| | | Min | 15 | 35 | 15 | 50 |
| NOx Mass Emission | kg/event | Cold | 121 | 121 | 121 | 121 |
| | | Warm | 60 | 60 | 60 | 60 |
| | | Hot | 20 | 20 | 20 | 20 |
| Vol Flowrate | Nm$^3$/s | | 650 | 650 | 650 | 650 |
| | Nm$^3$/hr | | 2,340,000 | 2,340,000 | 2,340,000 | 2,340,000 |
| Electrical Output | MW per unit | | 299 | 299 | 299 | 299 |

## Gas Fired Reciprocating Engine Data

6.2.19 Data for the gas engine options is summarised in **Error! Reference source not found.** below. Two engine options have been considered, the proposed large engines (supplied by Man) with SCR falling under the large combustion plant BATC and smaller engines just below 10 MWth input falling under the Medium Combustion Plant Directive (MCPD)[18] emissions performance.

6.2.20 For the larger engine option $NO_x$ emissions data is based on the manufacturer's guaranteed performance with SCR installed. SCR is proposed as it is accepted as BAT for reducing NOx

[17] Evaluation of gas turbine start-up and shut-down emissions for new source permitting, Paper # 546 Session No. EI-2a Joseph J. Macak III Mostardi Platt Environmental, 1520 Kensington Road, Suite 204, Oak Brook, IL 60523-2139

[18] Directive (EU) 2015/2193 on the limitation of emissions of certain pollutants into the air from medium combustion plant, October 2015

emissions. Similarly, the exhaust gas flowrate and energy efficiency performance are based on data provided by Man. Start-up $NO_x$ emissions data has also been provided by Man. For all scenarios considered each start-up has assumed to be a cold start-up, this is considered conservative; where a warm start-up occurs, low start-up emissions could be achieved.

6.2.21 Data for the smaller engines is based on data for 4.5 MWe units as installed at the permitted Creyke Beck facility (permit reference VP3831DS). This facility is subject emissions limits set out in the MCPD and this is reflected in the issued permit. Emissions flowrate data reflects that used for modelling of emissions from the facility as submitted with the permit application and was based on data from GE. Energy efficiency performance and start-up emissions are based on data from manufacturers for this size of engine.

6.2.22 The thermal input of the engine options has been calculated from the unit electrical output and manufacturers' efficiency as indicated in **Error! Reference source not found.**.

6.2.23 To achieve lower $NO_x$ emissions SCR is applied which can give rise to ammonia slippage. The comparison of ammonia emissions is based on ammonia slippage as set out in the BATC which provides a range of 3-10 mg/Nm$^3$. The smaller MCP engines do not include SCR and therefore ammonia slippage associated with the abatement plant does not occur.

6.2.24 Gas engines can give rise to methane slippage. In the assessment below methane slippage during normal operation has been calculated using measured emissions concentrations from the Creyke Beck facility. In the absence of measured data for the larger engines it has been assumed that similar emission concentrations of methane would be emitted. Start-up $CO_2$ emissions have been provided by AECOM.

**Table 6.3. Summary of Gas Fired Reciprocating Engine data inputs**

| Technology | | | Gas Recip Engines | |
|---|---|---|---|---|
| | | | Man Engine with SCR | Creyke Beck MCPD |
| Thermal Input | MW per unit | | 24.7 | 9.9 |
| Start-up time | min | Cold | 6 | 2 |
| | | Warm | 6 | 2 |
| | | Hot | 6 | 2 |
| Net Efficiency | % | | 51 | 45.45 |
| NOx Concentration @ normal operation | mg/Nm$^3$ @15% $O_2$ | Max | 20 | 95 |
| | | Min | 20 | 20 |
| NOx Mass Emission | kg/event | Cold | 1.61 | 0.30 |
| | | Warm | 0.93 | 0.20 |
| | | Hot | 0.93 | 0.10 |
| Vol Flowrate | Nm$^3$/s | | 21.44 | 8.27 |
| | Nm$^3$/hr | | 77,184 | 29,772 |
| Electrical Output | MW per unit | | 12.6 | 4.5 |

## Emissions to air

6.2.25 The emissions to air of nitrogen oxides ($NO_x$), ammonia ($NH_3$), and methane ($CH_4$) / carbon dioxide ($CO_2$), i.e. global warming potential (GWP), for CCGT, OCGT and gas reciprocating engines have been compared to determine which combustion technique is BAT for the proposed plant in terms of emissions to air.

