ConocoPhillips (UK) Teesside Operator Limited

Teesside Crude Oil Stabilisation Terminal Environmental Permit Variation

Appendix D: Site-specific BAT Assessment

Reference: E2P-ARU-ZZ-ZZ-RP-YE-0021

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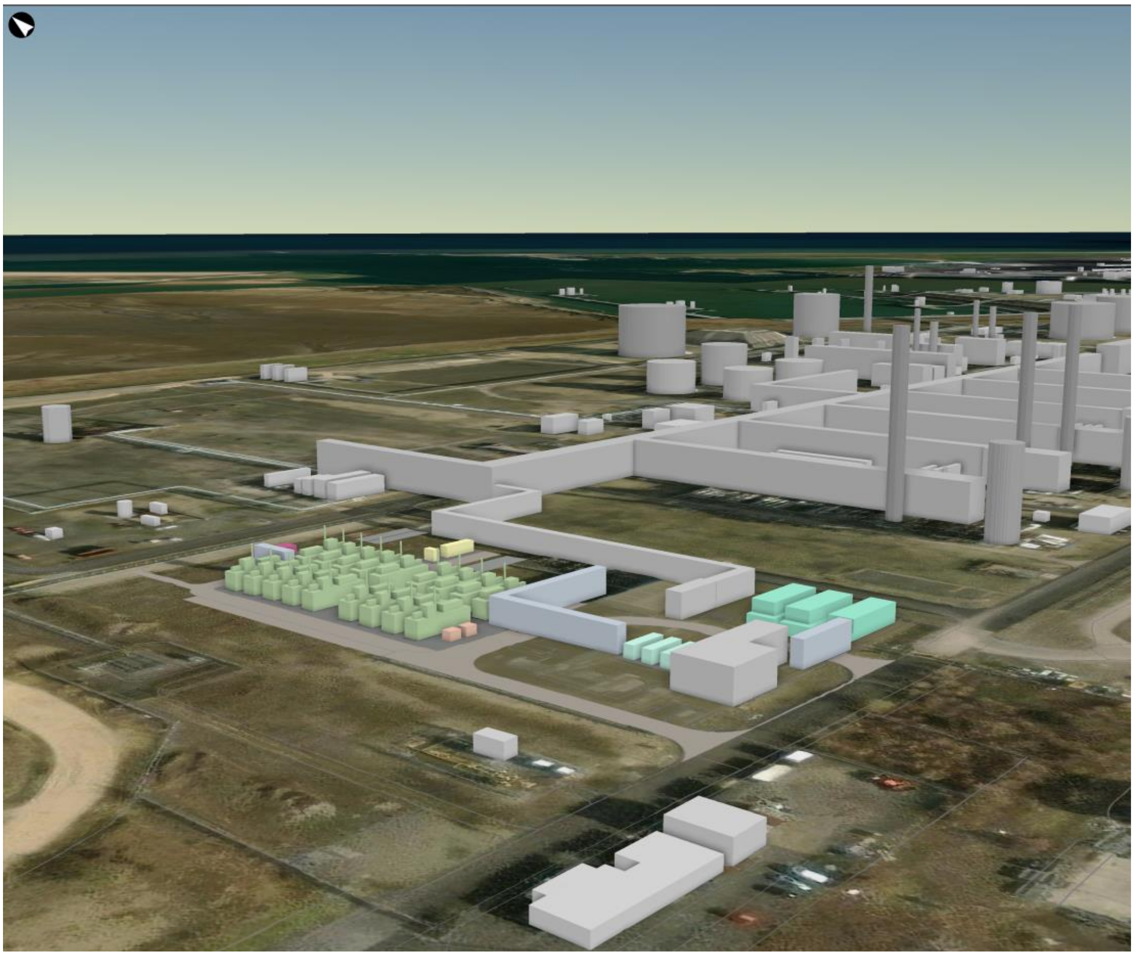

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List of Abbreviations

BAT	Best Available Techniques
BAT-AEELs	Best Available Techniques-Associated Energy Efficiency Levels
BAT-AELs	Best Available Techniques -Achievable Emission Levels
BATc	Best Available Techniques Conclusions document
BRef	BAT Reference document
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CCGT	Combined Cycle Gas Turbine
CoP	ConocoPhillips
DeC_2 OHs	De-ethaniser overheads
DLN	Dry Low-NOx
EA	Environment Agency
EED	Energy Efficiency Directive
E2P	Ethane to Power
EP	Environmental Permitting
FEED	Front End Engineering Design
FEL2	Front-end Loading Stage 2 – preliminary design (or pre-FEED)
FEL3	Front-end Loading Stage 3 – detailed design and optimisation (or FEED)
GHG	Green House Gas
GT	Gas turbine
IED	Industrial Emissions Directive
IPPC	Integrated Pollution Prevention and Control
LCP	Large Combustion Plant
MECL	Minimum Emissions Compliant Load
MWe	Megawatt electrical
MWth	Megawatt thermal
NGL	Natural Gas Liquids
NO_2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
OCGT	Open Cycle Gas Turbine
SCR	Selective Catalytic Reduction
SO_2	Sulphur Dioxide
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
STP	Standard Temperature and Pressure

1. Introduction

This Site-specific Best Available Techniques (BAT) assessment has been prepared to support the Environmental Permit variation submitted by ConocoPhillips (CoP) Teesside Terminal for the Ethane to Power (E2P) project. The E2P project would enable CoP to develop the E2P Power Island at their Teesside Crude Oil Stabilisation Terminal (the 'Installation' or the 'Teesside Terminal'), at Seal Sands, to utilise their surplus fuel gas comprising ethane/ methane product streams, to produce electrical power for use at the Installation, with excess power being exported to the grid.

The Teesside Terminal is designed to receive crude oil from UK and Norwegian fields via an offshore pipeline and to produce, store and export stabilised crude oil and refrigerated natural gas liquids (NGLs). The NGL feed is fractionated at the Teesside Terminal into individual components (methane, ethane, propane and mixed butanes) in a series of fractionating towers. The methane and a portion of ethane is consumed in the existing combustion plant on site as plant fuel and the remaining ethane, propane, and butanes are refrigerated and stored onsite ready for bulk sale to world markets.

Due to a combination of declining crude oil throughput, plant turndown limitations and a narrow market for ethane as a product, ConocoPhillips has identified the E2P Power Island as an alternative outlet for the methane/ethane mix, namely, to generate energy in gas engines. The amount of excess gas to burn is a function of the crude oil throughput and therefore will decline over time as the Terminal throughput declines. Consequently, the overall emissions from the existing Terminal will continue to decline as the amount of process plant requiring process gas as fuel will also decline.

The Installation has three gas turbines and three steam boilers, which form one integrated steam raising plant. In addition, there are six crude oil stabilisation reboilers. These 'consumers' all operate on fuel gas (methane) extracted from the oil processed at the Teesside Terminal; however, the existing plant does not have the capacity to utilise all of the excess ethane/ methane stream that will become available.

Therefore, following a review of potential solutions for alternatives, CoP consider that the most viable option is to use the ethane/ methane product stream to produce electrical power for use of the Teesside Terminal, and as such are proposing the installation of a new E2P Power Island within the existing Environmental Permit Installation Boundary.

The E2P Power Island will consist of up to 16 gas engine units with each engine delivering 2 MWe, with a total installed generation capacity not exceeding 32MWe. Based on the maximum of 16 x 2 MWe engines, the total thermal input of the gas engines would be in the region of 77MWth, however not all engines will operate concurrently as additional engines have been built into the design for redundancy. The E2P Power Island comprises a listed activity under Environmental Permitting (England and Wales) Regulations 2016 (as amended) (EP Regulations) as a Section 1.1 Part A(1)(a): Burning of any fuel in an appliance with a rated thermal input of 50MW or more.

