ARUP

ConocoPhillips (UK) Teesside Operator Limited

Teesside Crude Oil Stabilisation Terminal Environmental Permit Variation

Appendix H - Combined Heat and Power (CHP) Cost Benefit Analysis (CBA) and CHP Readiness

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List of Abbreviations

Abbreviation	Description
BAT	Best Available Technology
BEIS	Department for Business, Energy and Industrial Strategy
CBA	Cost Benefit Analysis
CHP	Combined Heat and Power
CHP-R	CHP-Readiness
DECC	Department of Energy and Climate Change (now BEIS)
EA	Environment Agency
EED	Energy Efficiency Directive (European Union)
MW	Megawatts – Unit of Energy
MWe	Megawatts Electric – Unit of Energy (electric)
MWh	Megawatt Hours – Unit of Energy (hourly)
MWth	Megawatts Thermal – Unit of Energy (thermal)
NGL	Natural Gas Liquids
TWh	Terawatt Hours – Unit of Energy (1TWh = 1000MWh)

1. Introduction

Ove Arup & Partners (Arup) has been commissioned by ConocoPhillips (UK) Teesside to undertake a Combined Heat and Power Study to accompany the Environmental Permit application for the development of a Power Island (herein referred to as the Proposed Development) at the ConocoPhillips Teesside Crude Oil Terminal, Seal Sands.

The Site lies within the Norsea Terminal boundary (herein referred to as the 'Oil Terminal'), on land leased to the applicant from PD Teesport Ltd, operated by ConocoPhillips (UK) Teesside Operator Ltd (herein referred to as ConocoPhillips). Most of the Site was previously occupied by RWE which has been decommissioned and all process equipment removed from the Site.

The key operational area of the Proposed Development would be located within a fenced area north of the South Boundary Road at the western edge of the Oil Terminal.

The Proposed Development comprises up to a maximum 16 gas engine units that would generate electrical power for use at the Oil Terminal, with excess power being exported to the National Grid. The maximum total generation capacity of the Power Island would be 32 MWe, based on the maximum number of 16 installed engines at 2 MWe each.

The number of operational engines would be dependent on the quantities of fuel gas available, although it is anticipated to be up to a maximum of 11 in number at full load based on projections of the maximum fuel gas volumes. The Power Island includes up to three no. electrical rooms, utilisation of an existing substation at the southern end of the Site, existing electrical transformers, tanks for fresh lubrication oil and recovered, waste lubrication oil, fuel gas metering control kiosk.

Ancillary infrastructure is required to support the Proposed Development includes lighting, parking area, connection to existing Oil terminal, utilising existing access roads, fencing and drainage.

The Proposed Development will be in continuous operation 24 hours per day, seven days per week.

The Environment Agency (EA) requires that all applications for Environmental Permits for new installations regulated under the Environmental Permitting (England and Wales) Regulations 2016 (as amended) (EP Regulations) demonstrate the use of Best Available Techniques (BAT) for a number of criteria, including energy efficiency. One of the principal ways in which energy efficiency can be improved is through the use of Combined Heat and Power (CHP). This report details the cost-benefit analysis (CBA) carried out to identify opportunities for cogeneration (or Combined Heat and Power (CHP)), and an assessment of the requirement to be CHP Ready.

2. Methodology and Policy

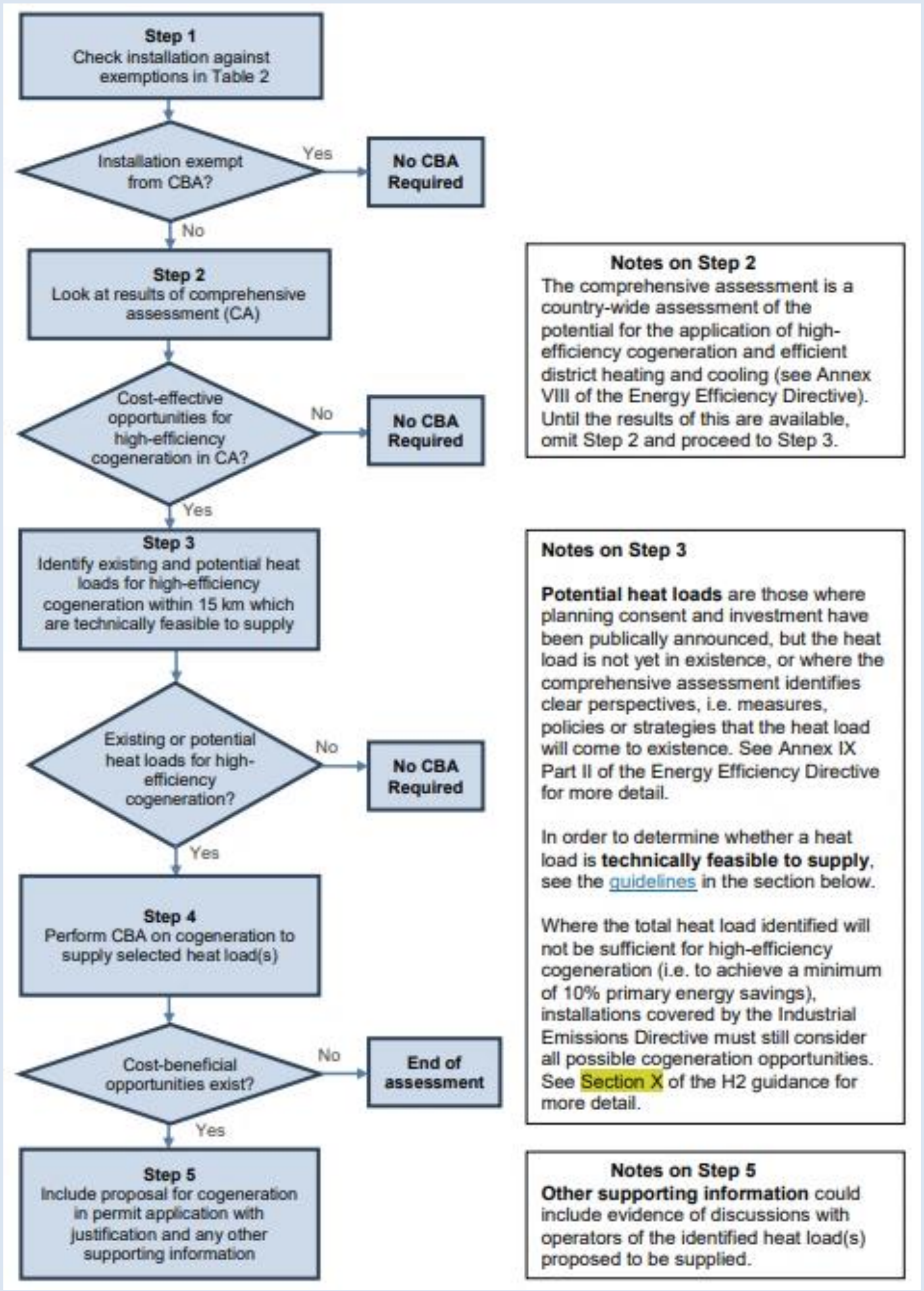
2.1 Overview

From March 2015 onwards, operators of combustion installations are required to complete a CBA to identify opportunities for cogeneration (or CHP) or supply of a district heating network when applying for a new environmental permit, or for a variation when this includes new combustion plant[1]. The requirements of a CBA are outlined in an EA document supporting Article 14 of the Energy Efficiency Directive (EED).

As the E2P Power Island will have a thermal input >20MW, Table 1 of the EA Guidance Document outlines that the CBA is required to cover "the operation of the installation as a high-efficiency cogeneration installation". Steps required to complete a CBA are defined in Figure 1.

