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Project Title: **IED BAT 52 Derogation Request**

REVISION	NRW Review	Post NRW Meet	Formal Issue	Redacted Issue
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IED BAT 52 Derogation Request

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Fig 1: Typical Ship Loading via two arms. Yellow painted ship vapour connections shown.

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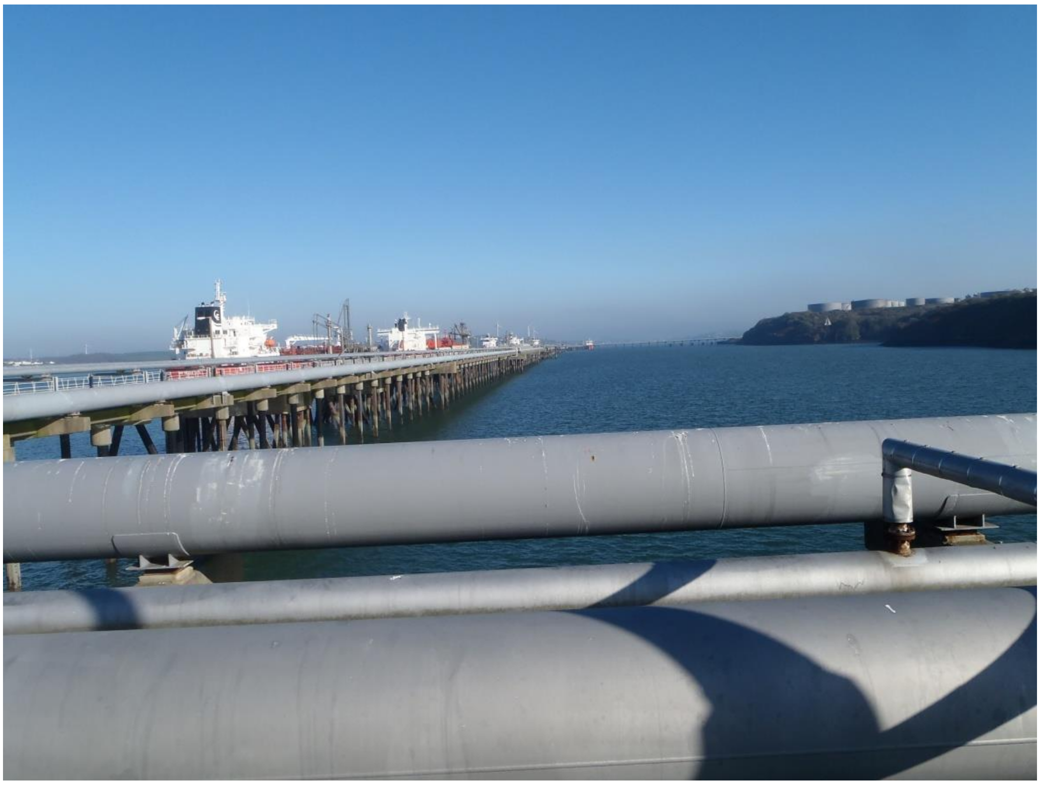

Fig 2: View from Berth 8 looking east ~ 2km

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1. Derogation Summary

Industrial Emissions Directive (IED) Best Available Technique (BAT) 52 requires the installation of a vapour recovery technique to reduce Non-Methane Volatile Organic Compound (NMVOC) emissions from marine loading.

A Derogation to the IED is requested for technical reasons. Pembroke's 2km berth infrastructure and multiple gasoline products results in a Vapour Recovery Unit (VRU) installation of much higher capital cost than expected under the Reference Document (BREF).

- A disproportionate net present value (NPV) of -69.9 was calculated using the Environment Agency's IED Derogation Cost-Benefit Analysis Tool for a 14 year derogation, from 2026 to 2040.
    - The year 2023 was used as year 0, to account for current cost forecasts, the cumulative emissions from 2019-2023 were included in the 2023 column for the BAT-AEL data section.
- BAT compliance may require new piles, the berths are located in the Milford Haven Special Area of Conservation (SAC) meaning the damage of installing new piles may outweigh the benefits of NMVOC abatement for the longer term.
- Alternative infrastructure projects that would reconfigure the jetty to reduce gasoline volumes to below one million cubic meters a year per berth result in lost business, ruling out these alternatives.
- Future gasoline volumes may decline with the announced UK government policies. This may reduce gasoline volumes below 1 million cubic meters a year per berth and thereby meet the IED requirement without need for installation of controls.
- UK Emissions Trading Scheme (UKETS) government policy and rising carbon cost may also result in gasoline exports decreasing below 1 million cubic meters a year per berth and thereby meet the IED requirement without need for installation of controls.
- The NMVOC environmental damage values, as stated in the Environment Agency's IED Derogation Cost-Benefit Analysis Tool, are outweighed by the new carbon emissions associated with operating a new vapour recovery system (and not accounting for the additional carbon emissions created by third parties in extracting the raw materials and manufacturing the vapour recovery equipment).
- Derogation to 2040 provides time for Pembroke Refinery gasoline production to adjust to the current UK government policies likely to reduce UK gasoline demand through the 2030s, with the likely reduction in vapour recovery project scope required to comply with the IED BAT 52 requirements.

