FICHTNER
Consulting Engineers Limited

# Corby ERF

## Covanta

Heat and Power Plan

ENGINEERING + CONSULTING

# Document approval

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# Document revision record

| Revision no | Date | Details of revisions | Prepared by | Checked by |
|---|---|---|---|---|
| 0 | 07/12/2022 | Draft for Client comments | VBT | RO |
| 1 | 23/12/2022 | Amended to address Client's comments | VBT | RO |
| | | | | |

# Contents

# 1 Introduction

## 1.1 Background

Covanta Energy Limited (Covanta) is developing the Corby Energy Recovery Facility (the Facility) in Corby, Northamptonshire. The Facility will incinerate a range of residual municipal solid waste (MSW), commercial and industrial (C&I) waste and refuse derived fuel (RDF).

## 1.2 Objective

The principal objectives of this study are as follows.

1. Prepare a Heat Plan in line with the Environment Agency (EA) guidance on cost-benefit assessment (CBA) for combustion installations, which will support an Environmental Permit (EP) application.
2. Provide a technical description of the proposed Facility and heat export infrastructure.
3. Calculate heat demands based on identified heat consumers and assess the feasibility of connecting identified heat consumers to the network.
4. Based on the heat loads anticipated for the outline solution identified, calculate relevant energy efficiency measures to demonstrate legislative compliance.
5. Produce a drawing of the provisional pipe routing from the Facility to the likely heat consumers.
6. Conduct an economic assessment feeding into the CBA as required under Article 14 of the Energy Efficiency Directive.
7. Produce a CHP-Ready Assessment as required under the EA CHP-Ready guidance, including a clear statement on best available techniques (BAT), combined heat and power (CHP) envelope and the CHP-Ready Assessment form.

## 1.3 Location

The Facility will be located on a 2.53 hectare site to the west of Shelton Road in the Willowbrook East Industrial Estate, ca. 3 km north-east of Corby town centre.

A site location plan and Installation Boundary drawing are presented in Appendix C.

# 2 Conclusions

## 2.1 Technical solution

1. The Facility will have a gross electrical output of 30.8 $MW_e$ (design power output when operating in fully condensing mode) and a parasitic load of 2.7 $MW_e$. The balance of approximately 28.1 $MW_e$ will be exported to the National Grid.
2. The Facility will be designed with the capability to export up to 15.0 $MW_{th}$ of heat to local consumers. The maximum heat capacity will be subject to the requirements of the heat consumers and confirmed during the detailed design stage. Based on the heat network identified within this Heat Plan, the average heat load is expected to be 4.65 $MW_{th}$, resulting in an average gross electrical generation of approximately 30.1 $MW_e$.
3. A number of options for heat recovery and export from the Facility are available. Given the requirements of the heat consumers, flexibility in terms of export temperatures and capacity, and the associated environmental benefits, steam extraction from the turbine is considered the most favourable solution. It is proposed that heat will be transferred to a closed hot water circuit via a series of condensing heat exchangers and supplied to consumers through a pre-insulated buried hot water pipeline, before being returned to the Facility for reheating. This technology is well proven and highly efficient.

## 2.2 Potential heat consumers

1. A heat demand investigation was carried out as part of the planning application process. The review considered opportunities from both existing heat loads and planned developments within a 2 km radius of the site where the Facility will be located.
2. The investigation identified five key heat zones made up of demands that would be appropriate for connection to a heat network. Suitable businesses (12 in total) within the two heat zones closest to the Facility form the "base case" for the assessed heat network development.

## 2.3 Heat network profile

1. The heat demand of the preferred heat consumers has been estimated based on generic heat demand profiles. The average and diversified peak heat demand of the proposed heat network has been estimated to be 4.65 $MW_{th}$ and 7.51 $MW_{th}$ respectively, with an annual heat demand of 40,755 MWh/year.
2. A heat demand profile has been developed to assess diurnal and seasonal variation in heat demand for the proposed heat network. The heat demand profile indicates that base and peak loads can be met by the Facility independently. Detailed techno-economic modelling will be undertaken when there is a better understanding of consumer heat demands.

## 2.4 Economic assessment

1. An analysis of costs and revenues associated with the construction and operation of the proposed heat network has been carried out. The results of this analysis have been uploaded into the EA's CBA template. The CBA takes account of heat supply system capital and operating costs, heat sales revenue and lost electrical revenue as a result of diverting energy to the heat network.