[1] Environment Agency, "Cost-benefit assessment for combustion," April 2015. [Online]. Available: https://consult.environment-agency.gov.uk/psc/mcp-and-sg-regulations/supporting_documents/Draft%20Article%2014%20guidance%20April%202015%20V0.9.pdf

Figure 1: Article 14 CBA Assessment Methodology for Type 14,5(b) Installations[2]



In 2013, the EA published detailed guidance on CHP readiness assessments required for thermal generating stations[3] (the CHP-R Guidance), to be used by developers and the EA as part of the of the Environmental Permitting regime. The EA requires applications for Environmental Permits to demonstrate BAT is implemented at any new 'installation'. BAT applies to a number of operational criteria, including energy efficiency.

In accordance with the CHP-R Guidance, the EA requires that developers satisfy three BAT tests in relation to CHP. These are as follows:

First BAT Test:

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[2] Environment Agency, "Cost-benefit assessment for combustion," April 2015. [Online]. Available: https://consult.environment-agency.gov.uk/psc/mcp-and-sg-regulations/supporting_documents/Draft%20Article%2014%20guidance%20April%202015%20V0.9.pdf

[3] Heading 1

"The Environment Agency considers that BAT for energy efficiency for new combustion power plant is the use of CHP in circumstances where there are technically and economically viable opportunities for the supply of heat from the outset. The term CHP in this context represents a plant which also provides a supply of heat from the electrical power generation process to either a district heating network or to an industrial/ commercial building or process. However, it is recognised that opportunities for the supply of heat do not always exist from the outset (i.e. when a plant is first consented, constructed and commissioned)."

Second BAT Test:

"In cases where there are no immediate opportunities for the supply of heat from the outset, the Environment Agency considers that BAT is to build the plant to be CHP Ready (CHP-R) to a degree which is dictated by the likely future opportunities which are technically viable and which may, in time, also become economically viable. The term 'CHP-R' in this context represents a plant which is initially configured to generate electrical power only but which is designed to be ready, with minimum modification, to supply heat in the future. The term 'minimum modification' represents an ability to supply heat in the future without significant modification of the original plant/ equipment. Given the uncertainty of future heat loads, the initial electrical efficiency of a CHP-R plant (before any opportunities for the supply of heat are realised) should be no less than that of the equivalent non-CHP-R plant. For these cases, the Environment Agency has developed this CHP-R Guidance to be used for applications for Environmental Permits for new plants under the EP Regulations."

Third BAT Test:

"Once an Environmental Permit has been issued for a new CHP-R plant, the operator should carry out periodic reviews of opportunities for the supply of heat to realise CHP. Such opportunities may be created both by new heat loads being built in the vicinity of the plant, and/ or be due to changes in policy and financial incentives which improve the economic viability of a heat distribution network for the plant being CHP."

2.2 Project Categorisation and Exemptions

The exact steps required are determined by the classification of the combustion plant, including the fuel source and type of technology being installed at the Installation. Step 1 (Figure 1) involves assessing the Installation against various classification and exemption criteria. The relevant points are listed below.

2.2.1 Categorisation

The E2P Power Island meets the criteria for 14,5(b) due to the installation including multiple new generators and a thermal input >20MW. As per EA guidance, sites meeting the following description are classified as 14,5(b): "Existing thermal electricity generation installation with a total aggregated net thermal input of more than 20 MW which is substantially refurbished (e.g. power station or energy from waste plant)".

2.2.2 Exemptions

The E2P Power Island does not meet the criteria to be considered exempt, the only exemption criteria met informs a search area limited to a radius of 15km from the centre of the Installation.

2.3 DECC Report

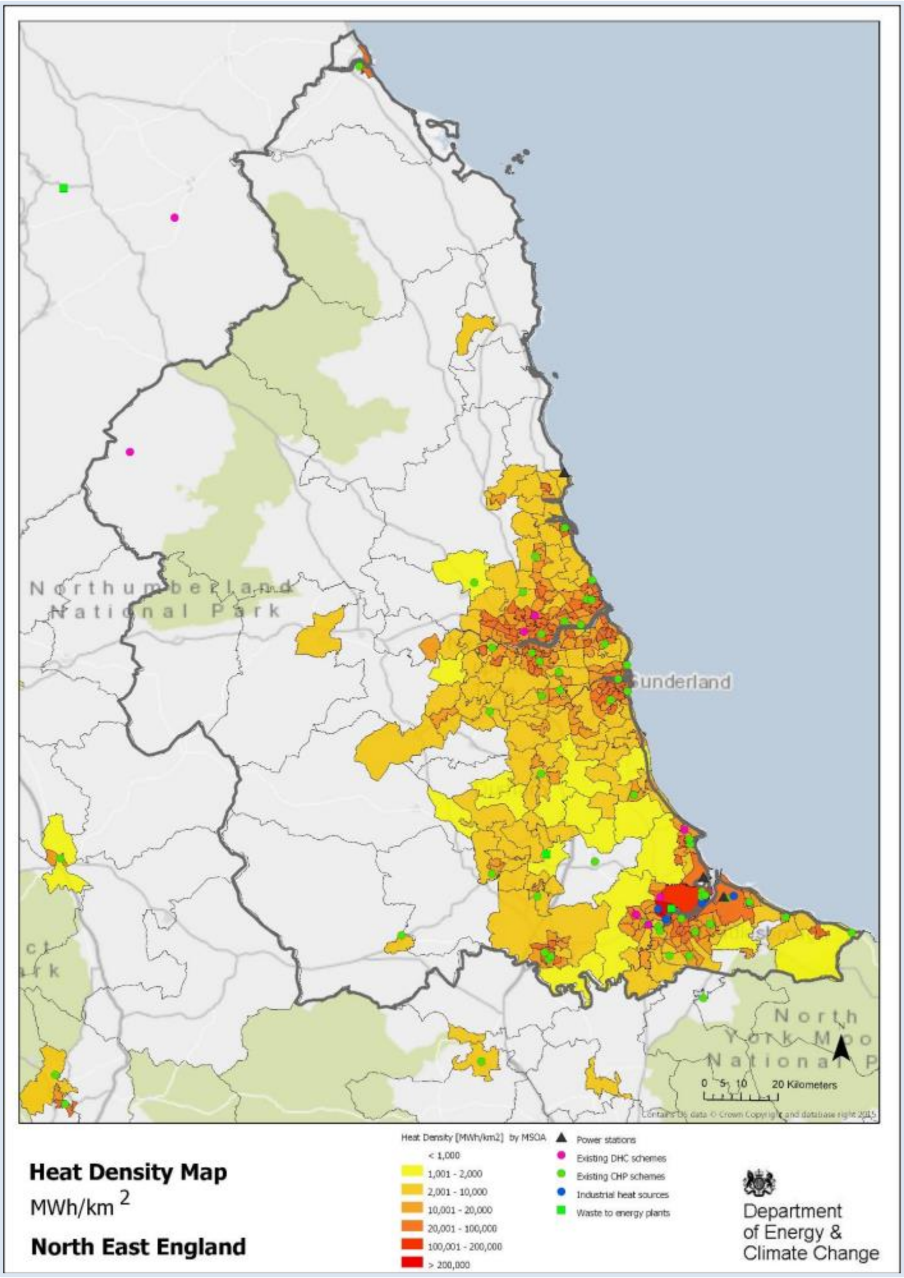
The Department of Energy and Climate Change (DECC) Report, also referred to as the 'Comprehensive Assessment', was published in December 2015. The purpose of the report included the establishment of technical and socially cost-effective potential for high-efficiency cogeneration (CHP) and district heating / cooling. The report makes specific reference to Article 14[4]. A review of the report is required for completion of Step 2.

[4] Ricardo Energy & Environment, "National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK," 15 December 2015. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a7f207340f0b62305b853c1/Final_NCA_Report_for_publication.pdf

The results from the DECC Report relevant to the Installation are for the whole of the region defined as North East England. The area encompassed by this can be seen in Figure 2 below, and is the area referred to in the tables in Section 4 when discussing the results from the DECC Report.