6.2.26 Table 6.4 provides a comparison of specific $NO_x$ emissions performance. The table shows that the proposed $NO_x$ emissions are within the ranges given for all CCGT and OCGT options and for all operational scenarios considered. The performance of the proposed engines is significantly better than smaller engines operating to emissions performance specified within the MCPD.

6.2.27 The summary of the specific ammonia emissions from each combustion technique is provided in Table 6.5**Error! Reference source not found.** below. Given ammonia emissions are a function of the exhaust gas flow and for each option operation at full load is assumed, emissions do not differ across the various operating scenarios. As stated above the smaller MCP sized engine without SCR will not give rise to ammonia slippage associated with the operation of the abatement plant, on this basis this option gives rise to best ammonia emissions performance. All other options operate across a relatively similar performance range. The proposed larger gas engines can achieve lower specific ammonia slippage than OCGT options. Compared to the CCGT options the proposed larger gas engines are capable of providing a similar specific ammonia performance, although above around 8 $mg/Nm^3$, slightly higher specific ammonia performance would be expected. The proposed larger engines are expected to achieve ammonia slippage of 5 $mg/Nm^3$ and therefore the specific ammonia performance of the engines will be within the performance range for the CCGT options considered.

6.2.28 To compare the global warming potential (GWP) performance of each option the $CO_2$ equivalent ($CO_2e$) per MWh electrical output has been calculated for each option and scenario as defined above for each of the technologies (see paragraphs 6.2.12 & 6.2.24 above). For OCGTs start-up emissions has not be made available. In the absence of other data start-up data for CCGTs has been assumed and continuous running data is based on gas consumption of the OCGT. This comparison is presented in Table 6.6.

**Table 6.4. Summary of specific NOx emissions from CCGT, OCGT and gas reciprocating engines**

| Scenario | Maximum hours per annum | CCGT | | | | | | | | | OCGT | | | | Gas Recip Engines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H-Class | | BREF New CCGT | | BREF Existing | | Rapid Start | Mid Merit | | New | | Existing | | Man Engine | Creyke Beck |
| | | BATC low | BATC high | BATC low | BATC high | BATC low | BATC high | BATC low | BATC low | BATC high | BATC low | BATC high | BATC low | BATC high | With SCR | MCPD |
| Scenario 1 - Baseload operation | 8,760 | 0.050 | 0.149 | 0.049 | 0.148 | 0.049 | 0.198 | 0.049 | 0.049 | 0.223 | 0.117 | 0.274 | 0.117 | 0.391 | 0.123 | 0.629 |
| Scenario 2 - Peaking (2 shift) | 2,920 | 0.095 | 0.194 | 0.095 | 0.194 | 0.095 | 0.243 | 0.062 | 0.119 | 0.292 | 0.134 | 0.291 | 0.134 | 0.408 | 0.154 | 0.645 |
| Scenario 2a - Peaking (2 shift) | 1,500 | 0.154 | 0.252 | 0.154 | 0.252 | 0.154 | 0.302 | 0.082 | 0.205 | 0.378 | 0.176 | 0.333 | 0.176 | 0.450 | 0.155 | 0.645 |
| Scenario 3 - Super peaking (12 hour run) | 4,380 | 0.073 | 0.173 | 0.080 | 0.179 | 0.080 | 0.228 | 0.059 | 0.094 | 0.267 | 0.134 | 0.291 | 0.134 | 0.408 | 0.133 | 0.634 |
| Scenario 4 - 3 x 2 hour runs | 2,190 | 0.144 | 0.243 | 0.170 | 0.269 | 0.170 | 0.319 | 0.085 | 0.232 | 0.405 | 0.173 | 0.330 | 0.173 | 0.447 | 0.186 | 0.662 |