- Berths 2, 7 & 8 NMVOC emissions are approx. 0.14% of UK total NMVOC emissions (based on latest published data, 2021)
- Berths 2, 7 & 8 NMVOC emissions are approx. 2.5% of Wales total NMVOC emissions (based on latest published data, 2020)

1.1. References

1) Official Journal of the European Union, EU Directive, 28 October 2014, Decisions, "Commission Implementing Decision of 9 October 2014 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the refining of mineral oil and gas"
2) "Best Available Techniques (BAT) Reference Document for the Refining of Mineral Oil and Gas Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control)", 2015; European Commission, Joint Research Centre
3) "IED Derogation Cost-Benefit Analysis (CBA) tool: User Guide" internet download; Environment Agency
4) "Industrial Emissions Directive, Derogation Methodology", February 2015 (Draft); Natural Resources Wales
5) Shell DEP (30.73.10.30)
6) AEAT/ENV/R/0469 Issue 2 "Measures to Reduce Emissions of VOCs during Loading and Unloading of Ships in the EU", A report produced for the European Commission Directorate General – Environmental, AEA Technology – Environment, August 2001

2. System Description

Gasoline (and blend components) are exported via three gasoline sea lines which may be directed via valves to two loading arms per berth. Since 2016, for example, gasoline has been produced to meet 44 different product specifications for the global market. This flexibility is key to the refinery survival, and that flexibility requires strict segregation to avoid product contamination.

2.1 Alternatives Technical Assessment

The following alternatives were identified and technically screened:

- Business as Usual (BAU)
- Vapour Recovery (VRU)
- Vapour Recovery (VRU) Derogation

3. Alternatives Technical Assessments

3.1 Qualitative Assessment

3.1.1 Business as Usual (BAU)

3.1.1.1 Description

Marine exports are loaded into several ship compartments to allow the ship to remain level ('on an even keel') and prepared for sea. Each ship compartment may be vented to atmosphere via individual tank vents or via a vapour header to a central vent (ship type dependent).

Three gasoline sea lines can load to multiple berths up to three different gasoline grades or components simultaneously, as is the business norm.

3.1.1.2 Qualitative Assessment

- Air Pollutant emissions of VOCs from ship vents have the potential to form local ground level (tropospheric) ozone. For the majority of the loading period, ship vented VOC concentrations are expected to be relatively low (with respect to equilibrium content) due to the stratified ship compartment vapour. Peak emissions occur toward the end of loading (see appendix 1 for the emission profile).
    - Considered a small negative
- Noise associated with ship venting is considered negligible
- Visual plume from ship vents is considered negligible
- Odour of VOCs from ship vents is considered negligible

3.1.2 Vapour Recovery (VRU) and Vapour Recovery (VRU) Derogation

3.1.2.1 Description

Engineering to date, in line with BAT 52, uses the most plausible and lowest cost design approach of adsorption - absorption (see also section 3.3A) with the following design premise:

Vapours per BAT 52 are collected via existing ship's vapour manifolds that are connected to new vapour capture arms at the Berth, routed through a Dock Safety Unit (deflagration/detonation arrestor and shutdown valve) to a vapour collection pipe (approximately up to 2 km in length). These vapours travel through pipes from berth's 2,7, and 8 to two Vapour Recovery Units (VRU).

The VRU adsorbs the VOCs onto activated carbon before venting to atmosphere. The concentrated VOCs are removed under vacuum (vacuum pumps) and transported to a liquid absorption column (possibly requiring booster blowers, not costed) where gasoline from the export sea-line absorbs the

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VOCs for re-use in the gasoline. Vapours leaving the absorber column pass back through the adsorber beds prior to venting to the atmosphere.

The absorbent flow is cooled via a chilled water exchanger and is returned by a pump from the VRU. The chilled closed loop water system is first cooled by a fin fan, ambient air, exchanger and when required, by an R410a refrigerant chiller (or equivalent). The absorbent is cooled to remove the heat from the vacuum pumps (and booster blowers if required) and to ensure the absorbent Total Vapour Pressure (TVP) is below 75kPa to allow the VOCs to be absorbed (the need for chilling is dependent on the RVP of the gasoline being produced, its temperature and the ambient temperature).