The required 15km radius around the Installation, within which potential sites are identified, is located in the southeast of this region. Numerous other towns and cities including Sunderland, Newcastle-upon-Tyne and Darlington sit within the area defined as North East England, and this is worth keeping in mind when looking at demands in the results of the DECC Report.

Figure 2: Heat Density Map for North East England (as defined in the DECC report [1])



2.4 Identification of Feasible Loads

Article 14 outlines a suite of sources from which to begin a search for feasible sites, these include the aforementioned DECC Report, the CHP Development Map (covered in 4.2) and the National Heat Map (support for which was discontinued in 2018[5]).

[5] Centre for Sustainable Energy, "National Heat Map," [Online]. Available: https://www.cse.org.uk/research-consultancy/consultancy-projects/national-heat-map/

As outlined, any search should be conducted at a radius of 15km from the Installation. An effort should be made to engage with any heat loads identified regarding the feasibility of supplying waste heat to the site. Considerations include the amount and type of waste heat on both the supply and demand side, discussed in more depth in Section 3 and Section 4 below.

Specific considerations from Article 14 relevant to the E2P Power Island and potential loads are the following:

- The compatibility of the heat source(s) and load(s) in terms of temperature and load profiles
- Whether thermal stores or other techniques can be used to match heat source(s) and load(s) which will otherwise have incompatible load profiles
- Whether there is enough demand for heat to allow high-efficiency cogeneration
- For existing installations which are substantially refurbished, the ability to retrofit heat take-off or waste heat recovery (including space considerations)

2.5 Cogeneration CBA

Following this, for sites that are deemed to be technically feasible, completion of the EA's CBA template needs to be completed for each individual sites to assess whether the potential loads are also economically feasible to supply.

If the CBA returns a positive result, a proposal to realise the scheme with justification and supporting information is required. Conclusions are noted in Section 6 of this report.

3. The Site and Installations

3.1 Location and Background

The Teesside Terminal is a crude oil reception, storage and trans-shipment facility. It is designed to receive crude oil from UK and Norwegian oil fields (Ekofisk) via an offshore pipeline and to produce, store and export stabilised crude oil and refrigerated Natural Gas Liquids (NGLs). The NGL feed is fractionated into individual components (methane, ethane, propane and mixed butanes) in a series of fractionating towers. The methane is consumed in the combustion plant on site as fuel gas and the remaining ethane, propane, and mixed butanes are refrigerated and stored in various pressurised, ambient and low pressure refrigerated storage tanks ready for bulk sale to world markets.

The current 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 asset life limitations. As such, an alternative outlet for the ethane is required.

The Teesside Oil Terminal 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 extracted from the oil processed at the Installation; however, the existing plant does not have the capacity to utilise all of the excess ethane stream.

Therefore, following a review of potential solutions for alternative outlets for the ethane product stream, ConocoPhillips consider that the most viable option is to use the gas to produce electrical power for use by the Teesside Terminal, and as such are proposing the installation of a new power island within the existing Environmental Permit Installation Boundary.

3.2 Heat Output

Excess ethane for use at the E2P Power Island is projected to be available until the mid-2030s. Availability of ethane at the Power Island is predicted to steadily decline over the coming decades. Initial generation capacity at the installation will not exceed 32MWe from a thermal input of a maximum of 77MWth (based on the maximum number of 16 installed engines). These values have been used as a worst-case for the Environmental Permit variation and accompanying impact assessments. However, the expected range is more likely to be a generation capacity of 20MWe from a thermal input of 48MWth, decreasing to <20MWe within 10 years, as demonstrated in Table 1. The number of engines installed will need to include up to four engines for redundancy. This will ensure that sufficient operational engines are available at all times to burn the fuel gas available, thereby minimise the potential that the gas would need to be flared.

A high proportion of the waste heat produced by the reciprocating engines will be in the range of 90°C, with potentially up to 10% recovered at a higher grade (250-300°C). Further information regarding generation potential can be found in Appendix D (BAT Assessment) of the Main Supporting Document.

Table 1: Future Fuel Input Availability and Example Engine Requirements

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

4. Identification of Potential Heat Users

4.1 Methodology

The identification of potential heat users has been conducted at a high level to cover the required 15km radius, and at a site level to identify specific sites that could be potential consumers of waste heat.

The high-level search was conducted using the following tools:

- CHP Development Map*:* Use of the CHP Development Map, published by The Department for Business, Energy & Industrial Strategy (BEIS, last updated 2021), is required as part of the search for potential heat loads. The map was used to identify the total heat load within the required 15km radius and provide a breakdown of the load by sector and area (1km x 1km grid squares)[6].

Similarly for the identification of specific heat consumers:

- CHP Development Map: The CHP Development Map contains the location for large individual heat loads (>25,000MWh) within the search radius. However, it does not specify the operator or any technical detail on the type of site or heat load required which is accomplished with the tools below.
- Google Earth & Google Maps: Satellite data, including historical data is useful for observing temporal changes, including the shuttering and demolition of sites. Google Maps can often help identify the operator of a site providing a useful starting point for finding out about the specific type and amount of heat required by a site.
- OS Data: Ordinance Survey data can be visualised using geospatial tools to identify the size and type of a specific building, helping to support information or assumptions gathered using other data sources.
- OSM Data: Open Street Map data is a useful back-up tool if other searches are unable to identify a potential heat load. The data is less reliable; however, it can provide initial information to inform a secondary search.

Alongside digital tools, the local knowledge of ConocoPhillips assisted in the identification of potential heat consumers, particularly within the boundaries of the Seal Sands industrial estate.