As the proposed activity falls under Section 1.1 Part A(1)(a) of the EP Regulations, it is therefore considered to be an Industrial Emissions Directive[1] (IED) activity. As such, the EP Regulations require that such installations be designed and operated in line with the appropriate BAT guidelines. BAT guidance is provided either by European BAT Reference documents (BRefs), a series of documents covering as far as is practicable the industrial activities listed in Annex 1 to the EU's Integrated Pollution Control (IPPC) Directive, or national guidance produced by the relevant regulator, where BRef guidance is not available.

BAT means the most effective and advanced stage in the development of activities and their methods of operation as set out in the BRef guidance. This indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0075&from=EN

As the main activity at the Installation is the stabilisation of Crude Oil, BAT for the Installation must be reviewed against the BAT Reference Document for the Refining Mineral Oil and Gas BRef[2] (Refineries BRef). This assessment has been presented in Appendix C of the Main Supporting Document.

The E2P Power Island will provide a 'flexible outlet' for excess process gas at the Teesside Terminal allowing decarbonisation of the existing Teesside Terminal fuel gas consumers and a planned switch to electrification. This will, in the longer term, achieve a further step change reduction in overall emissions from the Installation. The E2P Power Island scheme is the key element to unlock this opportunity, as there will be no other outlet for excess process gas other than to the site flare system.

The BAT assessment presented in this Appendix considers the Site-specific BAT issues of the using the ethane/ methane fuel gas in multiple gas engines for generating electrical power for the Installation.

[2] Refining of Mineral Oil and Gas | Eippcb (europa.eu)

2. Project Description

2.1 Project Need

The current liquid ethane processing system at the Teesside Terminal is reaching the end of its life due to a combination of declining volumes (including related throughput challenges) a narrow market for product and key assets approaching the end of their economic operational life. However, the Installation will need to operate until the last remaining Ekofisk offshore production facility can viably produce oil and gas economically. The current premise is that the Teesside Terminal will continue operating until 2048 however this may need to be extended if the offshore production facilities continue operation beyond this date.

Ethane represents only 1% by volume of export products from the Installation, however it employs the most process equipment of any product stream produced and exported at the Teesside Terminal and represents a significant proportion of the total plant balance of process safety risk exposure.

The declining crude oil volumes mean that the De-ethaniser columns will reach the limit of their turndown rate in 2033, based on current long-term processing forecasts for the Installation. As such, a NGL process or product reconfiguration would be needed to enable the export of ethane to continue from the site as a pure product.

In addition, the ethane storage tank is approaching the end of its economic operational life. It is also considered that, due to changes in legislation covering pressurised storage vessels since the construction of the ethane storage tank, it would no longer be possible to build an equivalent storage provision for ethane at the Installation.

The market for refrigerated liquid ethane as a delivered product in Europe is narrow, and historically there has been a sole buyer for the ethane produced at the Teesside Terminal. In more recent years, ethane available from abundant shale gas supplies imported from the United States has put increased pressure on this existing market for the Teesside Terminal's ethane product. Therefore, investing to renew major parts of the ethane export system to extend liquid exports is not economically viable, given the limited market for ethane as a single product from the Teesside Terminal. However, ending processing and export of NGLs would leave more ethane than the Installation requires for its current fuel gas usage and an excess of ethane/ methane until the early to mid-2030s by latest forecast and estimates.

Although decommissioning plans are still to be finalised, it is likely that CoP will decommission much of the ethane processing and storage equipment in the late 2020s, which will result in gas (fuel gas) being available from the De-ethaniser overheads (DeC_2 OHs) from a termination point downstream of the De-ethanisation plant. The De-ethaniser overheads fuel gas stream is produced by processing the liquid hydrocarbons from the Feed Surge Drums in the De-ethanisation plant and comprises mainly ethane, with a small proportion of methane. The composition of the fuel gas stream is provided in Table 2.1.

Table 2.1: Composition of the Fuel Gas Streams

Component	De-ethaniser overheads (DeC_2 OHs)
Ethane	80 – 85%
Methane	15 – 20%
Propane	Trace
Butane	Trace
Carbon dioxide	<0.5%%
Hydrogen sulphide	<10ppm (wt)
Mercury	<1 ppb (µg/kg)

Unless alternative arrangements for the storage, processing or use for the fuel gas stream is found, it would need to be safely disposed of as waste gas to flare. It is considered that flaring the excess fuel gas would not be desirable from both a business and environmental compliance perspective.

2.2 Options Under Consideration

A number of options to deal with the surplus fuel gas stream have been considered, which have included maximising the existing ethane storage tank's economic operational life. However, as detailed in Section 2.1, it is considered that the end of the ethane storage tank's operational life is approaching, and therefore an alternative solution needs to be found.

Options that have been identified as being potentially viable are set out below, and are evaluated further within this Site-specific BAT assessment:

- Use of floating storage - direct loading of ethane product to floating storage (and subsequent ship to ship transfer of the liquid ethane for sale).
- Minimising processing of NGLs at the Teesside Terminal, by reducing the volume of this fraction following pre-processing of the oil stream offshore.
- Gaseous export of the fuel gas to a neighbouring onshore facility adjacent to the Terminal for blending into the UK Natural Gas Transmission system if they have capacity to accommodate the gas stream.
- E2P Power Island – use the fuel gas as a fuel for reciprocating gas engines to generate electricity for Installation usage and export to the grid.

These options have been considered further in the following sections.

2.2.1 Use of Floating Storage

CoP commissioned a feasibility study in 2023 to look at the viability of using a ship, located at the Installation's quay, as floating ethane storage to replace the requirement for a fixed storage tank at the Installation. This would then enable the transfer of ethane from ship to ship (lightering) for further transportation, provided that a market for the ethane remains available.

Whilst this option would address the storage limitation on ethane, it does not address the NGL processing challenges resulting from the declining volumes faced by the Teesside Terminal.

The 2023 feasibility study considered the level of risk associated with this option and the potential modifications that would be required to the existing Installation infrastructure. The aim of the study was to ultimately verify whether the concept was a viable option if no alternative solution could be found, due to it only addressing the storage issues and not the long-term issues associated with declining throughput.

The outcome of the study concluded it would be dependent on plant turndown limits and be considered as detrimental to the overall risk profile of the operations at the Teesside Terminal, due to numerous issues identified, including, a risk of vessel collision and increased risk of connection failures/ loss of containment. Whilst direct loading of ethane to ships could be achieved at short notice as a contingency if required, to enable the move to a lightering mode of operation would require significant changes to the existing Teesside Terminal operations. Therefore, given the limitations of this option, it was discounted from further consideration.

2.2.2 Minimising Processing of NGL

This option would see minimising export of NGL from the offshore assets to the Teesside Terminal by modification of the offshore processes prior to the crude oil being despatched.

Initial trials have been undertaken to determine if it is possible for the existing equipment at the offshore platform to reduce the liquid ethane volumes produced and subsequently coming into the Teesside Terminal. Modelling of this option has been carried out and identified that a significant reduction in ethane volume is possible.

Although this has resulted in smaller volumes of NGL that will requiring processing at the Teesside Terminal, the aforementioned challenges relating to De-ethaniser turndown limits and storage of ethane on-site remain.

Therefore, this option only provides a partial solution and, as such, would need to be considered alongside other potential solutions.