In order to minimize cross-contamination and producing off-specification gasoline at disport (high Reid Vapour Pressure (RVP)) when loading different grades across multiple berths per current operating norm, a minimum of two VRUs are required. To re-use the vapours recovered, they are absorbed back into the gasoline sea-line (one of three) they were exported from, requiring each VRU to be connected to each gasoline sea-line and to each berth (where vapour collection is required), relying on the Operator to correctly line-up the vapour recovery system.

NMVOC adsorbing onto carbon within the VRU has the potential to generate high heats from adsorption, which may be high enough to cause the carbon bed to burn. In order to mitigate the safety risk of an adsorbent carbon bed fire, nitrogen purging of the ship vapours has been included. This is in line with Shell Design Engineering Practices (DEP) which are engineering standards Valero design to. At this stage of project development, it is assumed a Pressure Swing Adsorber (PSA) will be used to generate a 99+% nitrogen (N_2) gas stream for this purpose. The PSA system comprises of an air compressor and solid adsorbent which concentrates the nitrogen within the air. A back up liquid nitrogen storage and re-vaporisation facility will be used to account for PSA system outages. The equipment will be installed alongside the VRU systems. All ships above 20,000 dead weight tonnage (DWT) (per International Convention for the Safety of Life at Sea (SOLAS) code) are purged to less than 5% oxygen. Smaller ships may not be purged. Those ships' vapours will be purged to 5% O_2 by use of nitrogen gas routed to the inlet to the carbon bed adsorbers (located within the VRU). Lowering the oxygen content below the flammable limit for NMVOCs increases the volume of gas passing through each VRU and hence the capacity required of each VRU needs to be significantly larger to accommodate the nitrogen and mitigate the safety risk. This leads to increased capital and operating costs to account for the increased carbon bed capacity (located within the VRU), and nitrogen required.

3.1.2.2 Qualitative Assessment

- Air Pollutant emissions of VOCs from carbon bed vents with the potential to form local ground level (tropospheric) ozone.
    - Considered a small negative as the majority of VOCs are removed

- Greenhouse gas emissions: occur from incineration of spent carbon beds and from onsite electricity generation to power the vapour recovery and associated equipment.
    - Considered a large negative as the additional (vs BAU) carbon damage costs, calculated in the Environment Agency (EA) IED Derogation Cost-Benefit Analysis (CBA) tool, are significant in the scale of the project
- Noise: associated with the vacuum pumps and booster blowers, plus vacuum pumps liquid sealant and absorbent pump. Noise from the absorbent fin fan coolers and chiller, plus the closed loop chilled water circulation pump.
    - Considered a small negative as noise levels at nearest boundary fence may incur a slight increase in background noise
- Visual: Minimum of two VRU's plus nitrogen plant, chilled water and interconnecting piping on the water-front
    - Considered a small negative as the new equipment will be partly obscured by ship loading and existing berth loading arms.
- Odour of VOCs from the VRU vents
    - Considered to be negligible
- Waste: Carbon adsorbent will be spent from 3 beds per VRU every approximate 15 years
    - Considered a small negative - contaminated carbon (along with trace VOCs) will be incinerated at end of life, see discussion of greenhouse gas emissions above.
- Construction: new platforms will be required at each berth collecting vapours, and these are highly likely to require new piles into the sea floor. These berths are located in the Milford Haven Special Area of Conservation (SAC)
    - The damage of installing new piles may outweigh the benefits of NMVOC abatement for the longer term.
    - Considered a medium negative, if native species are present in those specific pile locations.

3.2 Quantitative Assessment (Reference 3) – For all Alternative Cases

3.2.1 Air Pollutant emissions (Berths 2, 7 & 8)

Emissions - Tonnes per year	BAU	VRU	BAU TAR years	VRU TAR years
Benzene	8.3	0.0065	5.4	0.0042
NMVOCs	1085	65	701	42
Energy – kWh p.a.				
Electricity	-	3,718,851	-	2,669,763
Additional Natural Gas to the CHP unit to generate the required electricity	-	7,207,345		5,174,153

Note: Turnaround (TAR) years are those where extensive maintenance is carried out during partial or full refinery shutdown. Annual gasoline volumes are lower during these years.

The NMVOC emissions have been calculated based on the equations and method in Reference 6 (see section 1.1) and key data is presented in Appendix 1.

Benzene emissions are based on: BAU - maximum 1vol% in the gasoline per product specification maximum, actual benzene emissions will be lower as we blend gasoline to a lower benzene concentration. A 10 g/Nm3 emission limit for VOCs and 1mg/Nm3 emission limit for benzene, were used from Reference 2.