4.2 Opportunity Search

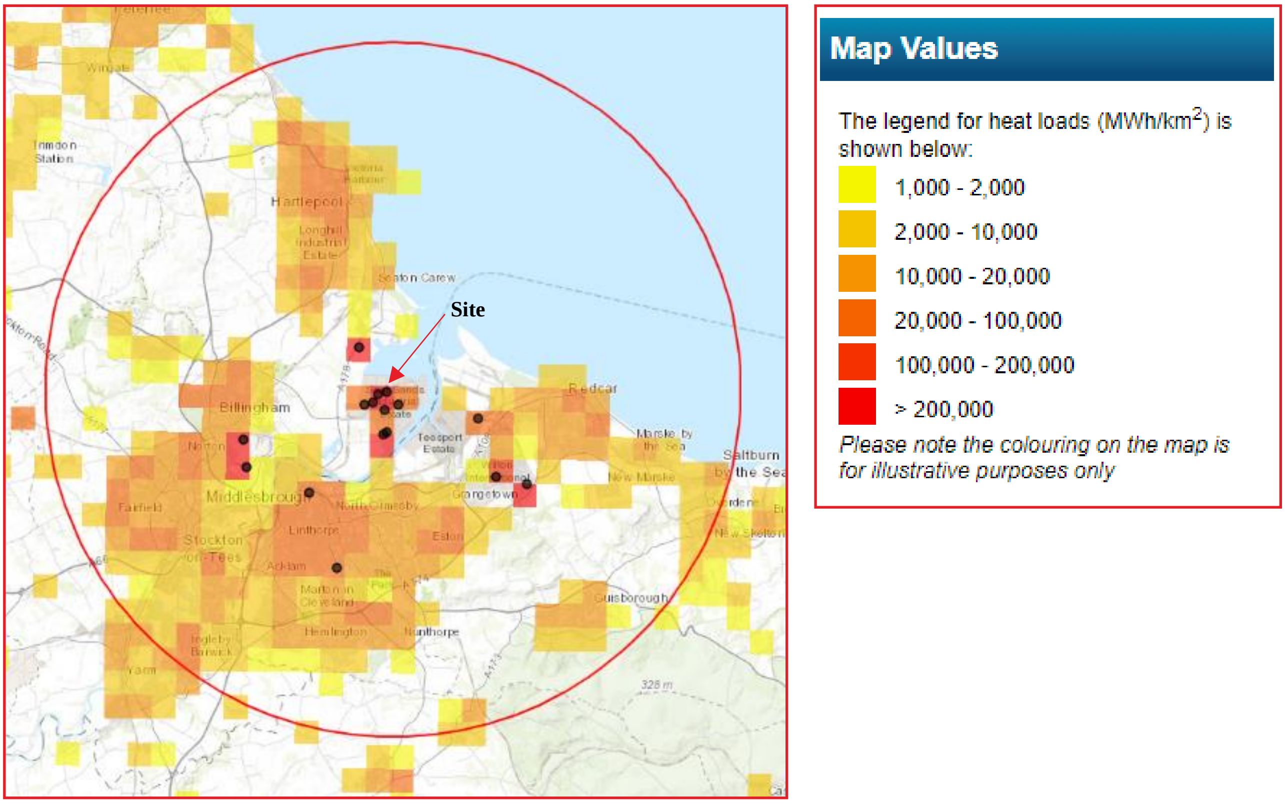
4.2.1 Overview of Area

The area within a 15km radius of the Teesside Terminal is densely populated, both with people and industry, therefore significant existing and potential heat loads exist in most directions around the Installation.

The geographical context presents significant challenges, with the Tees Estuary and surrounding bodies of water enclosing the Seal Sands industrial estate. In particular, the River Tees acts as a substantial barrier, limiting the practical feasibility of extending heat supply beyond approximately 2 km south of the installation. This constraint arises due to the estuary's role as a major industrial shipping route and the presence of a deep-water port, which makes the installation of a crossing within a reasonable distance of the site highly impractical.

[6] Department for Energy Security and Net Zero, "UK CHP Development Map," Department for Energy Security and Net Zero, 2021. [Online]. Available: https://chptools.decc.gov.uk/developmentmap

Figure 3: Results from the UK CHP Development Map (15km radius)



The CHP Development Map demonstrates the urban and industrial characterisation of the area with large and dense heats loads within 15km of the Installation. Significant loads exist on the Seal Sands industrial estate where the Teesside Terminal itself is located, and at sites south of Billingham and east of Grangemouth, both areas with large-scale industrial activity.

Additionally, the CHP Development Map details the total heat load and a breakdown by sector within 15km of the site, as shown in Table 1 below. The total heat load is ~11,810,000MWh annually, comprised mainly of large industrial (53.82%), district heating (21.88%) and domestic (20.50%) loads.

Table 2: Heat Loads from CHP Development Map by Sector (15km Radius)

Sector	Share	Total MWh
Communications and Transport	0.04%	4,895
Commercial Offices	1.07%	125,852
Domestic	20.50%	2,420,768.
Education	0.61%	72,067
Government Buildings	0.16%	18,508
Hotels	0.17%	19,632
Large Industrial	53.82%	6,356,851
Health	0.39%	45,716
Other	0.04%	5,035
Small Industrial	0.91%	107,763
Prisons	0%	0
Retail	0.30%	35,622
Sport and Leisure	0.09%	10,056
Warehouses	0.04%	4,136
District Heating	21.88%	2,583,901

Sector	Share	Total MWh
Total heat load in area		**11,810,807**

Whilst potential sites will be identified within a 15km radius, the specific distance to the site is impactful to the technical and economic feasibility of supplying heat. This is acknowledged in section 4.8.6 of the EN-1 "*To be economically viable as a CHP plant, a generating station needs to be located sufficiently close to industrial, non-domestic or domestic customers with heat demands. The distance will vary according to the size and type of the generating station and the nature of the heat demand.*"[7].

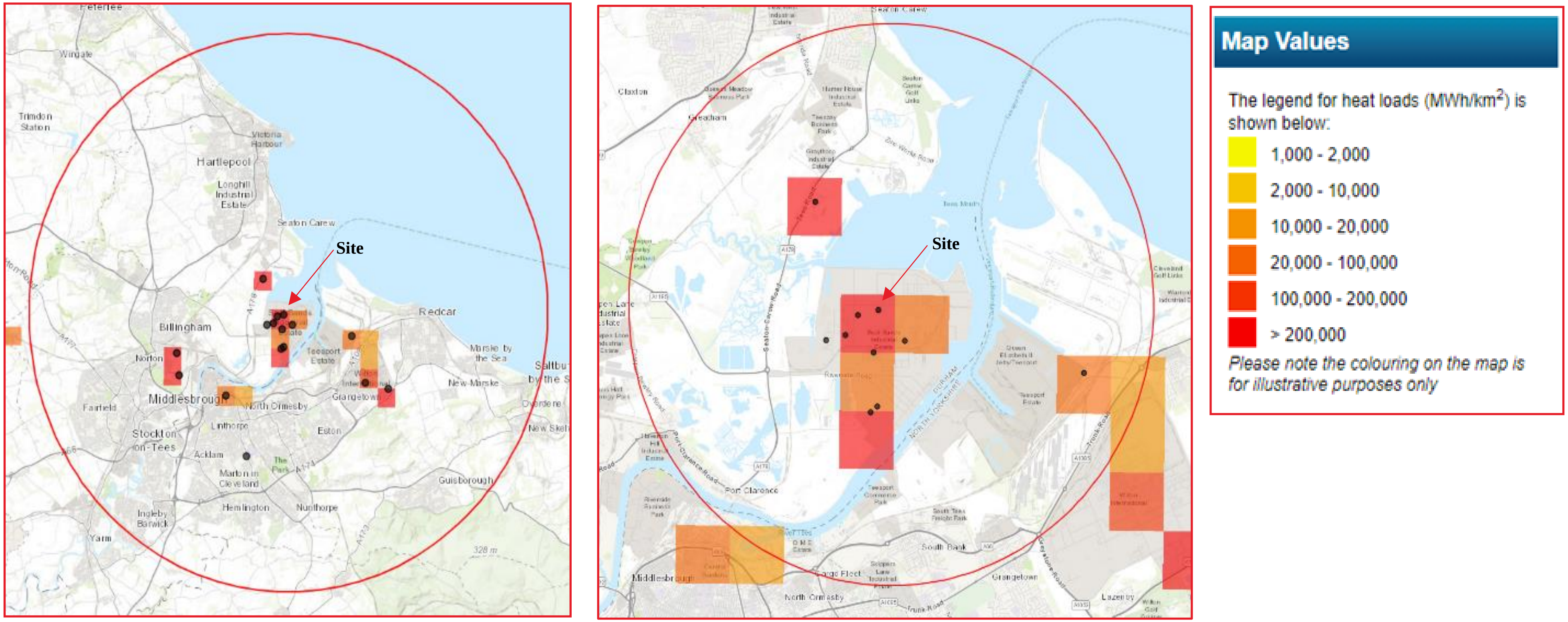
4.2.2 Large Industrial

The CHP Development map (Figure 4) shows that within a 15 km radius of the Installation, large industrial heat loads represent approximately 54% of the total demand, equating to around 6,357,000 MWh. These loads are densely concentrated in a limited number of areas, most notably within the Seal Sands industrial estate. Significant demand also exists to the south-west and south-east of the site, across the River Tees. While technically feasible, supplying heat to these areas is rendered impractical due to the estuary's function as a major shipping lane and deep-water port. These constraints make the installation of a suitable crossing unviable, effectively excluding this area from being served by the Installation.

Within 5km, the total large industrial load decreases to 1,528,000MWh, over 90% of which is within 2km of the Installation and potential heat loads within this radius should be prioritised due to their technical feasibility.