2. The results of the CBA indicate that the estimated £8.7 million capital investment will not be offset by heat sales revenue. The nominal project internal rate of return (before financing and tax) over 30 years is projected as 12.9%, with a net present value of -£1.82 million.
3. The detailed economic feasibility of the scheme will be reassessed in the future when consumer heat demands are confirmed. A decision on progressing with the heat network will be taken once the economic feasibility has been confirmed.
4. As construction of a heat network is currently not economically feasible, the Facility will be built to be CHP-Ready. A decision on progressing with the heat network will be taken once its economic feasibility has been confirmed. As such, the Facility will meet the BAT tests requirements outlined in the EA's CHP-Ready Guidance.

## 2.5 Energy efficiency measures

1. To qualify as technically feasible under the draft Article 14 guidance, the consumer heat demand must be sufficient to achieve high efficiency cogeneration, equivalent to at least 10% savings in primary energy usage compared to the separate generation of heat and power. When exporting heat to the proposed heat network, the Facility will achieve a primary energy saving (PES) of 20.37%, which meets the technical feasibility threshold of 10% defined in the draft Article 14 guidance.
2. To be considered '*Good Quality*' CHP under the CHPQA scheme, the quantity of heat exported to a heat network must be sufficient to achieve a Quality Index (QI) of at least 105 at the design stage (reducing to 100 at the operational stage). Changes to CHPQA guidance in December 2018 mean that the maximum QI score which could be achieved by the proposed heat network would be 62.8. On this basis, the heat network would not qualify as *Good Quality* CHP. The efficiency criteria set out in the latest CHPQA guidance mean that it is unlikely that any current or future energy recovery facility wanting to provide CHP will be able to achieve '*Good Quality*' status.

## 2.6 CHP-Ready Assessment

1. A CHP-Ready Assessment has been carried out as part of this Heat Plan and the completed CHP-Ready Assessment form is provided in Appendix E. As the economic case for the proposed heat network is not economically viable, constructing the Facility as CHP-Ready is considered to represent BAT.
2. As CHP-Ready, the Facility will be designed to be ready, with minimum modification, to supply heat in the future. Given the uncertainty of future heat loads, the initial electrical efficiency of a CHP-Ready facility (before any opportunities for the supply of heat are realised) should be no less than that of the equivalent non-CHP-Ready facility. The Facility will include steam capacity designed into the turbine bleeds to facilitate heat export in the future, and safeguarded space on site to house CHP equipment.
3. To satisfy the third BAT test (see section 3.1) on an ongoing basis, Covanta is committed to carrying out periodic reviews of opportunities for the supply of heat to realise CHP.

# 3 Legislative requirements

## 3.1 CHP-Ready guidance

In February 2013, the EA produced a guidance note titled 'CHP Ready Guidance for Combustion and Energy from Waste Power Plants'[1]. This guidance applies to the following facilities, which are regulated under the Environmental Permitting (England and Wales) Regulations 2016:

- new combustion power plants (referred to as power plants) with a gross rated thermal input of 50 MW or more; and
- new energy from waste plants with a throughput of more than 3 tonnes per hour of non-hazardous waste or 10 tonnes per day of hazardous waste.

The Facility will be regulated as a waste incineration facility with a throughput of more than 3 tonnes per hour. Therefore, the requirements of the CHP-Ready guidance will apply.

The EA requires developers to demonstrate BAT for a number of criteria, including energy efficiency. One of the principal ways of improving energy efficiency is through the use of CHP, for which three BAT tests exist. The first involves considering and identifying opportunities for the immediate use of heat off-site. Where this is not technically or economically possible, the second test involves ensuring that the plant is built to be CHP-Ready. The third test involves carrying out periodic reviews to determine whether the situation has changed and if there are opportunities for heat use off site.