The reduction in fuel gas volumes has been taken into account in the latest design of the E2P Power Island and has resulted in a decrease in the original proposed maximum number of engines from 24 to the current maximum of 16, although it is considered that this may be reduced further through further design optimisation.

2.2.3 Gaseous Export of Ethane

Consideration has been given to the potential for directly exporting the fuel gas to a neighbouring onshore facility adjacent to the Teesside Terminal for blending into the UK Natural Gas Transmission system. In 2016 CoP pursued a potential export scheme with a neighbouring facility, which was not progressed after undergoing Front-end Loading (FEL) 3 (or Front-end Engineering Design (FEED)) engineering studies due, mainly, to insurmountable commercial considerations between parties.

It is considered that there are distinct disadvantages to such an arrangement with a third party, not least of which that the Installation would become wholly reliant on a single outlet for the ethane stream. If the third party was off-line for instance, then the fuel gas would need to be flared until the third-party recommenced operation.

Subsequently, the most recent discussions with potential off takers in 2023 have yielded no appetite from either party to take the excess fuel gas stream and therefore this option is not considered to be viable.

2.2.4 E2P Power Island

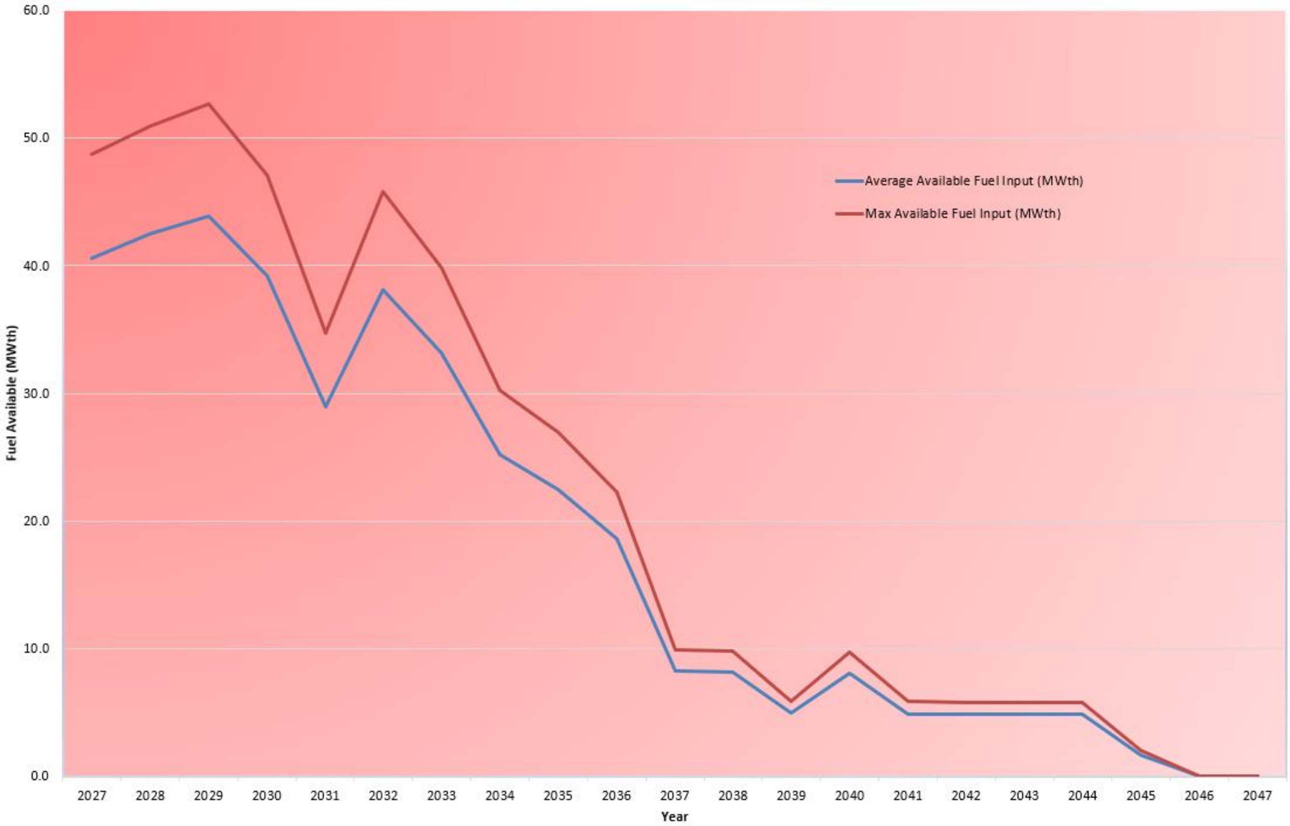
This option would enable CoP to combust any excess fuel gas in reciprocating gas engines located on a power island within their existing Installation Boundary, to generate electricity for use by the Installation with any excess electricity being exported to the grid.

This option would take fuel gas directly from the Teesside Terminal, removing the requirement for any storage facilities, and would enable consumption of the excess gas produced to be within the overall remit of the Installation, with no dependency on third parties.

Maximising availability and minimising flaring of the fuel gas stream is one of the key criteria in the engine selection process, with upwards of 99% availability being desirable.

Due, in part, to the inherent modular construction of individual gas engine units, this would also be deliverable within any time constraints on continued operation of the existing liquid ethane system. As the ethane rich source gas is declining, the modular system will also be advantageous with regards to matching the turndown needs of the production by reducing the number of engines over time to match the feed gas supply, which is shown in the estimated fuel gas volumes shown in Figure 1.

Figure 1: Estimated Fuel Gas Volumes Available Until 2047



Gas engines are also very flexible in terms of the specification of the gaseous fuel that they can be fired on. The engine system can be optimally matched to the required fuel-gas composition, with known industrial applications using petroleum gas, landfill gas, biogas, process gases from the steel industry and mine gas all being in operation. Therefore, it is considered that the Teesside Terminal fuel gas feed would be suitable for use in gas engines.

In addition, it is considered that this option is an enabler to the long-term emissions reduction strategy for the Installation, by providing a flexible, scalable outlet for excess gas from the crude oil, enabling longer term electrification of the existing gas ‘consumers’ at the Teesside Terminal. The power generated and used at the Installation would not only reduce direct energy operating costs, but also enable future electrification opportunities on the Teesside Terminal for those current fuel consumers, thus supporting the Installation’s proposed Green House Gas (GHG) reduction roadmap. This will also lead to a reduction in the combustion emissions from other sources across the Installation and therefore a reduction in the associated impacts.

Given the obvious advantages outlined for this option, it is considered that this is the preferred solution. As such, the E2P Power Island option has undergone FEL2 (pre-FEED) engineering and began FEL3 or FEED stage of development in April 2024.

As stated previously, the proposed E2P Power Island would consist of up to 16 gas engine units (including standby machines) with each engine being 2 MWe, and this proposal has been carried forward to the Site-specific BAT Assessment detailed in Section 4.

3. Regulatory Considerations

The E2P Power Island will be constructed within the existing Installation Boundary and comprise a listed activity under the EP Regulation as a Section 1.1 Part A(1)(a): Burning of any fuel in an appliance with a rated thermal input of 50MW or more. As the proposed activity falls under Section 1.1 Part A(1)(a) of the EP Regulations it is therefore considered to be an IED activity, and as such the EP Regulations require that permitted installations are designed and operated in line with the appropriate BAT guidelines.

The European Union (EU) Withdrawal Act 2018 ensures that existing EU environmental law will continue to have effect in UK law, including the Industrial Emissions Directive (European Council Directive 2010/75/EU) (IED) and BAT Conclusion Implementing Decisions made under it. In addition, the UK Government has indicated that there will be a clear process for determining future BAT Conclusions for UK industrial emissions that broadly maintains a consistent approach with the IED.