[7] Department for Energy Security & Net Zero, "Overarching National Policy Statement for Energy (EN-1)," November 2023. [Online]. Available: https://assets.publishing.service.gov.uk/media/65bbfbdc709fe1000f637052/overarching-nps-for-energy-en1.pdf

Figure 4: Results from the UK CHP Development Map Filtered for Large Industrial Heat Loads (15km & 5km radius)



Visible on the CHP Development Map are specific large heat loads (>25,000MWh), however these are not filtered by sector. It is assumed that most of these would be categorised as large industrial loads and as such a granular site level search has been undertaken to identify the operators of these sites.

Figure 5 below shows the location of the large heat loads within the Seal Sands estate. The image is taken from the CHP Development Map with only the large heat loads loaded, indicated by the black dots. Other industrial sites on the estate have then been identified using satellite and map data and overlaid in blue.

Figure 5: Map of Large Heat Load Sites from the CHP Development Map (black), Overlaid with Additional Sites Identified as Potential Heat Consumers (blue), CHP Map Data as of 2021

Table 3: List of Sites Included in Figure 5

#	Site	Heat Demand (MW)	Type / Grade of Heat Required
1	Teesside Gas Processing Plant (TGPP)	>30MW	Hot Oil (>350°C)
2	CATS Terminal	>15MW	Hot Oil (>350°C)
3	*Confirmed no operational site*	N/A	N/A
4	*Included in Oil Terminal Facilities*	N/A	N/A
5	Liantech	<5MW	Unknown
6	INEOS Chemical Plant	N/A (now closed)	N/A (now closed)
7	Sabic Teesside (North Tees Works)	Unknown	Unknown
8	Sabic Teesside	Unknown	Steam Boiler (250°C / 40barg)
1	KD Pharma	<5MW	Unknown
2	Fine Environmental Services	>5MW	GCHP (Reciprocating Engines)
3	Greenergy Biofuels Teesside	>10MW	Steam Boiler (250°C / 10barg)

#	Site	Heat Demand (MW)	Type / Grade of Heat Required
4	Navigator	>5MW	Steam Boiler (250°C / 5barg)
5	Exolum Limited	>5MW	Steam Boiler (250°C / 5barg)

Table 3 details the individual heat loads displayed in Figure 5. Identification of the sites has been achieved using the tools outlined in section 4.1. The amount of heat (MWh) and the type of heat have been obtained for sites where possible.

The satellite images below (Figure 6) show the west of the Seal Sands estate in both 2020 (left) and 2024 (right). There are a few important observations. To the west of the image, Wood UK [#2] can be seen, northeast of that is an unidentified load [#3], where there doesn't appear to be any industrial installation that would require a significant heat load and remains unidentified. At the bottom of both images is the INEOS Chemicals Plant [#6], the site was decommissioned between 2020 and 2024, and demolition of the site is underway which can be observed in the second image.

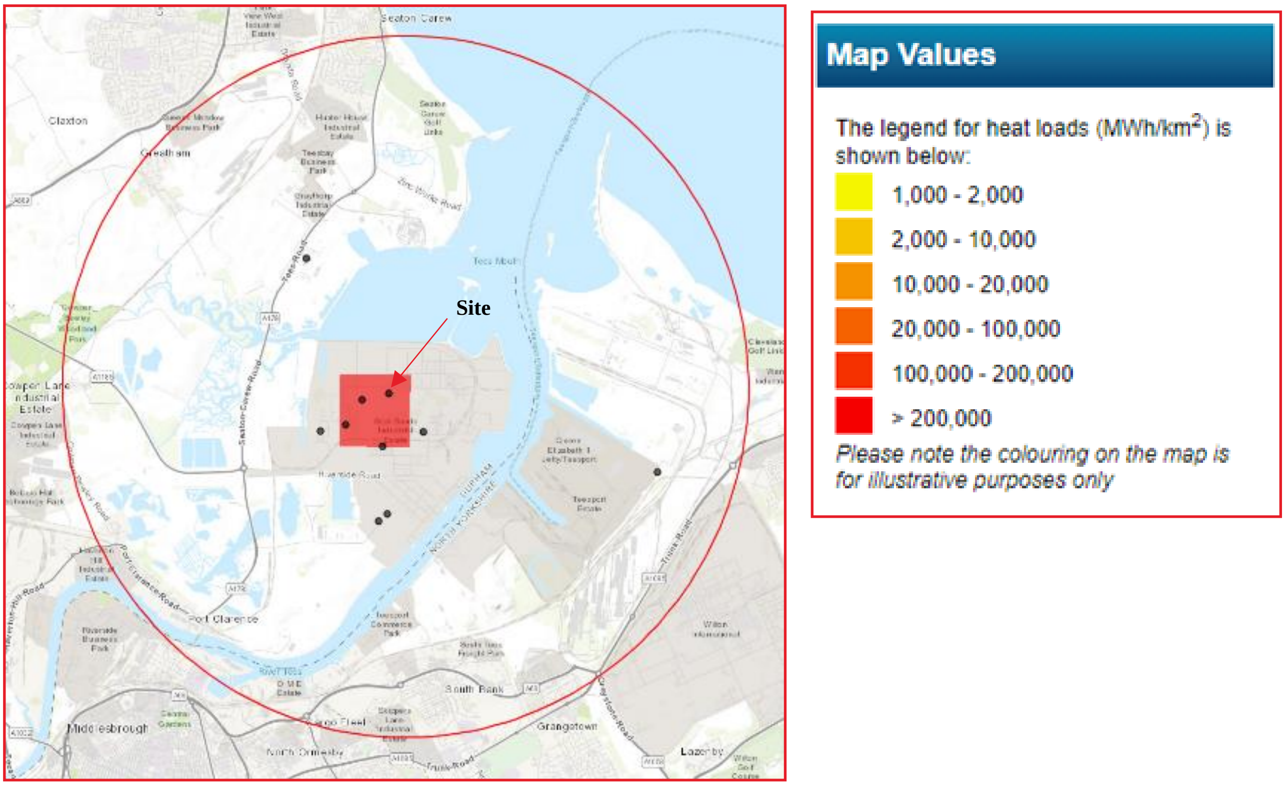
Figure 6: Satellite Images of part of the Seal Sands Industrial Estate in 2020 (left) and 2024 (right)

Technical feasibility for the sites identified in this section will be expanded upon in Section 4.3. At this stage there is not enough evidence to rule out the existence of potential large industrial loads that could be technically feasible to supply from the E2P Power Island.

4.2.3 District Heating

The CHP Development map indicates that within 15km of the Installation (Figure 7) district heating loads account for 21.88% of the total load, approximately 2,584,000MWh, within 5km this decreases marginally to 2,551,929MWh. The load is concentrated to within a 1km^2 area adjacent to the Teesside Terminal. There are no known active district heating networks in the vicinity, the former network in Billingham has been decommissioned for over a decade and even if active, would be too far from the site to be responsible for the load seen on the CHP Development map. Discussion with other stakeholders within the Seal Sands industrial estate has also not yielded information as none are aware of any heat load supplied using district heating that exists in the vicinity.

Figure 7: Results from the UK CHP Development Map Filtered for District Heating Heat Loads (5km radius)



The now closed INEOS (formerly BASF) chemical plant in Seal Sands is likely responsible for the District Heating load on the map, importantly the plant was still in operation when the CHP Development Map was last updated. BASF had an agreement to supply a proportion of electricity created by the on-site CHP back to the National Grid and significant heating loads were being transported between installations at the site[8,9]. Additionally, the CHP Development Map indicates a heat load of 2,551,929MWh for site [#6], identified as the INEOS chemical plant. When compared to the total district heating load within 5km of the E2P Power Island, it is an exact match. The government heat network planning database does include CHP based installations, so it is plausible that the site was included as 'district heating' on the CHP Development map.

Given that there have been no existing or planned district heating loads identified within a reasonable distance of the E2P Power Island, district heating is not considered to be a viable opportunity for the supply of heat from CHP.