**Table 6.5. Summary of specific ammonia emissions from CCGT, OCGT and gas reciprocating engines**

| Scenario | Maximum hours per annum | CCGT | | | | | | | | | OCGT | | | | Gas Recip Engines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | New H-Class | | New | | Existing | | Rapid Start | Mid Merit | | New | | Existing | | Man Engine with SCR | |
| Scenario 1 - Baseload operation | 8,760 | 0.015 | 0.050 | 0.015 | 0.049 | 0.015 | 0.049 | 0.015 | 0.015 | 0.049 | 0.023 | 0.078 | 0.023 | 0.078 | 0.018 | 0.061 |
| Scenario 2 - Peaking (2 shift) | 2,920 | 0.015 | 0.050 | 0.015 | 0.049 | 0.015 | 0.049 | 0.015 | 0.015 | 0.049 | 0.023 | 0.078 | 0.023 | 0.078 | 0.018 | 0.061 |
| Scenario 2a - Peaking (2 shift) | 1,500 | 0.015 | 0.050 | 0.015 | 0.049 | 0.015 | 0.049 | 0.015 | 0.015 | 0.049 | 0.023 | 0.078 | 0.023 | 0.078 | 0.018 | 0.061 |
| Scenario 3 - Super peaking (12 hour run) | 4,380 | 0.015 | 0.050 | 0.015 | 0.049 | 0.015 | 0.049 | 0.015 | 0.015 | 0.049 | 0.023 | 0.078 | 0.023 | 0.078 | 0.018 | 0.061 |
| Scenario 4 - 3 x 2 hour runs | 2,190 | 0.015 | 0.050 | 0.015 | 0.049 | 0.015 | 0.049 | 0.015 | 0.015 | 0.049 | 0.023 | 0.078 | 0.023 | 0.078 | 0.018 | 0.061 |

**Table 6.6. Summary of $CO_2e$ emissions from CCGT, OCGT and gas reciprocating engines**

| Scenario | Maximum hours per annum | CCGT | | | | | | | | OCGT | | | | Gas Recip Engines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H-Class | BREF New CCGT | | BREF Existing | | Rapid Start | Mid Merit | | New | | Existing | | Man Engine with SCR | |
| | | | BATC low | BATC high | BATC low | BATC high | | BATC low | BATC high | BATC low | BATC high | BATC low | BATC high | | |
| Scenario 1 - Baseload operation | 8,760 | 0.319 | 0.349 | 0.385 | 0.378 | 0.443 | 0.408 | 0.349 | 0.408 | 0.566 | 0.491 | 0.566 | 0.491 | 0.449 | 0.531 |
| Scenario 2 - Peaking (2 shift) | 2,920 | 0.496 | 0.526 | 0.562 | 0.555 | 0.620 | 0.585 | 0.526 | 0.585 | 0.743 | 0.668 | 0.743 | 0.668 | 0.452 | 0.534 |
| Scenario 2a - Peaking (2 shift) | 1,500 | 0.424 | 0.454 | 0.490 | 0.483 | 0.549 | 0.513 | 0.454 | 0.513 | 0.672 | 0.597 | 0.672 | 0.597 | 0.452 | 0.534 |
| Scenario 3 - Super peaking (12 hour run) | 4,380 | 0.354 | 0.384 | 0.420 | 0.413 | 0.478 | 0.443 | 0.384 | 0.443 | 0.601 | 0.526 | 0.601 | 0.526 | 0.450 | 0.516 |
| Scenario 4 - 3 x 2 hour runs | 2,190 | 0.625 | 0.655 | 0.691 | 0.684 | 0.749 | 0.714 | 0.655 | 0.714 | 0.872 | 0.797 | 0.872 | 0.797 | 0.455 | 0.521 |

**Table 6.7. Summary of $CO_2e$ emissions from CCGT, OCGT and gas reciprocating engines – further analysis of Scenario 4**

| Scenario | Maximum hours per annum | CCGT | | | | | | | | | OCGT | | | | Gas Recip Engines | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H-Class | | BREF New CCGT | | BREF Existing | | Rapid Start | Mid Merit | | New | | Existing | | Man Engine with SCR | |
| | | | | BATC low | BATC high | BATC low | BATC high | | BATC low | BATC high | BATC low | BATC high | BATC low | BATC high | | |
| Scenario 4 (modified) - 3 start-ups variable hours | 3,500 | 0.510 | 0.510 | 0.540 | 0.576 | 0.569 | 0.635 | 0.599 | 0.540 | 0.599 | 0.758 | 0.683 | 0.758 | 0.683 | 0.453 | 0.519 |
| Scenario 4 (modified) - 3 start-ups variable hours | 4,750 | 0.460 | 0.460 | 0.490 | 0.526 | 0.519 | 0.584 | 0.549 | 0.490 | 0.549 | 0.707 | 0.632 | 0.707 | 0.632 | 0.452 | 0.518 |
| Scenario 4 (modified) - 3 start-ups variable hours | 5,000 | 0.453 | 0.453 | 0.483 | 0.519 | 0.512 | 0.577 | 0.542 | 0.483 | 0.542 | 0.700 | 0.625 | 0.700 | 0.625 | 0.452 | 0.518 |
| Scenario 4 (modified) - 3 start-ups variable hours | 5,250 | 0.446 | 0.446 | 0.476 | 0.512 | 0.505 | 0.571 | 0.535 | 0.476 | 0.535 | 0.694 | 0.619 | 0.694 | 0.619 | 0.452 | 0.517 |
| Scenario 4 (modified) - 3 start-ups variable hours | 5,500 | 0.440 | 0.440 | 0.470 | 0.507 | 0.499 | 0.565 | 0.530 | 0.470 | 0.530 | 0.688 | 0.613 | 0.688 | 0.613 | 0.452 | 0.517 |