## 3.2 Energy Efficiency Directive

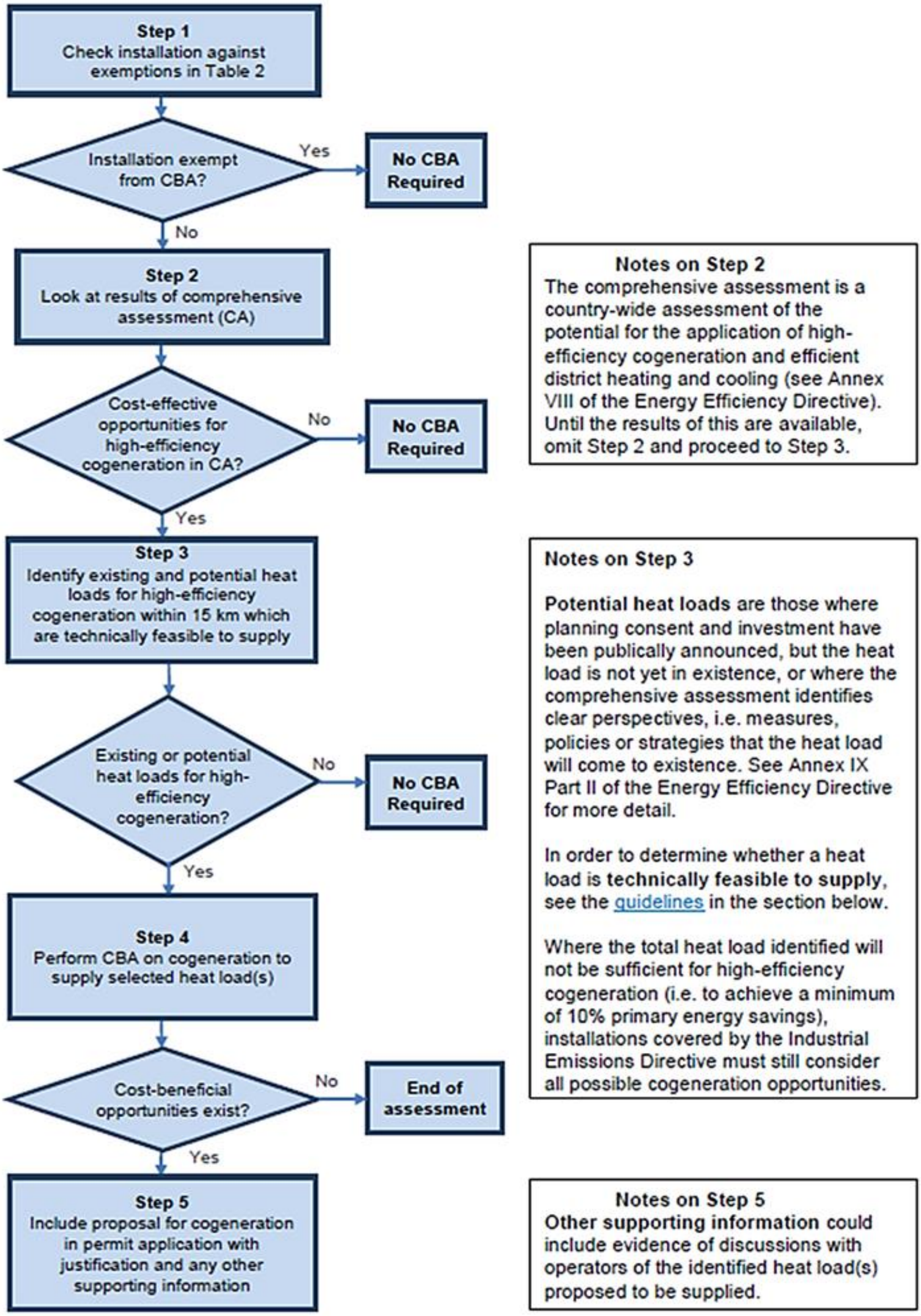
From 21st March 2015, operators of certain types of combustion installations are required to carry out a CBA of opportunities for CHP when applying for an EP. This is a requirement under Article 14 of the Energy Efficiency Directive and applies to a number of combustion installation types. As a new electricity generation installation with a total aggregated net thermal input of more than 20 MW, the Facility will be classified as an installation type 14.5(a).

In April 2015, the EA issued draft guidance on completing the CBA, entitled '*Draft guidance on completing cost-benefit assessments for installations under Article 14 of the Energy Efficiency Directive*'[2]. Figure 1 describes the process that must be followed for type 14.5(a) and 14.5(b) installations.