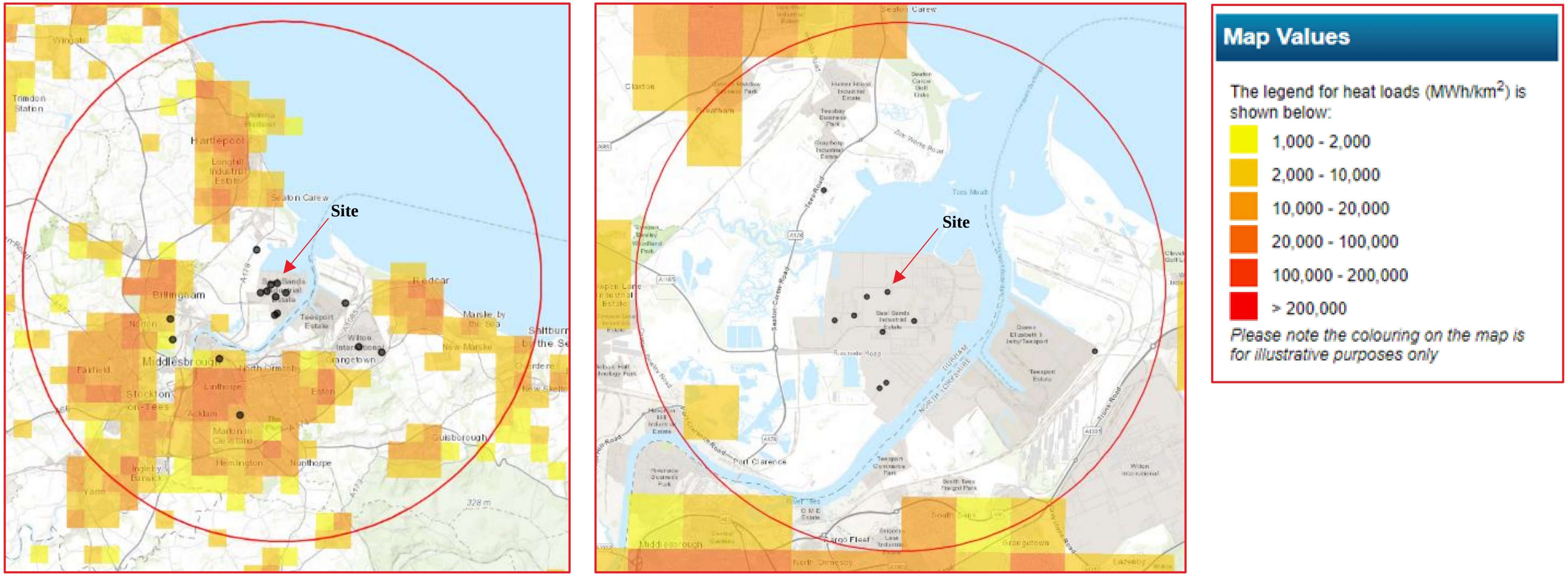
4.2.4 Domestic

The CHP Development map states that within 15km of the Installation (Figure 8) domestic heat loads account for 20.5% of the total load, approximately 2,420,000MWh. The load is low density and far from the Teesside Terminal with almost all of the load outside of 5km from the Installation. Within 5km, the domestic heat load accounts for only 1.94% (~84,000MWh) of the total heat load.

[8] The Journal, "Npower Cogen is energising BASF's Seal Sands operation," 26 June 2006. [Online]. Available: https://www.thefreelibrary.com/Npower+Cogen+is+energising+BASF%27s+Seal+Sands+operation.-a0147457114

[9] NS Energy, "Full integration works at Seal Sands CHP," 23 April 1998. [Online]. Available: https://www.nsenergybusiness.com/analysis/featurefull-integration-works-at-seal-sands-chp/?cf-view

Figure 8: Results from the UK CHP Development Map Filtered for Domestic Heat Loads (15km & 5km radius)



The majority of the domestic load is centred around settlements south of the Tees, with the exception of Hartlepool to the North and Billingham to the West. Transporting heat either across the Tees or around the numerous other bodies of water (e.g. Teesmouth Nature Reserve, Greatham Creek) adds significant cost and complexity to the system given the multiple export routes required to reach the demand.

The DECC report, indicates that for the North East of England (as defined previously) there exists the technical potential for up to 11TWh of Individual Gas CHP + Boiler solutions to be implemented. However, for cost-effective potential, this drops to 0TWh for both the Full Finance and Zero Finance scenarios which is shown in Tables 3 and 4 below[10]. The methodology undertaken to define "cost-effective" solutions is outlined in Section 2.2.5 of the DECC Report but involves a similar approach to this report with feasible heating loads identified and a cost-benefit analysis undertaken to compare the "socially cost-effective" viability of a district heating solution across multiple financing scenarios.

Table 4: Cost-effective Potential of High-efficiency Solutions Under the Full Finance Costs Scenario (TWh of heat output pa)

Heating solutions	Total	Industry (incl. agriculture)	Commercial Services	Public Services	Residential
	TWh pa	TWh pa	TWh pa	TWh pa	TWh pa
High efficiency, total	**10**	**10**	**1**		
Individual	*10*	*10*	*0*	*0*	*0*
District heating	0		0		
Non-CHP baseline, total	**14**	**1**	**0**	**0**	**12**
Total heat output	**25**	**11**	**14**		

Table 5: Cost-effective Potential of High-efficiency Solutions Under the Zero Finance Price Scenario (TWh of heat output pa)

Heating solutions	Total	Industry (incl. agriculture)	Commercial Services	Public Services	Residential
	TWh pa	TWh pa	TWh pa	TWh pa	TWh pa
High efficiency, total	**16**	**10**	**6**		
Individual	*11*	*10*	*0*	*0*	*0*
District heating	*6*		*6*		
Non-CHP baseline, total	**9**	**0**	**0**	**0**	**8**
Total heat output	**25**	**11**	**14**		

A 2009 report referenced by the DECC indicated that to be economically feasible, an exported load from waste heat would have to be sufficiently large and close to the domestic heating load being supplied, *"This would, for example, be the case for a load of 200MW (equivalent to over 50,000 domestic customers)"*, a load far in excess of what would be feasible to supply from the E2P Power Island[11].

Given the above factors, domestic heating loads are not considered to be a viable opportunity for the supply of heat from the E2P Power Island.

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[10] Ricardo Energy & Environment, "National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK," 15 December 2015. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a7f207340f0b62305b853c1/Final_NCA_Report_for_publication.pdf

[11] Poyry and FABER Maunsell, "The Potential and Costs of District Heating Networks," April 2009. [Online]. Available: https://webarchive.nationalarchives.gov.uk/ukgwa/20100809173317/http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/distributed%20energy%20heat/1_20090711113452_e_@@_areportprovidingatechnicalanalysisandcostingofdhnetworks

4.2.5 Other

Outside of the three sectors already covered, heat loads in the vicinity of the Installation (<5km radius) are limited to commercial and office buildings, and smaller industrial sites which have already been identified in Section 4.2.2. The area containing heat loads relating to commercial and office buildings is dominated by loads connected to industrial sites already captured in the report and so are unlikely to provide feasible standalone opportunities.

No viable opportunities for the supply of heat from CHP in any other sectors have been identified.

4.3 Analysis of Search Results

The opportunity search concluded that the only potential feasible sites for supply are industrial sites close to the Teesside Terminal. Industrial sites that have been successfully identified are listed in Table 6 alongside the size and type of demand.