3.1 IED and Environmental Permitting Regulations

The IED lays down rules on integrated prevention and control of pollution arising from specified industrial activities (listed as Annex 1 within the Directive) designed to prevent or, where that is not practicable, to reduce emissions into air, water and land and to prevent the generation of waste, in order to achieve a high level of protection of the environment taken as a whole.

The IED forms the basis of regulation for the Refining of Mineral Oil and Gas and Large Combustion Plant (LCP) (combustion units >50 MWth).

Central to the principle of IED is the requirement on operators to take appropriate preventative measures against pollution through application of BAT. European BAT Reference documents, or BRefs, have been drawn up for each of the principal sectors defined within the IED, to provide guidance on techniques that may be considered to represent BAT. The latest version of the BRef for LCP[3] (LCP BRef) was published by the European Commission at the end of 2017. In addition to the LCP BRef, further clarification of the requirements for BAT relating to LCP is published in the BAT Conclusions (LCP BATc) document[4].

The LCP BATc specifically states that it does not address the combustion of refinery fuels at refinery sites, as this is covered by the BAT conclusions for the Refining of Mineral Oil and Gas.

The latest version of the Refining Mineral Oil and Gas BRef[5] (Refineries BRef) was published by the European Commission at the end of 2015. In addition to the Refineries BRef, further clarification of the requirements for BAT relating to Refineries is published in the BAT Conclusions (Refineries BATc) document[6] and includes BAT for the combustion of refinery fuel gases in combustion plant.

According to Article 14(3) of the IED, BATc are the reference for setting the permit conditions for installations covered by the Directive.

Although the LCP BATc specifically states that it does not address the combustion of refinery fuels at refinery sites, it is considered that there may be relevant aspects of the LCP BATc, such as the requirements on energy efficiency, that do need consideration.

Chapter III of the IED applies to new and existing LCPs which have a total rated thermal input which is greater or equal to 50MW. Articles 28 and 29 explains exclusions to Chapter III and aggregation rules respectively, of which the following may be relevant for the E2P Power Island:

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[3] Large Combustion Plants | Eippcb (europa.eu)

[4] Implementing decision - 2017/1442 - EN - EUR-Lex (europa.eu)

[5] Refining of Mineral Oil and Gas | Eippcb (europa.eu)

[6] Implementing decision - 2014/738 - EN - EUR-Lex (europa.eu)

- For the purpose of calculating the total rated thermal input of a combination of combustion plants…. Individual combustion plants with a rated thermal input below 15MW shall not be considered.

The thermal input of the individual engines proposed for the E2P Power Island will each be 4.8 MWth, and therefore the E2P Power Island will not be considered to be an LCP under the IED. However, the use of multiple small gas engines rather than a potentially more efficient single combustion plant with a thermal input of >50MW, does need to be considered in terms of the LCP BATc and be subject to a BAT justification.

In relation to the combustion of natural gas specifically, the LCP BATc (BAT 40) specifically states that *"....to increase the energy efficiency of natural gas combustion, BAT is to use……Combined Cycle…generally applicable to new gas turbines and engines, except when operated <1,500 hours per year."* This therefore implies that the operation of a gas engine in open cycle for greater than 1,500 hours per year may not represent BAT due to lower energy efficiency of such a unit compared to the operation of a Combined Cycle Gas Turbine (CCGT). As such, gas engine installations are typically associated with peaking plant, and to date this has been applied by the EA as a basis that all gas engine sites are restricted to operating to 1,500 hours annually on a 5-year rolling average, with maximum operations in any one year not exceeding 2,250 hours.

The operation of the E2P Power Island would be continuous (24 hours per day, 365 days/ 8,760 hours per year) in order to utilise the fuel gas straight from the Teesside Terminal, and limit flaring.

During pre-application discussions with the Environment Agency, the EA confirmed that as a refinery operation, the LCP restrictions on running hours for gas engine sites (i.e. 1,500 hours over a 5-year rolling average or 4,000 hours if SCR is applied) would not apply.

The determination of BAT is specific to a particular installation in a particular location, as there may be geographical, technological or local environmental reasons why a particular technique cannot be applied to the installation's process which precludes the use of a particular technique on the basis of pollutant sensitivity. In some cases, this could mean that the competent authority permits techniques which are not recognised in the BAT conclusions as indicative BAT, provided a justification is given for the departure. As such, it is considered that this will be required for the Environmental Permit variation that will be required to enable the operation of the E2P Power Island.

3.2 Energy Efficiency Directive

Under Article 14 of the Energy Efficiency Directive (2012/27/EU) (EED), operators of certain types of combustion installations >20MWth are required to undertake an assessment of opportunities for cogeneration (also known as combined heat and power (CHP)) or supplying a district heating or cooling network. It requires that a cost-benefit analysis in accordance with Part 2 of Annex IX of the EED is carried out in order to assess the cost and benefits of providing for the operation of a new installation as a high-efficiency cogeneration installation.

A cost benefit analysis has been carried out to support the Environmental Permit variation application required for the E2P Power Island and is provided in Appendix G of the Main Supporting Document. The analysis identified numerous theoretical heat loads do exist within the vicinity of the Installation. However, none offer an economically viable opportunity for the export of heat. Therefore, CHP is not proposed to be installed at E2P Power Island however the engines will be CHP Ready.

4. Site-specific BAT Assessment

This BAT assessment aims to demonstrate that the installation of the E2P Power Island would represent site specific BAT, based on the relevant BATc and permit guidance documents and considering the local site context. The BRef guidance documents provide a broad direction as to what BAT may be, but where the design requires selection between different feasible options, these choices should be based on environmental criteria. The EA provide direction on which criteria are relevant, considering both the activities being assessed and the local environment.

Criteria considered to be of relevance to this assessment includes:

- Proposed type of combustion plant, including;
    - Consideration of the type of operation and operating regime, frequency, duration of operation; and
    - Consideration of the size of the units;
- Emissions to air;
    - Including abatement techniques to reduce emissions (if applicable);
- Global warming potential; and
- Energy efficiency.

These criteria have been considered in the following sections.

4.1 Proposed Combustion Plant

There are typically three types of power plant which operate in different scenarios; baseload, mid-merit, and peaking plant.

Baseload plant produce electricity continuously, only shutting down for maintenance and repair. These types of plant are typically highly energy efficient CCGTs and, therefore, run for typically up to 8,000 hours per year.

Mid-merit plant typically comes on-line when daily electricity usage is high, e.g. in the morning, and then shut off when demand drops in the evening. These plants are typically in between baseload and peaking power plants in efficiency, speed of start-up and shutdown and typically run for approximately 4,000 hours per year. Typically, these comprise older CCGT plants, that have previously operated as baseload plants.

Peaking plants operate only during times of peak demand, such as the start and end of the working day. A typical peaking power plant will be quick to start up as demand ramps up to a peak and will rapidly shut down as the demand subsides. The duration of operation for peaking plants may vary from a few hours per day to less than a couple dozen hours per year, however they are generally considered to operate for no more than 1,500 hours per year. Peaking plant tend to either be Open Cycle Gas Turbines (OCGT) or gas engines, to allow them to rapidly come on-line, but which have higher emissions and lower efficiencies than mid-merit and baseload plant.

The selection of gas engines for the E2P Power Island is primarily based on the operational requirements that the E2P Power Island will be required to fulfil, as detailed in the following sections.

4.1.1 Operational Requirements for the E2P Power Island

The impact of interruption of the gas export stream on the Terminal would be significant and ultimately would result in fuel gas going to flare. Therefore, the E2P Power Island must have high reliability and availability, to minimise potential for flaring to occur.