3.2.2 NMVOC Damage Costs and Other Inputs

- The damage costs used are those built into the Environment Agency (EA) IED Derogation Cost-Benefit Analysis (CBA) tool.
  - these are the product of both UK Government and EEA work (as compared to the situation in 2016 when a Valero built benefit cost ratio tool was used to draft NRW guidelines), and are intended to be used for these purposes (hence integration into the CBA tool)
- Valero weighted average cost of capital (WACC) provided by corporate at 9 to 10%, per market conditions.
- Decommissioning cost & clean-up are considered insignificant between alternatives and so not included.
- Electricity demand was taken from VRU vendor data and cooling / chilling vendor data with estimates for the % of the year peak cooling would be required. An estimate for the nitrogen plant power has been calculated based on the equivalent air compressor power.
- Pembroke refinery has a Combined Heat and Power (CHP) unit to provide site power, fueled by natural gas. The VRU related electricity demand was used to calculate the additional natural gas required to provide that electricity. The net additional imported natural gas flow was reduced by the calculated additional steam the CHP would produce, reducing the imported natural gas required at the refinery boilers.
- Nitrogen costs have assumed nitrogen gas pricing obtained from the current third-party supply [confidential]. These are expected to be lower (hence a more conservative NPV assessment) than would likely be obtained for a new facility, where the new third-party investment capital would need to be paid in addition to the nitrogen costs. The nitrogen flows required exceed the current nitrogen supply’s full capacity, requiring new third-party investment.

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General quantitative data for all alternatives (per Reference 3)

- Installation was assumed to be December 2018 for the BAT case (or December 2039 for the derogation case)
- Technology is assumed to have a 40-year life time in line with Reference 4, which seems reasonable with ongoing annual maintenance
- Carbon life for the VRU is estimated at 15 years. Typical life range is estimated at 10 – 15 years, hence this is a conservative estimate regarding replacement costs.
- For the BAT-AEL case, after the 40-year asset life the 2023 estimated capital is assumed to be re-invested (less engineering costs, assuming like for like replacement).

3.2.4 Capital Cost

The capital cost is based on vapours collected from Berths 2, 7 & 8 (Berths which currently exceed the 1 million m3 per annum of products loaded with an RVP (Reid Vapour Pressure) above 4kPa [Reference 1]) via new vapour collection arms and into new vapour pipes routing vapours from each berth to each of two VRUs. Each VRU is also connected to each of the three gasoline sea lines to provide the VRU absorbent. Each absorbent supply is cooled to remove the VRU heat generated and to allow absorption of the concentrated vapours. New platforms will be required at each berth and new groundworks at the foreshore for the VRUs. New instrument and electrical infrastructure are required at each berth and the VRU location.

The Shell DEP (30.73.10.30) (Reference 5) discusses the process of VOC adsorption onto carbon beds and states "Vapour streams feeding carbon beds shall be purged with nitrogen to maintain [Maximum Safe Oxygen Concentration] MSOC below 2%". This DEP is for vapour control for wastewater collection and treatment systems, yet raises valid points regarding the risks of a flammable atmosphere within carbon adsorption beds and their ability to achieve high adsorption temperatures, enough to ignite the beds. Consequently, nitrogen purging is considered necessary for the safe operation of the VRU.

The marine codes (SOLAS) requirements state that all oil and chemical tankers of 20,000 DWT and above are required to have an inert gas system fitted, and this must result in an oxygen content of not more than 5 volume %. At this stage of the project we have based the VRU carbon bed sizing on an MSOC of 5%, thus significantly decreasing the size and capital costs of the units compared to designing to a DEP basis of 2% oxygen. There is a risk that further engineering may determine that 2% MSOC is required, incurring additional costs, so the basis selected is conservative. Additionally,

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SOLAS requires all oil and chemical tankers of 8,000 DWT and above, constructed since 2016, to have an operational inert gas system fitted. This assessment assumes that half of the smaller ships over the asset life require external nitrogen to be added to the vapours before entry to the VRU.

A new nitrogen plant will be installed next to the VRUs and will produce 99% pure N2 through the use of a pressure swing absorber (PSA) that extracts nitrogen from the air and compresses it to 4 bar.

VRU installed cost estimate is £REDACTED million *(Confidential to avoid prejudicing vendor bid pricing)*

From appendix 2 it may be observed that berth 8 is over 2km away from the refinery foreshore (that part which is outside of the National Park, within the existing site boundary and close to existing infrastructure {roads, etc..}) and this distance is a major factor in the high abatement capital cost. In addition, new instrument and electrical infrastructure is required at each berth and the vapour abatement equipment plot.

The current total installed project cost is a significant increase from the 2016 value of REDACTED (*confidential*), which is mainly due to the increased size of the VRUs to accommodate nitrogen purging, and the infrastructure costs of a new nitrogen plant on site. Combining this with inflation since 2016 results in the higher total installed project cost.

Inflation since 2016 has been evaluated by obtaining a VRU vendor re-quote and by comparing current material and services costs vs 2016.