6.2.29 Based on the analysis presented OCGTs perform worst for all scenarios. For the scenarios presented the engines demonstrate variable performance against CCGTs. It is clear that the performance is not tied to the number of hours the plant is operating but the number of start-ups. The greater the number of start-ups the better the proposed larger engines perform against CCGTs. **Table 6.7** presents further analysis of scenario 4, looking at 3 start-ups per day but operating for longer, and shows that for hours up to circa 4,750 hours the larger engines perform well against all CCGTs including H-Class turbines, and for OCGT options based on BAT conclusion energy efficiency performance, the larger engines perform well for total operating hours in excess of 5,000 hours.

6.2.30 Whilst not supportive of the proposed larger engines operating baseload, the analysis does demonstrate that these engines perform well when operating in a flexible generating market where multiple start-up and shutdowns are required and perform well against CCGT options for significantly more than the proposed 3,500 hours.

## Energy Efficiency

6.2.31 The proposed gas engines are capable of net efficiencies of up to 51%. The LCP BAT-C[13] Table 23 gives a BAT-associated energy efficiency level (BAT-AEEL) of 39.5 – 44% for natural gas fired engines. The efficiency of the proposed engines to be installed is above the identified BAT range. Typical and maximum efficiencies are provided in Table 6.8 below.

**Table 6.8: BAT Associated Energy Efficiency Levels (BAT-AEELs) for Different Combustion Technologies (new)**

| Option | Electrical Efficiency (%)(1) | |
|---|---|---|
| | Minimum | Maximum |
| 1: Gas Reciprocating Engines | 39.5 | 44(2) |
| 2: OCGT | 36 | 41.7 |
| 3: CCGT | 53 | 58.5(3) |

1. ISO efficiency when new.
2. The proposed larger engines are capable of higher efficiencies up to 51%
3. H-Class CCGTs are capable of higher efficiencies up to 64%.

6.2.32 Overall CCGTs provide the best efficiencies, although noting that the proposed larger engines achieve much higher efficiencies than the range in the BATC and are approaching the efficiencies of new gas turbines. OCGTs show the lowest energy efficiency performance.

6.2.33 The above efficiencies are for operation at full load. For CCGTs, efficiencies can fall below 50% when operating at anything less than 65% of the full load. At efficiencies of 50% a CCGT is operating at a similar efficiency to the proposed high efficiency engines. For OCGTs operating at half load, the efficiency can drop below 30%[19]. The efficiency of gas engines will similarly drop if operated at part load, but efficiency effects based on manufacturers' data sheets only reduce typically by 3-5%[20]. With multiple engine units in place, the reciprocating engines can provide the flexibility to only operate the number of units required for the specific peaking demand to be met, and therefore keeping the operational units at high efficiency, avoiding the need to operate units at part loads with lower efficiency.

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[19] Wärtsilä, Combustion Engine vs. Gas Turbine: Part Load Efficiency and Flexibility. Available online: https://www.wartsila.com/energy/learning-center/technical-comparisons/combustion-engine-vs-gas-turbine-part-load-efficiency-and-flexibility

[20] RPS (2018). JAS9081 BAT Assessment, RPS, February 2018.

6.2.34 NOx control in engines without SCR is achieved by lean burn operation, which lowers efficiency. Using SCR means lean burn operation is not required, with associated efficiency improvements.

## Meeting Flexible Energy Demands

6.2.35 Fundamentally the operating nature of a flexible generating facility requires rapid response times and therefore short start up times. Gas engines can start up in as little as 2 – 5 minutes, open cycle gas turbines (OCGT) in 20 minutes and combined cycle gas turbines (CCGT) in 30 minutes, although some fast-start aeroderivative CCGT plants have been known to start up in 10 minutes from warm[20]. Combined cycle operation does not facilitate the short start up times and therefore this mode of operation has been discounted. Some of the oldest CCGT plants in the market have already opted to go open cycle, which allows them to start within 30 minutes and to run for much shorter periods of time (providing this required flexibility), although it brings trade-offs with efficiency. The use of open cycle gas turbines does not offer the highest levels of efficiency (maximum 38.7%[20]); consequently the preferred technology to provide flexible supply is spark ignition reciprocating gas engines, which can start up in less than 5 minutes.