Refineries BATc BAT 55 states that *"In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or for non-routine operational conditions (e.g. start-ups, shutdowns)."* It is therefore essential that the E2P Power Island is designed to enable a high level of availability and reliability to minimise the potential for flaring.

In addition, as the fuel gas flow will vary over the course of the E2P Power Island's operational lifetime, with volumes reducing to approximately half of that available at the outset by years 9-10, flexibility to deal with the reducing fuel gas flows is also key to the E2P Power Island design.

4.1.1.1 Availability and Reliability

The use of gas engines enables the E2P Power Island to be modular – i.e. numerous small individual units that can be brought onto site and can be connected to the power supply system as required. Therefore, although a maximum number of gas engines of 16 is proposed for the E2P Power Island, there will be redundancy within this. A reduced number of engines (e.g. up to 12 for the maximum 16 engine case) would actually be operational at any one time, when peak fuel gas flows are available in year 1. The built-in redundancy will enable plant availability to not fall below target levels (upwards of 99% being desirable) and therefore ensure that flaring is minimised.

A Gas Turbine (GT) solution would not be modular and would likely consist of either one large unit (49.9MWe) or two smaller units (2 x 24.9MWe). As such, this would mean that there would be no redundancy built into the design, and if maintenance or repairs were required, the only option would be to flare the fuel gas. For any such GT to meet the higher efficiency achieved by running as a combined cycle plant, this would reduce the operational flexibility of the plant to meet and accommodate the changes in fuel gas availability. In addition, as the plant operation continued and fuel gas volumes decreased, additional natural gas would need to be provided for the GT to operate at higher loads, otherwise it would need to be operated at progressively lower loads with progressively reduced efficiency as a result.

Gas engines are therefore considered to be the most viable combustion plant given that they have a high availability and reliability, with the modular small engines proposed enabling flexibility within the E2P Power Island to minimise the potential for flaring and allow on site capacity to flex to meet the changing availability of the fuel gas.

4.1.1.2 Flexibility

The use of multiple gas engines will provide the flexibility required for the future operation of the E2P Power Island.

Over time, the generation of the fuel gas stream will decrease, with generation decreasing to approximately a half of that of the opening year by 2035/ 2036 (i.e. after 8 - 9 years of operation). By utilising gas engines, this enables the number of operational gas engines to be reduced over time without compromising the availability, reliability, and efficiency of the E2P Power Island. The reduction in fuel gas production and operational engines is shown in Table 4.1 for both the average and maximum fuel gas flows.

Table 4.1: Fuel Input Availability and Example Engine Requirements

Year	High Fuel Gas Production Average Fuel Gas Flows		High Fuel Gas Production Maximum Fuel Gas Flows	
	Available Fuel Input (MWth)	No. of Operational Engines (at full load)	Available Fuel Input (MWth)	No. of Operational Engines (at full load)
2027	40.6	9	48.7	11
2028	42.5	9	51.0	11
2029	43.9	9	52.7	11
2030	39.2	9	47.0	10
2031	28.9	6	34.7	8
2032	38.1	8	45.8	10
2033	33.2	7	39.9	9
2034	25.2	6	30.3	7
2035	22.4	5	26.9	6
2036	18.6	4	22.3	5
2037	8.3	2	9.9	2
2038	8.2	2	9.8	2
2039	4.9	1	5.9	2
2040	8.1	2	9.7	2
2041	4.9	1	5.8	2
2042	4.8	1	5.8	2
2043	4.9	1	5.8	2
2044	4.9	1	5.8	2
2045	1.7	1	2.0	1
2046	0.0	0.0	0.0	0
2047	0.0	0.0	0.0	0

It is considered that GTs would not be able to provide the flexibility in operation required due to the decreasing fuel gas volumes. Reduced fuel gas volumes would result in the GTs having to operate in 'turn down' modes and this reduces their efficiency considerably, increasing their overall level of emissions, and adding additional strain on the turbine. The impacts of GTs operating in turndown modes is further detailed in Section 4.2 and 4.4.

Gas engines have inherently quick start-up times relative to other combustion plant and will be more responsive, therefore can be ramped up to match any fluctuation in gas flows, further adding to the schemes overall ability to manage the total fuel gas stream from the Teesside Terminal.

In addition, gas engines are also inherently more flexible to changes in gas feed compositions than other types of combustion plant. Gas engines are proven across a range of industries and considered to be much more flexible than GTs.

4.2 Emissions to Air

Emissions from the E2P Power Island will need to meet the BAT-AELs for gas-fired combustion units as detailed in the Refineries BATc.

4.2.1 Emissions of Oxides of Nitrogen (NOx)

The Refineries BATc BAT-AELs for emissions of oxides of nitrogen from different types of new combustion plant are detailed in Table 4.2.

Table 4.2: Refineries Combustion Plant BAT-AELs

Combustion Unit	Averaging Period	NOx BAT-AEL (mg/Nm^3)
Gas turbine (including combined cycle gas turbine — CCGT) and integrated gasification combined cycle turbine (IGCC))	Monthly average	20 - 50
Gas-fired combustion units (except gas turbines)	Monthly average	30 - 100

Normalised to STP and 15% oxygen.

It can be seen in Table 4.2 that GTs have a lower NOx BAT-AEL than other gas-fired combustion plant. However, when operating at sub-optimum loads it is anticipated that NOx emissions from GTs will increase above the BAT-AELs, and therefore it is considered that GTs would not represent BAT.

BAT 34 in the Refineries BATc details the applicable techniques for preventing or reducing NOx emissions from combustion units and is summarised in Table 4.3. Table 4.3 also provides a comparison of the E2P Power Island gas engines against BAT 34.

Table 4.3: Comparison of the Gas Engines with BAT 34

Technique	Description	Comparison with BAT
I. Primary or process-related techniques, such as		
i) Selection or treatment of fuel		
a) Use of gas to replace liquid fuel	Gas generally contains less nitrogen than liquid and its combustion leads to a lower level of NOx emissions.	The gas engines will be fired exclusively on the fuel gas from the Teesside Terminal and not liquid fuel.
b) Use of low nitrogen refinery oil (RFO) e.g. by RFO selection or by hydrotreatment of RFO	Refinery fuel oil selection favours low nitrogen liquid fuels among the possible sources to be used at the unit. Hydrotreatment aims at reducing the sulphur, nitrogen and metal contents of the fuel.	
ii) Combustion modifications		
a) Staged combustion: - Air staging - Fuel staging	Fuel staging for mixed or liquid firing may require a specific burner design	The use of NOx burners meeting the Refinery BRef (which will be installed) supersedes the requirement for staged combustion.
b) Optimisation of combustion	Generally applicable	Inclusion of air preheat to maximise efficiency is currently undergoing economic analysis by the design team, however BAT-AELs can be met regardless of whether this is installed.
c) Flue-gas recirculation	Applicable through the use of specific burners with internal recirculation of the flue-gas. The applicability may be restricted to retrofitting external flue-gas recirculation to units with a forced/ induced draught mode of operation	Not applicable to gas engines.
d) Diluent injection	Generally applicable for gas turbines where appropriate inert diluents are available	Not applicable to gas engines.