Table 6: Sites Identified as Part of the Opportunity Search

Site	Heat Demand (MW)	Type / Grade of Heat Required
Teesside Gas Processing Plant (TGPP)	>30MW	Hot Oil (>350°C)
Wood UK (BP CATS)	>15MW	Hot Oil (>350°C)
Liantech	<5MW	Unknown
Sabic Teesside	Unknown	Unknown / Steam (>400°C)
Sabic Teesside	Unknown	Unknown / Steam (>400°C)
KD Pharma	<5MW	Unknown
Fine Environmental Services	>5MW	GCHP (Reciprocating Engines)
Greenergy Biofuels Teesside	>10MW	Steam Boiler (250°C / 10barg)
Navigator	>5MW	Steam Boiler (250°C / 5barg)
Seal Sands Storage	>5MW	Steam Boiler (250°C / 5barg)

The type of heat required by potential consumers ranges from 250°C – 400°C+. The majority of the waste heat produced by the operations at the E2P Power Island are in the range of 90 - 100°C which is entirely unsuitable to serve the heat demands identified. Whilst it would be technical feasible to recover ~10% of the thermal input at a temperature of 250 - 300°C, the economics involved for the production of an amount of heat smaller than any identified demand (<5MW), which decreases significantly over time, is considered not to be economically feasible.

The size of heat demands identified range from less than 5MW, to upwards of 30MW. The majority of these loads would likely be feasible to supply using the initial 22MW that would be available from the E2P Power Island, but considering the turndown of production, as detailed in Section 4.2, large loads in this range would likely not be feasible to supply long-term, significantly reducing economic feasibility.

For these reasons, none of the sites identified are considered to be a viable opportunity for the supply of heat from CHP at the E2P Power Island.

5. CHP Readiness

The CHP-R Guidance states that the Environment Agency require applications for Environmental Permits to demonstrate BAT for a number of criteria, including energy efficiency. Aside from the selection of efficient plant, one of the principal ways of improving energy efficiency is through the use of CHP. The EA therefore requires developers to satisfy three BAT tests in relation to CHP.

The first involves considering and identifying opportunities for the use of heat off-site, which for the E2P Power Island has concluded there are no viable opportunities at the current time.

Where this is not technically or economically possible and there are no immediate opportunities, the second test involves ensuring that the plant is built to be 'CHP Ready'.

The generator containers will be provided with flow/ return flanges on one side which could be used to retrofit jacket water heater recovery equipment at a later date if opportunities for CHP are identified in the future. Additional heat recovery equipment is available from the engine provider, which would include changing the dual coil radiator to two separate radiators (jacket water & intercooler radiators). It is therefore considered that that E2P Power Island will be CHP-Ready should future opportunities become available. The EA’s CHP-R template form has been completed and is included in Annex A.

The third BAT test requires ongoing review of CHP potential, which will be required under the Environmental Permit for the Installation.

6. Conclusions

This report has been completed to support the application of an Environmental Permit variation for the inclusion of the E2P Power Island at the Teesside Terminal and is to be submitted alongside other documents.

In accordance with the requirements outlined in The Guidance Document for EED Article 14 (Environment Agency 2015) a CBA analysis has been undertaken to understand the feasibility of CHP export from the E2P Power Island at the Teesside Terminal.

The report has identified that numerous theoretical heat loads do exist within the required 15km radius of the Installation. In spite of the existence of these loads, relating to the industrial and domestic sectors, none offer an economically viable opportunity for the export of heat.

Due to no feasible heat loads being identified, no EA cost-benefit analysis templates, as defined in Section 2.5, were required to be completed as part of the CBA.

Therefore, CHP is not proposed to be installed at the E2P Power Island from the outset. Given the turndown and decreasing volume of heat available from the E2P Power Island over the coming decade CHP will continue to become even less economically viable. More detail regarding Best Available Techniques for the site can be found in the BAT assessment submitted as Appendix D of the Main Supporting Document.

7. Bibliography

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Annex A – CHP Readiness Assessment

#	Description	Units	Response
Requirement 1: Plant, Plant location and Potential heat loads			
1.1	**Plant name**		ConocoPhillips E2P Power Island
1.2	**Plant description**		16 gas engine units that would generate electrical power from fuel gas produced at the Teesside Terminal, for use at the Teesside Terminal, with excess power being exported to the National Grid. The maximum total generation capacity of the E2P Power Island would be 32 MWe, based on the maximum number of 16 installed engines at 2 MWe each. Based on a reported efficiency in the order of 41% the 16 engines have a gross thermal input of 77.3MWth, however, up to four engines will be installed for redundancy purposes, and it is considered that the maximum number of engines that will be operational concurrently will be 11 - equating to a maximum thermal input of 53MWth. This mode of operation will only be in place for 3 - 4 years, after which time the number of operational engines will decrease, such that after 10 years of operation, only approximately 2 engines will be required for the fuel gas volumes available.
1.3	**Plant location (Postcode / Grid Ref)**		Teesside Crude Oil Stabilisation Terminal Seal Sands Middlesbrough United Kingdom TS2 1UH Location of the plant is shown in Figures 1 and 2 of the Main Supporting Document.
1.4	**Factors influencing selection of plant location**		The E2P Power Island will be located within the existing Installation of the Teesside Crude Oil Stabilisation Terminal, as the plant will utilise fuel gas produced at the Terminal and provide electrical power to the Terminal. The land is currently vacant; however it was previously used for the RWE Cogeneration Power Station, which was demolished in 2023. The potential for CHP opportunities are detailed in the CHP CBA Report, Table 6.
1.5	**Operation of plant**		
a)	Proposed operational plant load	%	Based on the maximum fuel gas volumes, a maximum of 11 engines at 100% load would be required to be operational at the start of operations. This will reduce over the lifetime of the E2P Power Island, such that by 2037 it is envisaged that a maximum of 2 engines will be required to operate at full load to use the available fuel gas.

b)	Thermal input at proposed operational plant load	MW	At average fuel gas flows this is 44MWth, however from 2033 onwards this reduces to <33MWth, then <9MWth from 2037. A full profile of fuel gas flows and engine numbers is provided in CHP CBA Report, Table 1.
c)	Net electrical output at proposed operational plant load	MW	At average fuel gas flows this is 20MWe, however from 2033 onwards this reduces to <12MWe, then <4MWe from 2037.
d)	Net electrical efficiency at proposed operational plant load	%	This will be in the order of 41.4%.
e)	Maximum plant load	%	100%
f)	Thermal input at maximum plant load	MW	At maximum fuel gas flows this is 53MWth, however from 2033 onwards this reduces to <40MWth, then <10MWth from 2037. A full profile of fuel gas flows and engine numbers is provided in CHP CBA Report, Table 1.
g)	Net electrical output at maximum plant load	MW	At maximum fuel gas flows this is 22MWe, however from 2033 onwards this reduces to <16MWe, then <4MWe from 2037.
h)	Net electrical efficiency at maximum plant load	%	Reported efficiency of 41.4%
i)	minimum stable plant load	%	In the order of 40%.
j)	Thermal input at minimum stable plant load	MW	<44MWth, however from 2033 onwards this reduces to <33MWth, then <9MWth from 2037. A full profile of fuel gas flows and engine numbers is provided in CHP CBA Report, Table 1.
k)	Net electrical output at minimum stable plant load	MW	<20MWe, however from 2033 onwards this reduces to <12MWe, then <4MWe from 2037.
l)	Net electrical efficiency at minimum stable plant load	%	Reported efficiency of 41.4%
1.6	**Identified potential heat loads**		
			None identified - see Main Report.
1.7	**Selected heat load(s)**		
a)	Category (e.g. industrial / district heating)		No potential heat loads identified - see Section 4 of the Main Report.
b)	Maximum heat load extraction required	MW	No potential heat loads have been identified - see Section 4 of the Main Report.
1.8	**Export and return requirements of heat load**		