Note: Costs to install the vapour recovery at Fort Popton (within the National Park) are much higher still, due to there being even less infrastructure present. The three gasoline sea lines used as absorbent, pass close to the proposed site at the current marine office location, and all three would need to be extended to the Popton site. The 2016 work put this alternative at greater than 150% higher total installed cost and nothing has changed to reduce that. It should also be noted that the actual project cost may be much higher still, because the current cost estimate assumes the jetty structure can support the additional absorbent pipes (as well as the new vapour pipes), and the additional electrical, instrumentation and ground work costs may prove to be an under-estimate (very little infrastructure is existing).

3.3 Sensitivity Study

A) Alternatives to Vapour Recovery

Alternative vapour recovery techniques were briefly reviewed. One vendor offering a condensing technique refused to bid in 2016 stating high capital cost vs recovery by adsorption – absorption, a technique they had no commercial offering. This matches the BREF (Reference 2) which highlights all of the recovery alternatives to be higher capital cost to the adsorption – absorption technique and were not investigated further.

Vapour destruction (thermal oxidation) was evaluated as a lower capital cost alternative. However, due to the CO2 emissions from NMVOC combustion, as well as the natural gas used to assist this combustion, the environmental damage costs are higher than vapour recovery. Vapour destruction was not BAT per the BREF, and consequently was not considered a valid alternative at this phase of the project development, because adsorption - absorption is neither unsafe or technically impossible (per footnote 1 to BAT 52). Operating a Vapour Destruction Unit (VDU) results in 5.1 times the carbon costs of operating a VRU when input into the EA IED tool; due to burning both the NMVOC vapours captured, and the support fuel gas required when the NMVOC vapours are too lean to burn (Reference 6).

Alternative infrastructure projects that would reconfigure the jetty to reduce gasoline volumes below the one million cubic meters a year per berth IED annual volume requiring vapour abatement, result in lost business, ruling out these alternatives. Modifications both at Pembroke and integration with Valero Pembrokeshire Oil Terminal Ltd (VPOT) the other side of Milford Haven waterway were considered. All variations result in additional business costs which are not outweighed by a reduction in capital spend as a result of not needing marine vapour abatement. The typical lost business cost was in the order of $REDACTED per year due to the resultant VPOT jetty congestion *(confidential).*

B) Including value of recovered gasoline

The gasoline vapours recovered were included and valued at the Valero 2023 business plan value of $REDACTED/bbl, recovering £REDACTEDk per year and £REDACTEDk per turn-around year (£1 = $1.2) *(confidential)*.

The recovery value stated was reduced to match what we might reasonably expect to achieve. We sell either on a meter basis, ship volume, shore tank volume or outturn volume (at the buyer). It is unlikely that sales by ship or shore tank volume will recover 100% of the recovered vapours due to sales having an acceptable discrepancy between ship and tank volume up to 0.2vol%. Vapour loss may represent 0.05 vol%, as such we expect to see no benefit from those sales; and the weighted recovery benefit falls to 35%.

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C) EA IED CBA Tool sensitivity results

The total installed project cost estimate is assumed to be accurate to +/- 30%, as are the operating costs. Using this and the WACC range of 9 – 10% the tool gives the following results:

Case	**BAT-AEL - Derogation NPV £ million**
Base case	-69.9
High WACC	-100.9
High NMVOC damage costs	-49
High capital, low damage costs	-127.9
Low capital, high damage costs	-51.3

In addition, two alternative base case models were run:

a) with 200p/therm natural gas price, which gave a base case BAT NPV of £-77.4 million;
b) with VRU electricity supplied via the grid rather than CHP (excluding, however, the capital required to achieve this), which gave a base case BAT NPV of £-70.5 million.

The base case BAT less Derogation NPV provided is the highest of all credible scenarios.

4. Derogation Net Present Value (NPV) Results

See attached pages from the Cost Benefit Analysis (CBA) tool *(confidential to avoid prejudicing vendor bid pricing)*.

The NPV cost to achieve BAT is £69.9 million higher than the proposed derogation until 2040 NPV cost, giving a BAT NPV delta of £-69.9 million, implying that the cost of compliance is disproportionate compared to the environmental benefit achieved.

The Benefit Cost Ratio (BCR) is 0.02. The PV costs are £-71.71MM with PV benefits of £1.79 million, giving the NPV of £-69.92 million.

The proposed derogation results in £2.08 million of NMVOC air pollutant emissions cost. BAT reduces these to £0.29 million, but does so at the cost of £13.92 million of greenhouse gas emissions. The proposed derogation to 2040 reduces these greenhouse gas emissions to £7.45 million, but greenhouse gas emissions cost still exceeds the Business As Usual (BAU) case NMVOC air pollution cost of £4.8 million. It may be argued that BAU results in the lowest total emissions costs, by a significant margin, when both NMVOC and greenhouse gas emissions are accounted for.