Technique	Description	Comparison with BAT
e) Use of low-NOx burners (LNB)	Generally applicable for new units taking into account, the fuel-specific limitation (e.g. for heavy oil).	The use of NOx burners meeting the Refinery BRef.
II. Secondary or end-of-pipe techniques, such as:		
i) Selective catalytic reduction (SCR)	Generally applicable for new units.	Further discussion of the application of SCR is provided in Section 4.2.1.1 of this BAT assessment.
ii) Selective non-catalytic reduction (SNCR)	Generally applicable for new units.	As above for SCR.
iii) Low temperature oxidation	The applicability may be limited by the need for additional scrubbing capacity and by the fact that ozone generation and the associated risk management need to be properly addressed. The applicability may be limited by the need for additional waste water treatment and related cross-media effects (e.g. nitrate emissions) and by an insufficient supply of liquid oxygen (for ozone generation).	Not considered to be applicable due to the limitations for this technique detailed.
iv) SNOx combined technique	Applicable only for high flue-gas (e.g. > 800 000 Nm^3/h) flow and when combined NO_x and SO_x abatement is needed	Not applicable due to the low flow rates of the individual gas engines.

The E2P Power Island gas engines will be able to achieve a NOx emission limit of 95mg/Nm^3, therefore slightly below the BAT-AEL.

4.2.1.1 Selective Catalytic Reduction (SCR)

The gas engines can comply with a proposed emission limit of 95mg/Nm^3, which is towards the upper end of the Refineries BATc NOx emissions of 100mg/Nm^3 by primary techniques alone, however it is considered that NOx emissions could be reduced to approximately 75mg/Nm^3 with the implementation of Selective Catalytic Reduction (SCR). This would reduce the potential for air quality impacts of NO_2, which may be particularly relevant where there are human health receptors that could be impacted by the emissions, or where NO_2 Air Quality Standard (AQS) objectives are close to being exceeded. It should however be noted that the nearest human health receptors are >3km from the E2P Power Island, and background NO_2 levels in the vicinity of the Installation are well below the AQS objectives (maximum 15.5µg/m^3 compared to the AQS of 40µg/m^3) and therefore it is not considered that there is a particular human health driver to reduce the impacts from emissions of the E2P Power Island.

In addition, the application of SCR, introduces an emission of ammonia, caused by ammonia slip, and this is an important consideration where sensitive habitat receptors are present. The impacts of nitrogen deposition caused by ammonia are considerably greater than the depositional impacts from NOx and therefore the reduction in NOx emissions achieved by SCR is countered by the additional nitrogen depositional impacts that result due to an emission of ammonia.

The Installation is adjacent to the Teesmouth and Cleveland Coast Special Protection Area (SPA), Site of Special Scientific Interest (SSSI) and Ramsar, with the E2P Power Island located approximately 400m to the south this habitat receptor. The Teesmouth and Cleveland Coast habitat site comprises a number of habitat types which are sensitive to nitrogen deposition, specifically areas where sensitive coastal dune habitats are present. Such habitats have a critical load range of 10 – 20 or 5 -15 kgN ha/yr and the background nitrogen deposition in the vicinity of the Installation is already exceeding this critical load range (at 13.3 – 13.8 kgN ha/yr).

A dispersion modelling impact assessment has been carried out (Appendix E of the Main Supporting Document) which indicates that the additional nitrogen deposition associated with the ammonia from the application of SCR at the Teesmouth and Cleveland Coast results in a maximum increase of 5.2% over the non-SCR model results, and an overall increase of 8.0% over the Baseline Assessment, based on the most conservative Critical Load range. It is therefore considered that the benefits of a slight reduction in the NOx emissions would be outweighed by the additional emission of ammonia associated with SCR and therefore it is not considered that SCR represents BAT for the E2P Power Island.

4.2.2 Emissions of Sulphur Dioxide (SO_2)

The existing diethyl amine (DEA) scrubber will continue to remove hydrogen sulphide (H_2S) from the fuel has upstream of the new connection points to the E2P gas conditioning system, to ensure that this does not compromise the operation of the engines and to ensure that the required emission limits can be met.

The achievable SO_2 emissions from the engines will be dependent on the H_2S content of the fuel gas supplied by the Teesside Terminal. The existing DEA unit removes H_2S to <10ppm (wt) and therefore it is therefore considered that SO_2 emissions at the Refineries BATc BAT-AEL for new plant of <35 mg/Nm^3 will be achievable by primary means. Actual emissions have been calculated to be significantly below this value (<5mg/Nm^3), however the BAT-AEL has been assumed in the assessments carried out.

Table 4.4: Comparison of the Gas Engines with BAT 36

Technique	Description	Comparison with BAT
I. Primary or process-related techniques, such as:		
i) Use of gas to replace liquid fuel	The applicability may be limited by the constraints associated with the availability of low sulphur fuels such as natural gas, which may be impacted by the energy policy of the Member State	The gas engines will be fired exclusively on the fuel gas from the Teesside Terminal and not liquid fuel.
ii) Treatment of refinery fuel gas (RFG)	Residual H_2S concentration in RFG depends on the treatment process parameter, e.g. the amine-scrubbing pressure.	There is sufficient capacity within the existing DEA unit to remove H_2S to <10 ppm wt within the fuel gas.
iii) Use of low sulphur refinery fuel oil (RFO) e. g. by RFO selection or by hydrotreatment of RFO	Refinery fuel oil selection favours low sulphur liquid fuels among the possible sources to be used at the unit. Hydrotreatment aims at reducing the sulphur, nitrogen and metal contents of the fuel.	There is sufficient capacity within the existing DEA unit to remove H_2S to <10 ppm wtwithin the fuel gas.
II. Secondary or end-of-pipe techniques:		
i) Non-regenerative scrubbing	The applicability may be limited in arid areas and in the case where the by-products from treatment (including e.g. waste water with high level of salts) cannot be reused or appropriately disposed of. For existing units, the applicability of the technique may be limited by space availability	The BAT-AELs can be met by primary techniques, and therefore it is not considered necessary to use secondary techniques.

Technique	Description	Comparison with BAT
ii) Non-regenerative scrubbing	The applicability is limited to the case where regenerated by-products can be sold. Retrofitting to existing units may be limited by the existing sulphur recovery capacity. For existing units, the applicability of the technique may be limited by space availability	The BAT-AELs can be met by primary techniques, and therefore it is not considered necessary to use secondary techniques.
iii) SNOX combined techniques	Applicable only for high flue-gas (e.g. > 800 000 Nm_3/h) flow and when combined NOx and SOx abatement is required	Not applicable due to the low flow rates of the individual gas engines.

4.2.3 Emissions of Carbon Monoxide

BAT for CO emissions (BAT 37) is to use combustion operation control. CO emissions from gas engines cannot meet the BAT-AEL of <100mg/Nm^3 by combustion controls alone, and therefore it is envisaged that a catalyst will be required to meet the BAT-AEL.

4.2.4 Emissions of particulates

There are no specific BAT-AELs for particulates or dust from combustion units firing gaseous fuels. The primary techniques detailed in BAT 35, such as the use of gaseous and low sulphur fuels, will ensure that emissions of particulates will be minimal.

4.2.5 Reducing Emission Impacts Through Stack Height and Aggregation

The proposed stack height for the individual engines is 10.4m, from ground level. This is the optimum stack height proposed by the engine providers. Increasing the stack height could potentially reduce the impacts from the emissions, however this would only be considered necessary where the predicted impacts are not considered to be acceptable. The Air Impact Assessment carried out to support the Environmental Permit variation application (Appendix E of the Main Supporting Document) demonstrates that the predicted impacts are unlikely to be significant for human health impacts, with any potential impacts only being associated with nitrogen deposition at the nearby locations of dune habitats.