a)	Description of heat load extraction		No potential heat loads identified.
b)	Description of heat load profile		No potential heat loads identified.
c)	Export pressure	bar a	No potential heat loads identified.
d)	Export temperature	°C	No potential heat loads identified.
e)	Export flow	t/h	No potential heat loads identified.
f)	Return pressure	bar a	No potential heat loads identified.
g)	Return temperature	°C	No potential heat loads identified.
h)	Return flow	t/h	No potential heat loads identified.
Requirement 2: Identification of CHP Envelope			
2.0	**Comparative efficiency of a standalone boiler for supplying the heat load**	90 % LHV	Not Applicable
2.1	**Heat extraction at 100% plant load**		No heat recovery is currently included. The ethane combustion is primarily a means of reducing routine flaring, which would otherwise waste the fuel and emit CO_2 and unburned hydrocarbons. Given the lack of a viable heat demand at the site or nearby, heat recovery has been deemed technically and economically unfeasible.
a)	Maximum heat load extraction at 100% plant load	MW	0
b)	Maximum heat extraction export flow at 100% plant load	t/h	0
c)	CHP mode net electrical output at 100% plant load	MW	22MWe
d)	CHP mode net electrical efficiency at 100% plant load	%	41.4%
e)	CHP mode net CHP efficiency at 100% plant load	%	87.7%.
f)	Reduction in primary energy usage for CHP mode at 100% plant load	%	As the E2P Power Island is burning waste gas that would otherwise be flared to atmosphere. This recovers value from an otherwise waste energy stream. The reduction in primary energy usage is therefore 100%.

2.2	**Heat extraction at minimum stable plant load**		
a)	Maximum heat load extraction at minimum stable plant load	MW	No potential heat loads identified therefore not applicable as no heat will be extracted.
b)	Maximum heat extraction export flow at minimum stable plant load	t/h	No potential heat loads identified therefore not applicable as no heat will be extracted.
c)	CHP mode net electrical output at minimum stable plant load	MW	0.6MW
d)	CHP mode net electrical efficiency at minimum stable plant load	%	This will be in the order of 41.4% efficient.
e)	CHP mode net CHP efficiency at minimum stable plant load	%	This will be in the order of 80% efficient.
f)	Reduction in primary energy usage for CHP mode at minimum stable plant load	%	As the E2P Power Island is burning waste gas that would otherwise be flared to atmosphere. This recovers value from an otherwise waste energy stream. The reduction in primary energy usage is therefore 100%.
2.3	**Can the plant supply the selected identified potential heat load (i.e.is the identified potential heat load within the 'CHP envelope')?**		No potential heat loads identified.
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	**Proposed operation of plant with CHP**		
a)	CHP mode net electrical output at proposed operational plant load	MW	No potential heat loads identified.

b)	CHP mode net electrical efficiency at proposed operational plant load	%	No potential heat loads identified.
c)	CHP mode net CHP efficiency at proposed operational plant load	%	No potential heat loads identified.
d)	Reduction in net electrical output for CHP mode at proposed operational plant load	MW	No potential heat loads identified.
e)	Reduction in net electrical efficiency for CHP mode at proposed operational plant load	%	No potential heat loads identified.
f)	Reduction in primary energy usage for CHP mode at proposed operational plant load	%	NA No potential heat loads identified.
g)	Z ratio		No potential heat loads identified.
Requirement 4: Technical provisions and space requirements			
4.1	**Description of likely suitable extraction points**		No potential heat loads have been identified. The engines will retain connection points that can be utilised to extract LTHW should a suitable heat load be identified in the future.
4.2	**Description of potential options which could be incorporated in the plant, should a CHP opportunity be realised outside the 'CHP envelope'**		N/A

4.3	**Description of how the future costs and burdens associated with supplying the identified heat load / potential CHP opportunity have been minimised through the implementation of an appropriate CHP-R design**		Accurately sized heat exchange equipment at specified extraction points will be provided to allow the maximum heat load to be extracted. Flow and Return temperatures of primary and secondary systems will be considered and provided at condition to allow maximum heat to be extracted. A suitable controls interface between the engine controls and secondary system will be provided to allow accurate control of primary side heat supply to match secondary side heat uptake.
4.4	**Provision of site layout of the plant, indicating available space which could be made available for CHP-R**		Suitable provisions will be provided in the detail design of the plant including the identification of future space provisions needed to supply and newly identified heat load.

Requirement 5: Integration of CHP and carbon capture			
5.1	**Is the plant required to be CCR?**		No
5.2	**Export and return requirements identified for carbon capture**		
	100% plant load		
a)	Heat load extraction for carbon capture at 100% plant load	MW	N/A
b)	Description of heat export (e.g. steam / hot water)		N/A
c)	Export pressure	bar a	N/A
d)	Export temperature	°C	N/A
e)	Export flow	t/h	N/A
f)	Return pressure	bar a	N/A
g)	Return temperature	°C	N/A
h)	Return flow	t/h	N/A
i)	Likely suitable extraction points		N/A
	Minimum stable plant load		
j)	Heat load extraction for carbon capture at minimum stable plant load	MW	N/A
k)	Description of heat export (e.g. steam / hot water)		N/A

l)	Export pressure	bar a	N/A
m)	Export temperature	°C	N/A
n)	Export flow	t/h	N/A
o)	Return pressure	bar a	N/A
p)	Return temperature	°C	N/A
q)	Return flow	t/h	N/A
r)	Likely suitable extraction points		N/A
5.3	**Operation of plant with carbon capture (without CHP)**		
a)	Maximum plant load with carbon capture	%	N/A
b)	Carbon capture mode thermal input at maximum plant load	MW	N/A
c)	Carbon capture mode net electrical output at maximum plant load	MW	N/A
d)	Carbon capture mode net electrical efficiency at maximum plant load	%	N/A
e)	Minimum stable plant load with CCS	%	N/A
f)	Carbon capture mode CCS thermal input at minimum stable plant load	MW	N/A
g)	Carbon capture mode net electrical output at minimum stable plant load	MW	N/A
h)	Carbon capture mode net electrical efficiency at minimum stable plant load	%	N/A
5.4	**Heat extraction for CHP at 100% plant load with carbon capture**		
a)	Maximum heat load extraction at 100% plant load with carbon capture [H]	MW	N/A
b)	Maximum heat extraction export flow at 100% plant load with carbon capture	t/h	N/A
c)	Carbon capture and CHP mode net electrical output at 100% plant load	MW	N/A
d)	Carbon capture and CHP mode net electrical efficiency at 100% plant load	%	N/A
e)	Carbon capture and CHP mode net CHP efficiency at 100% plant load	%	N/A
f)	Reduction in primary energy usage for carbon capture and CHP mode at 100% plant load	%	N/A

5.5	**Heat extraction at minimum stable plant load with carbon capture**		
a)	Maximum heat load extraction at minimum stable plant load with carbon capture	MW	N/A
b)	Maximum heat extraction export flow at minimum stable plant load with carbon capture	t/h	N/A
c)	Carbon capture and CHP mode net electrical output at minimum stable plant load	MW	N/A
d)	Carbon capture and CHP mode net electrical efficiency at minimum stable plant load	%	N/A
e)	Carbon capture and CHP mode net CHP efficiency at minimum stable plant load	%	N/A
f)	reduction in primary energy usage for carbon capture and CHP mode at minimum stable plant load	%	N/A
5.6	**Can the plant with carbon capture supply the selected identified potential heat load (i.e. is the identified potential heat load within the 'CHP and carbon capture envelope')?**		N/A No heat users identified
5.7	**Description of potential options which could be incorporated in the plant for useful integration of any realised CHP system and carbon capture system**		N/A
Requirement 6: Economics of CHP-R			
6.1	**Economic assessment of CHP-R**		It is not considered economically viable to develop a district heating network as there are no identified heat loads that can be supplied for the installation.
BAT assessment			
	Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)?		No - no viable heat loads have been identified.
	If not, is the new plant a CHP-R plant at the outset?		Yes - the plant will be CHP ready from the outset.
	Once the new plant is CHP-R, is it BAT?		Yes - the plant will have periodic review and is BAT.