## Meeting Future Energy Demands

6.2.36 The target for net zero UK carbon emissions by 2050 has now been set. To achieve this ambitious target alternatives to natural gas for energy generation are high on the agenda and hydrogen and green ammonia are very much under consideration.

6.2.37 These fuels, once fully commercially available, are well suited to combustion within the proposed engines. Although current proposals are based on burning gas, once alternative fuels become available the plant can readily switch to burning these alternative fuels.

6.2.38 In addition to removing $CO_2$ associated with burning natural gas, methane emissions and ammonia slippage from the operation of SCR will be avoided.

## Summary and Discussion

6.2.39 The comparison of combustion technologies has demonstrated that the proposed engines with SCR are capable of operation to a similar or better $NO_x$ specific emissions and GWP performance when compared to OCGT and CCGTs. This applies to all operational scenarios considered.

6.2.40 Ammonia slippage from the proposed engines is expected to achieve 5 mg/Nm$^3$, this is well below the BATC upper level of 10 mg/Nm$^3$. At this emissions level the specific emissions performance from the engines compares well with CCGT and exceeds the performance of OCGT options for all options.

6.2.41 The specific GWP performance of the options considered is not simply a factor of hours of operation but is very much influenced by the number of start-ups required. This is supportive of the larger engines operating within a flexible generation market where they can be required to start-up and shutdown several times per day, leaving CCGTs to predominantly serve baseload duties.

6.2.42 Currently this duty is met either by peaking plant based on gas engines with a combined thermal input less than 50 MW, typically with low efficiency and high $NO_x$ emissions which currently can be permitted to operate any number of hours (subject to demonstration of no significant air quality impacts) or by larger plants >50 MW thermal input operating similar smaller engines (see MCPD option included in some aspects of this assessment) but constrained to 1,500 hours operation per annum (based on a 5 year rolling average with 2,250 hours maximum).

6.2.43 The analysis presented is supportive of this technology in meeting flexible energy generation requirements, controlling emissions that compare well with or are better than other options and operating for the proposed 3,500 hours per annum. The assessment has demonstrated that for this duty the proposed larger gas fired engines including SCR are BAT.

6.2.44 The installation of the proposed engines whilst currently meeting BAT also includes flexibility to operate on future available fuels providing the opportunity to further enhance the plant's environmental future and contribute to meeting future UK carbon targets.

## 6.3 Stack Configuration

6.3.1 This application is being made on the basis of 4 gas engines discharging exhaust gases via 4 individual stacks each of 15 m in height.

6.3.2 For sites where there are multiple releases to air alternative options involving different stack configurations are possible. For this application there are 4 individual units and combining all 4 units into a single stack has been considered as an alternative arrangement.

6.3.3 Combining stacks could have small potential buoyancy benefits with overall improved dispersion effects. However, this assumes a comparison of stacks of the same height. In evaluating any scheme the initial step is to select an appropriate stack height. Such an assessment has been carried out for the selected design for which this application is being made. A stack height determination selects the optimum height beyond which increasing the stack further shows diminishing benefits in terms of air quality effects. A stack height assessment has been carried out for combining the flues within a single stack. Modelling has been carried out for the combined flue scenario and is reported in Appendix C. Overall for the potential aggregation of stacks compared with the proposed 4 stack arrangement the maximum short-term PC is higher and the maximum long term PC only marginally lower, with both stack configurations resulting in impacts which are not significant at human health receptors.

6.3.4 It should be noted that improved dispersion for combined stack designs would only be achieved with all engines within each stack running at the same time. If the plant were to operate with only a portion of the total engines connected to a stack in operation then with a reduced stack height there is the potential for scenarios where the plant releases would be worse due to the buoyancy benefits in combining stack not being fully realised. The current design can accommodate anything from 1 to 4 units in operation without affecting the predicted air quality effects.

6.3.5 To achieve a combined stack design has space, access, back-pressure, maintenance and significant cost implications which would make this option undesirable and for no significant air quality benefit.

6.3.6 For the above reasons combining stacks is not proposed and the proposed option including individual stacks to each engine is considered BAT.