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4.1. Comparison to the BREF

There are two key areas where Pembroke operation differs from the BREF analysis (reference 2):

1) Vapour Recovery Capital Cost:
    a. From Table 4.108, page 521 (reference 2) a peak investment cost per tonne of VOC avoided may be calculated: 0.98 Million Euros / 130 tonnes VOC avoided gives 7,539 Euros per tonne of VOC (1998 cost). Assuming 3% inflation gives 12,100 Euros per tonne of VOC (2016 cost), and inflate at 83% to give a 2023 cost of 22,143 Euros per tonne of VOC (2023 cost)
        i. From the table above our current estimate for annual VOCs emitted are 1085 tonnes from berths 2, 7 & 8, giving an equivalent BREF investment of 24 million Euros, or £21 million.
        ii. Investment significantly above £21 million, it may be concluded, is outside of the BREF consideration and may not be justified on a cost benefit assessment.
    b. From Table 4.109, page 522 (reference 2) a 2012 capital cost for a single 2,500m3/h capacity VRU was provided at 1.05 million Euros. From the text (page 521) it states the installation factor is typically 1.5 to 5, with marine loading being at the top end of this range. From table 4.109 the example provided also allows an installation factor of 6.6 to be calculated. The BREF anticipated maximum total installed capital cost may be viewed as 6.6 * 1.05million Euros, or 6.9 million Euros, or £5.4 million per 2,500m3/h VRU. Assuming 3% inflation provides a 2016 installed capital cost of £6.1 million per 2,500m3/h VRU. Inflated cost by 83% gives a 2023 cost of £11.2 million. Scale to 7000 m3/h VRU capacity (to account for the nitrogen purge) gives £31.4 million
        i. Investment significantly above £31.4 million, it may be concluded, is outside of the BREF consideration and may not be justified on a cost benefit assessment.

5. Derogation Request

A time limited Derogation to IED BAT 52, as allowed under Article 15(4) of the IED, is requested for technical reasons: the technical characteristics of the installation due to the location of the jetties in relation to the refinery, will lead to a disproportionately higher cost when compared to the environmental benefits. It is also questionable whether BAT would lead to any environmental benefits, given the degree to which costs in the associated GHG emissions outweigh NMVOC costs.

Pembroke's berth infrastructure is more than 2km long. Berths 7 & 8 (berths 2, 7 & 8 currently exceed the 1 million m3 per annum of products loaded with an RVP above 4kPa [Reference 1]) are the furthest from the refinery foreshore. Berths 7 & 8 were designed to handle the majority of domestic gasoline exports, and alternate berth occupancy levels prevents simply moving the gasoline exports to closer berths.

Around 83% of gasoline made in the refinery is moved across the jetty, rather than by road or pipeline transmission; and the refinery has no connections to the rail network.

Pembroke refinery manufactures multiple gasoline products (44 different grades since 2016) for the UK, European and International markets.

Large export volume, low RVP (Reid Vapour Pressure) gasoline products are most at risk of being off-specification (high RVP) when absorbing high RVP UK and European grade vapours. Each compartment is tested independently and any high in RVP will be in breach of contract, even if the whole ships aggregate quality is acceptable. This is important as vapour recovery techniques concentrate the VOCs absorbed such that as one smaller high RVP export is completed those peak VOCs will typically be absorbed into one ship compartment of the other (larger) export, with the increased potential to be off-specification. Continually swapping absorbent to each smaller, higher RVP, co-current export will add significantly to the business cost with shipping delays. This results in the need for multiple VRUs and a high business cost.

These technical challenges are compounded by the scale of the jetty making compliance more technically challenging and costly to comply than identified in the BREF.

- An NPV of £-69.9 million was calculated using the Environment Agency's IED CBA tool

New platforms will be required at each berth where vapour collection is required, and these may require new piles into the sea floor. These berths are located in the Milford Haven Special Area of Conservation (SAC) where native species maybe present. The damage of installing new piles may outweigh the benefits of NMVOC abatement for the longer term.

Future gasoline volumes may decline with the announced UK government policies. This may reduce gasoline emissions below 1 million cubic meters a year per berth and thereby meet the IED requirement without need for installation of controls. Also, if the number of berths exceeding the threshold reduce from three to two or one, this reduces the scope of emission controls required.

UK Emissions Trading Scheme (UKETS) government policy and rising carbon cost may also result in gasoline exports decreasing below 1 million cubic meters a year per berth and thereby meet the IED requirement without need for installation of controls.

The NMVOC environmental damage values, as stated in the Environment Agency's IED Derogation Cost-Benefit Analysis Tool, are outweighed by the new carbon emissions associated with operating a new vapour recovery system. The system electrical requirements will be met by the refinery combined heat and power (CHP) electrical generating unit which is fuelled by natural gas. In addition, it is noted that these new vapour recovery carbon emissions do not account for the additional carbon emissions created by third parties in extracting the raw materials and manufacturing the vapour recovery equipment, and in addition to the onsite installation carbon emission that are also not included.