Although the assessment shows that there is potential for nitrogen deposition to be over the 1% screening criteria at the closest dune location, there is uncertainty over the relevant critical load to apply and the evidence that nitrogen deposition is impacting the dune habitat in this location. In any case, due to the declining emissions over time from both the E2P Power Island, and also the wider Terminal as electrification replaces existing combustion sources, any potential impacts are considered to be limited to the initial years of operation of the E2P Power Island.

According to the engine provider, the maximum stack height that could be installed on the engines without requiring a separate, free-standing self-supporting arrangement would be 12m, i.e. an increase of only 1.6m over the proposed current height. It is considered that this would only have a minimal effect on the dispersion of the emissions from the gas engines, especially considering the high temperature of the release (484°C), which will result in significant thermal buoyancy regardless of the stack height.

Higher stacks would need to be self-supporting, which would increase the complexity and cost of the project. Self-supporting stacks would increase the area of land required for the E2P Power Island, increase the extent of piling and limit free movement space (and therefore potentially increase operational risk). It is also considered that the longer flue ducting runs that would be required for self-supporting stacks could affect the energy efficiency and lead to the potential of back pressure on the engines.

The cost estimate of providing 16 individual self-supporting stacks above 14m in height is in the region of £6 million.

An additional model run has been carried out to determine whether 15m individual stacks would reduce the potential nitrogen deposition from the project, however, for the realistic worst case operating scenario of 12 engines, this only reduces the nitrogen deposition at the identified sand dune habitats (E13) by <0.1% of the lower Critical Load, which is considered to be an insignificant reduction. It is therefore considered that the £6 million that this would cost outweighs the benefits of the minimal reduction in impacts that is achieved, especially considering that the maximum number of operational engines will reduce over time as the gas profile declines.

Generally speaking, combining emission stacks from multiple sources can improve the dispersion of the emissions, improving both thermal and momentive buoyancy of a release. However, small gas engines are designed to exhaust from a stack straight from the engine container, with the high temperature and exit velocity out of a single exhaust stack providing a high level of control for buoyancy and efflux velocity of the exhaust gases from the individual engines. With a combined flue this would be much more difficult to control, particularly with different numbers of engines operating and inbuilt engine redundancy, as would be the case with the E2P Power Island. The engine supplier has advised that for these reasons, aggregated stacks would not be possible.

An alternative would be to combine individual engine flues within a common free-standing windshield, however in order to do this, the plot size for the E2P Power Island would need to be increased to accommodate routing of flue gases to four free-standing multi-flue stacks. This would again increase piling requirements in numbers and depth, and could potentially require percussive piling, due to increased structural loads. Natural England are concerned about the impacts of percussive piling on the bird assemblages of the Teesmouth and Cleveland Coast Ramsar site, and therefore the current plans allow for Continuous Flight Auger piling, which would be less intrusive.

Four multi-flue stacks would put limitations on the flexibility to remove engines from site over time, as flues from four engines would be routed to each stack. This would again limit free movement space (and potentially increase operational risk). It could also have implications on back pressure issues on the engines, due to the distance that the flue gases would need to be transported to a multi-flue stack, which would impact on the plant's efficiency and output. There would potentially be a requirement for forced draft to drive the flue gases to the multi-flue stack, which would again decrease the efficiency of the plant.

There could also be increased process safety implications of clustered flues which would mean that operation of the remaining units could be impacted by safety isolations imposed for the protection of maintenance workers. Safety isolations also have the potential to fail.

The cost estimate of providing 4 multi-flue self-supporting stacks is in the region of £10 million and therefore again, it is considered that the costs outweigh the potential slight reduction in nitrogen deposition that might be achieved, especially considering that the maximum number of operational engines will reduce over time as the gas profile declines.

The flexibility that individual engine mounted stacks offer is key to the E2P Power Island project, as they facilitate maintenance to be carried out on individual engines/ stacks without impacting on the remaining units. Individual stacks are preferred to separate the exhaust gases to avoid back flow and pressure into the standby or idling sets.

It is therefore considered that individual engine mounted stacks are essential to the project to ensure that the engines can operate completely independently and unrestricted in any way. This will enable the operation of the E2P Power Island to only operate the required number of engines for the available fuel gas, and to ensure that the energy efficiency of the engines is maximised. This is therefore considered crucial for ConocoPhillips to achieve the main project aim of minimising flaring.

Again, it would only be considered necessary to increase the stack heights or use combined stacks to reduce the impacts where the predicted impacts are not considered to be acceptable. The Air Impact Assessment (Appendix E of the Main Supporting Document) demonstrates that for the realistic worst case operating case of 12 engines, the predicted impacts are unlikely to be significant, taking into account the worst case assumptions applied in the assessment and the reduction in the operating engines over time resulting in reduced impacts.

It is therefore considered that individual engine mounted stacks represent BAT for the E2P Power Island.

4.3 Global Warming Potential

CoP have developed an emission reduction roadmap to rationalise the overall Installation's CO_2 emissions profile with an aim to undertake equipment retirement, re-rate, and energy source rationalisation from 2027 - 2050.

The E2P Power Island will also contribute to the reduction of Scope 2[7] emissions from the national grid and Scope 3[8] emissions via the cessation of ocean-going tanker export of the ethane. It is also the key to enabling the aforementioned Emission Reduction Roadmap by providing a flexible, scalable outlet for excess gas from the oil, potentially enabling longer term electrification of existing gas consumers on the Teesside Terminal. The implementation of the emission roadmap is therefore dependent on the long-term solution for the ethane product stream.

In summary, the implementation of the chosen ethane solution is therefore essential to achieve the emission roadmap strategy. The roadmap currently assumes the implementation of the E2P Power Island scheme to combust all excess methane/ ethane other than plant fuelling requirements.

4.4 Energy Efficiency

There are no specific energy efficiency levels detailed in the Refineries BATc, however the LCP BATc details energy efficiency levels associated with the use of BAT (BAT-AEELs), which refers to the ratio between the combustion unit's net energy output(s) and the combustion unit's fuel energy input at the actual unit design.

The BAT-AEELs for different types of combustion plant are provided in Table 4.5.

Table 4.5: Large Combustion Plant BATc BAT-AEELs

Combustion Unit	Net Electrical Efficiency (%)
New CCGTs 50 - 600MW_{th}	53.0 – 58.5
New OCGT >50MWth	36 – 41.5
New Gas engines	39.5 – 44.0

The electrical efficiency of the proposed gas engines is >40% and therefore is in line with the BAT-AEELs provided in the LCP BATc for gas engines, and also in excess of the BAT-AEELs provided for OCGTs. It is therefore considered that in terms of their energy efficiency, the proposed gas engines are more efficient than comparable OCGTs.

The BAT-AEEL for CCGTs is higher than gas engines or OCGTs, which aligns with the LCP BATc statement that *to increase the energy efficiency of natural gas combustion, BAT is to use……Combined Cycle, applicable to new gas turbines and engines, except when operated <1,500 hours per year*.