## 6.4 Control of Other Emissions to Air

6.4.1 The LCP BAT-C states that BAT for controlling CO emissions is optimised combustion and/or to use oxidation catalysts[2]. Control and management of combustion conditions within the proposed gas engines, including performance monitoring, process control techniques and suitable maintenance regimes, will be in place to minimise CO emissions. This will be achieved by the control system which will control the combustion process to achieve efficient combustion.

6.4.2 The LCP BAT-C provides an indication of yearly average CO emission levels for new engines of 30-100 mg/Nm$^3$ but recognises that optimising the functioning of an existing technique to reduce NOx emissions further may lead to levels of CO emissions at the higher end of the indicative range for CO emissions given. An Oxicat layer will be fitted within the SCR for this facility to reduce the CO emissions to comply with the indicative BAT range.

6.4.3 Sector Guidance states that natural gas which meets the standard for acceptance into the National Transmission System (NTS) is considered to be a sulphur free fuel[21]. The gas to be used will come from National Grid's NTS or LDZ network and therefore emissions of sulphur are not anticipated. Likewise natural gas does not generate particulate matter emissions hence a BAT evaluation of PM abatement has not been considered necessary.

## 6.5 Selection of the Cooling System

6.5.1 A number of types of cooling system could be employed for this type of facility which include the following air or water cooled methods:

- Once-through sea or river water;
- Evaporative cooling tower;
- Hybrid cooling; and
- Fin-fan coolers.

6.5.2 As highlighted within the EU BREF for industrial cooling[22], there is a balance of environmental considerations when considering the cooling option to be employed. Any of the methods may be considered BAT depending on circumstance. All of the options have their relative advantages and disadvantages for their operation as detailed within **Table 6.9**.

**Table 6.9: Comparison of cooling systems**

| Cooling System | Advantages | Disadvantages |
|---|---|---|
| Once through cooling | Lower energy consumption<br>Low noise impact<br>Low visual impact | Possible fish kill<br>Possible thermal release effect in water course<br>Biofouling<br>Biocide discharges |
| Evaporative cooling tower | Lower Energy Consumption | High visual impact<br>Water consumption<br>Chemical treatments for biohazard control and scale/corrosion control |
| Hybrid Cooling | Lower water use than conventional wet cooling systems<br>Can achieve no visible plume | Possible noise impacts<br>Higher energy consumption than conventional wet cooling systems |
| Fin-fan coolers | No aqueous discharge<br>Lower visual impact<br>No water consumption | Possible noise impacts<br>Higher energy consumption |

6.5.3 Once through water cooling is not feasible for the proposed GFGF due to there being no suitable source of water for abstraction in the volumes of water that would be needed within the vicinity of the plant, the closest water features comprise an array of small Becks including Belasis Beck. Larger watercourses are the River Tees at circa 1.7km from the site. Providing infrastructure to this water source for once through cooling is not considered economically feasible.

6.5.4 Further as a consequence of the intermittent operation required there would be the issues surrounding biological control and issues of fouling from operation of once through cooling, which would result in additional cost and potential maintenance concerns. Siltation and settlement are also likely to be problematic as a result of the intermittent operation. These issues can be avoided for power plant which operate continuously as a minimum level of flow is maintained at all times.

[21] Environment Agency (2009). Combustion Activities (EPR1.01).

[22] European Commission (2001). Reference Document on the Application of Best Available Techniques to Industrial Cooling Systems.

The GFGF would not create a high enough load for this to be feasible, and there would be an energy penalty due to the intermittent operation which may exceed the savings that direct cooling can deliver.

6.5.5 The issues identified above would also apply to the remaining wet cooling options and therefore these options have not been considered further.

6.5.6 Fin-fan coolers have no significant water consumption requirement and hence are suited to the site location and operational profile and will not result in additional effluent discharges. Furthermore, they have a lower visual impact when compared with evaporative techniques together with lower associated storage requirements.

6.5.7 Whilst fin fan coolers can give rise to greater noise impacts, the noise assessment carried out has concluded that the noise effects from the GFGF will not result in significant noise impacts to health or amenity, with appropriate mitigation methods in place.

6.5.8 It is recognised that the fin-fan cooler option has a higher energy demand than other cooling options. However the energy consumption by the fin-fan coolers will not have a material impact on the overall energy efficiency for the project.

6.5.9 On the basis of the above, fin-fan coolers within a CCCW system are considered BAT for providing cooling to the gas engines at this site.