Derogation to 2040 provides time for Pembroke Refinery gasoline production to adjust to the current UK government policies likely to reduce UK gasoline demand through the 2030s, with the likely reduction in vapour recovery project scope required to comply with the IED BAT 52 requirements. It is also noted that compliance with IED Bat 52 will result in increased greenhouse gas emissions to power the unit. Reducing greenhouse gas emissions is a UK government focus area, and one Pembroke Refinery is focusing on going forward.

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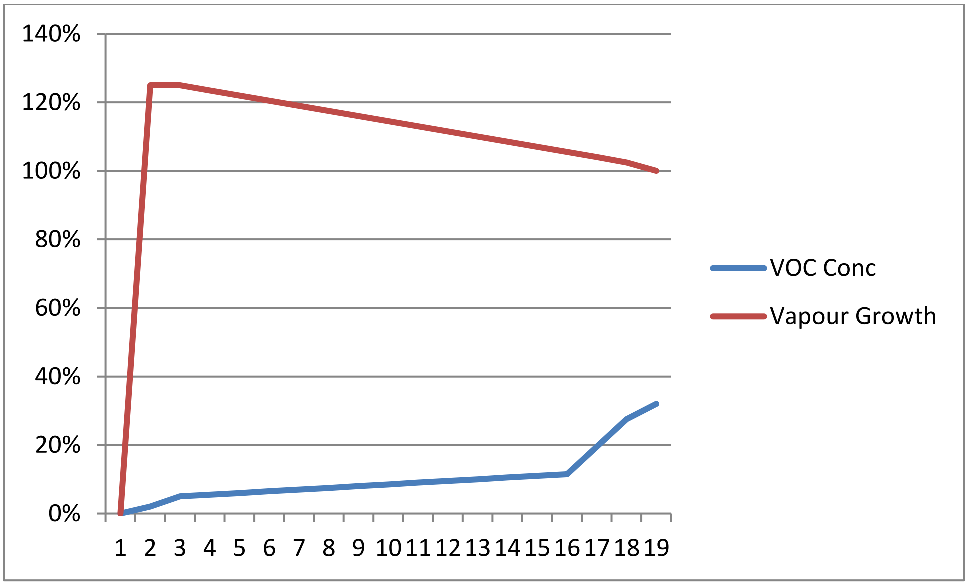
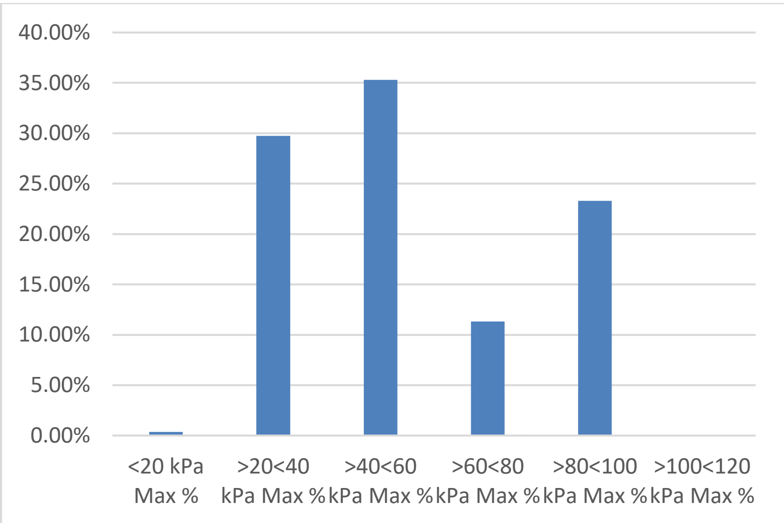
Appendix 1 – VOC Emissions Estimates

From vapour abatement equipment bid information (Companies in alphabetical order: Aereon, John Zink, and Zeeko - *Confidential*), a typical ship loading profile was provided:



Pembroke refinery normalized volume % grade split per RVP (data from 2016 through to October 2022):



To simplify (slightly) all VOC emissions were assumed to be from either 90kPa gasoline (normalized to 26.4 vol% per year) or 48 kPa gasoline (normalized to 73.6 vol% per year).