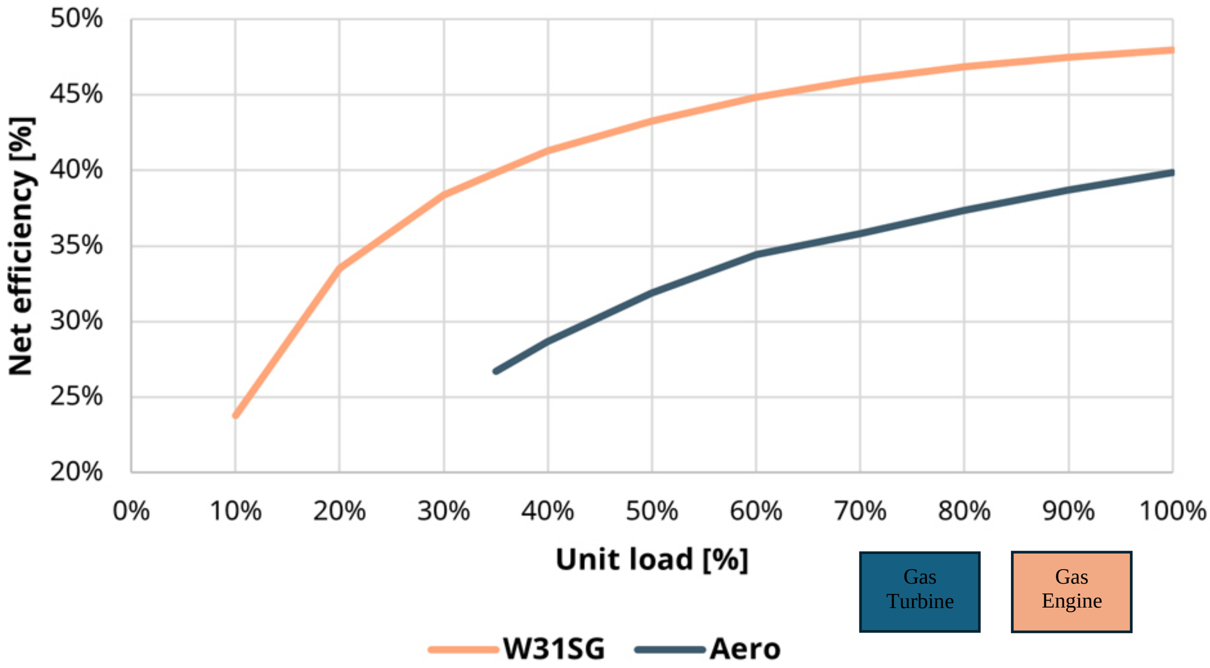
However, as with the BAT-AELs for emissions, the BAT-AEELs do not take into account the impact of operating at turn-down loads on the efficiency. As discussed in Section 4.1.1.2, employing GTs for the E2P Power Island when fuel gas volumes start to decrease after 9 years of operation, would mean that they would be required to operate at progressively reduced loads. GTs have an inherent minimum turndown capability, limited to approximately 5MWe, thus restricting the ability to turn down further beyond this limit. In addition, turn down results in a reduction in the efficiency of GTs, which achieve their stated BAT-AEEL energy efficiencies only at full or baseload and under favourable conditions. Partial load and turndown limitations can also restrict the flexibility of GTs.

[7] Scope 2 are emissions that a company causes indirectly and come from where the energy it purchases and uses is produced.

[8] Scope 3 encompasses emissions that are not produced by the company itself and are not the result of activities from assets owned or controlled by them, but by those that it is indirectly responsible for up and down its value chain.

Figure 2 provides a comparison of the performance of a simple cycle aeroderivative GT and a gas engine at varying load and is provided for illustrative purposes only (source: a gas engine providers website[9]).

Figure 2: Single Unit Net Efficiency at Varying Load Level – GT vs Gas Engine



It can be seen in Figure 2 that in open cycle mode, once the GTs unit load is less than 50%, the net efficiency will have reduced from around 40% to 32%, or by approximately 20% of its maximum net efficiency. In comparison, a gas engines drop in efficiency when operating at 50% load only drops by 10% of its maximum net efficiency.

Although the example shown in Figure 2 is for an OCGT, it is considered that the impact on a CCGT would be similar. A CCGT with a net electrical efficiency of 58.5% when operating at 100% load is likely to be operating at a net efficiency of <47% when operating at 50% load and therefore is likely to be comparable with the electrical efficiencies achieved by the gas engines. This reduction in load factor would also be accompanied by an increase in the NOx emissions, as discussed in Section 4.2.

The application of several small units for the E2P Power Island means that the number of operating engines at any given time would be matched to the fuel gas available, so that operating engines could be operated at optimum load factors for maximum energy efficiency.

It is therefore considered that gas engine power plants provide a much wider range of output flexibility than gas turbines without the constraints of turndown limitations or an impact on efficiency.

4.5 Other Considerations for BAT

4.5.1 Schedule

CoP need to have a solution to the ethane problem in place by the late 2020s to allow the existing liquid ethane system to be decommissioned in a timely manner.

In terms of the types of combustion plant, the higher degree of certainty afforded with the use of gas engines over GTs has led to this being the basis of the FEL2 studies. GTs and other concepts are wholly untested for the fuel gas and present a significant risk to schedule certainty as a consequence. In addition, a GT solution

[9] Combustion engine vs. Aeroderivative gas turbine: Part-load efficiency - Wärtsilä Energy (wartsila.com)

would not be modular (like the gas engine concept) and therefore would attract higher construction costs and a longer schedule for delivery of the finished solution.

4.5.2 Economics

Although a minor consideration in terms of BAT when considering environment impacts, it should be noted that the option of GTs, and particularly a CCGT, would be a much higher CAPEX per kW installed compared to gas engines, due, in part to increased complexity of construction and operation.

The brief period of operation and high capital costs of GTs means they are not economic for use only during the interval between the end of the ethane storage tank's life and the expected date for the De-ethaniser turndown to be reached (i.e. 9 years), when the higher quantities of fuel gas are available.

4.5.3 Electrification of the CoP Terminal

The E2P Power Island will enable CoP to use ethane/ methane to produce electrical power for use. The E2P Power Island would be within the control of the Teesside Terminal and will therefore provide a reliable supply of energy to the Teesside Terminal, with limited dependency on third parties. It will also enable future electrification opportunities at the Installation supporting the CoP GHG (Greenhouse Gas) reduction roadmap. Enabling electrification across the wider site will also lead to a reduction in combustion emissions from existing Installation sources.

In addition, any excess power can be exported to the UK National Grid.

5. Conclusions

Due to decreasing throughput, a decline in the market and the existing product storage facilities approaching the end of their economic operational life at the Teesside Terminal, and the De-ethaniser approaching turndown limit, an alternative use for the ethane stream is required by the late 2020s. Following a review of the potential available options, CoP consider that the most viable option is to utilise the surplus ethane/ methane to produce electrical power and as such are proposing the installation of the E2P Power Island within the existing Environmental Permit Installation Boundary.

The project driver is therefore a process efficiency measure to make a beneficial use of the ethane whose sale will no longer be economically viable and that would otherwise need to be flared, which would not be considered BAT.

The proposed E2P Power Island will consist of up to 16 gas engine units with each engine being 2MWe, with a total installed generation capacity not exceeding 32MWe. Based on the maximum of 16 x 2 MWe engines, the total thermal input of the gas engines would be in the region of 77 MWth and therefore the E2P Power Island will comprise a listed activity under the EP Regulations as a Section 1.1 Part A(1)(a): Burning of any fuel in an appliance with a rated thermal input of 50MW or more.

The rationale for selection of gas engines as a preferred technology is primarily driven by the required duty, which is not typical for power generation schemes of a similar scale. Essentially this entails a declining fuel stream, with a reduction of approximately a third of that of the opening year by 2036 (i.e. after 9 years of operation) and its varying composition. The main requirement for the E2P Power Island is therefore high availability, reliability and flexibility, which is provided by the gas engine concept.

It is considered that none of the other available options provide a means of using the fuel gas in a way which gives the level of reliability and control required by the Installation to ensure its key operations can continue with minimal flaring. It enables the retirement of the liquid ethane refrigeration processing equipment by the late 2020s at the latest and facilitates future electrification opportunities for the Teesside Terminal to support the Teesside Terminal GHG reduction roadmap.