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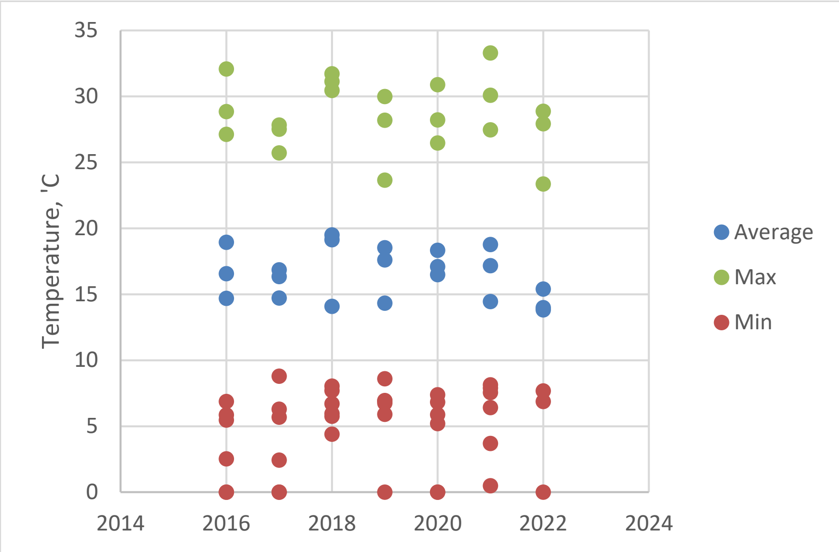
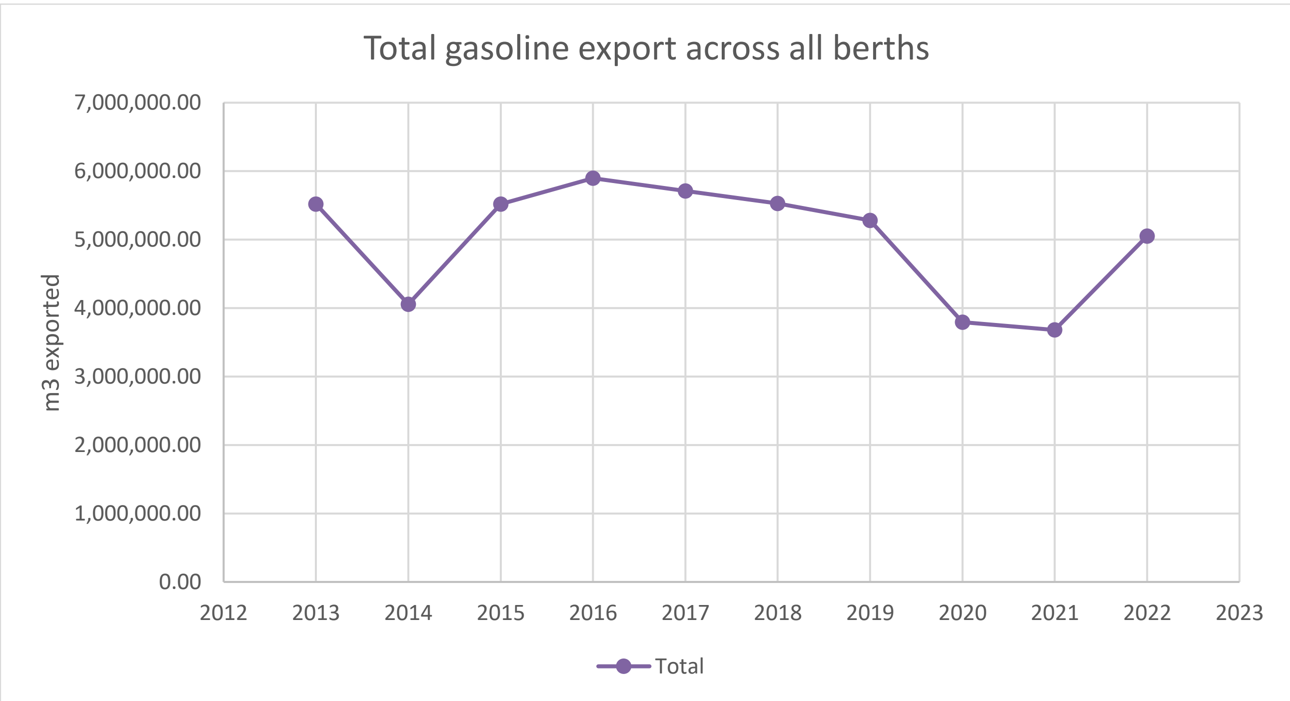
Gasoline is typically stored in 8 tanks whose annual temperatures (in degC) vary as shown:



Taking 20degC as the average for emissions estimates is believed credible, as the highest recently recorded average temperature, but also because both summer and winter grades of gasoline may be produced all year round for various global demands / gasoline trader requirements.



Annual jetty movements. 2014 was a maintenance turnaround year, and taken to be typical for future turnarounds. 2020 and 2021 were covid impacted and 2021 was also a turnaround year.

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Appendix 2 – Plot Plans showing key features & potential Equipment Locations

The following 2 pages print on A3 (Landscape)

Notes

1) Red boxed text = potential new equipment locations.

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<u>Plot plan</u> – key dimensions in mm