1 CHP Ready Guidance for Combustion and Energy from Waste Power Plants v1.0, February 2013

2 Draft guidance on completing cost-benefit assessments for installations under Article 14 of the Energy Efficiency Directive, V0.9 April 2015

*Figure 1: CBA methodology for type 14.5(a) and 14.5(b) installations*



# 4 Description of the Facility technology

## 4.1 The Facility

The main activities associated with the Facility will be the combustion of incoming non-hazardous waste to raise steam and the generation of electricity in a steam turbine/generator.

The Facility is currently configured to include a waste reception hall, one waste incineration line including the main thermal treatment process, one turbine hall, flue gas treatment, stack, on-site facilities for the treatment or storage of residues and wastewater, and systems for controlling operation of the waste incineration plant and recording and monitoring conditions.

In addition to the main elements described, the Facility will also include weighbridges, water, auxiliary fuel and air supply systems, site fencing and security barriers, external hardstanding areas for vehicle manoeuvring, access roads and car parking, transformers, a grid connection compound, firewater storage tanks, offices, workshop, stores and staff welfare facilities.

The nominal waste processing capacity of the Facility will be 33.2 tonnes/hour of mixed non-hazardous waste, with a net calorific value of 10.9 MJ/kg. The Facility will have an estimated average availability of around 8,000 hours/year, implying a nominal capacity of 265,541 tonnes/year.

The Facility will provide a net electrical export of 28.1 $MW_e$, based on a gross electrical output of 30.8 $MW_e$, (when operating in fully condensing mode), and a parasitic load of 2.7 $MW_e$. Simultaneously, the Facility will be designed to export up to 15 $MW_{th}$ of heat to local consumers. The maximum heat capacity will be confirmed during the detailed design stage and will be set as a minimum load to meet the requirements of the heat consumers identified.

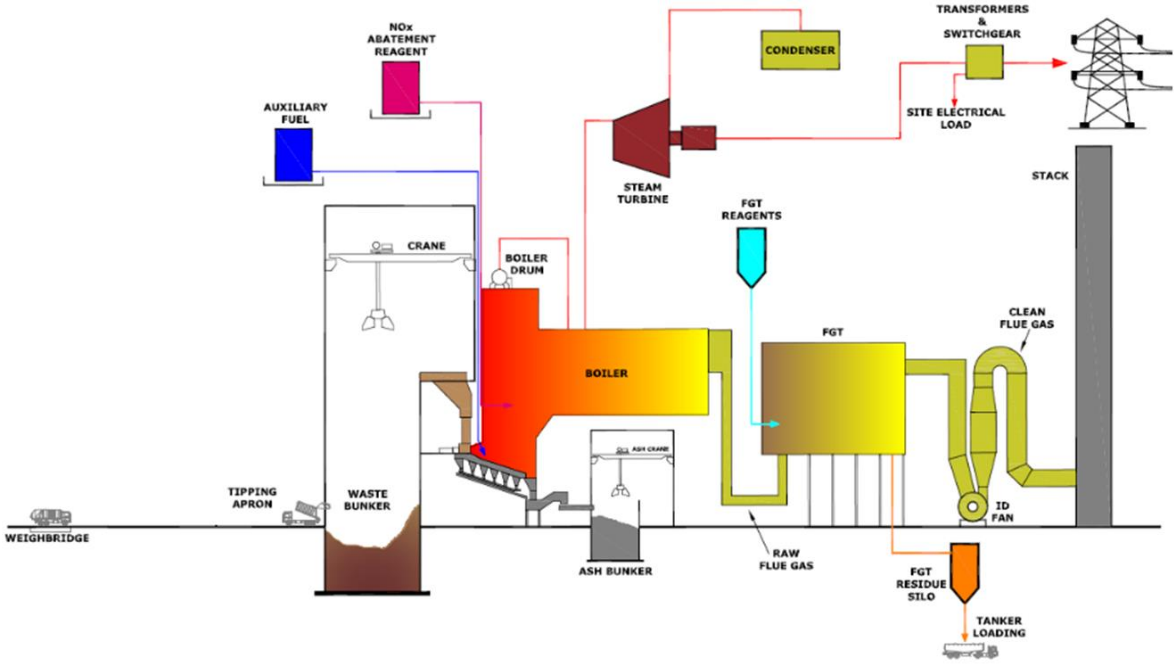
Based on the heat network identified within this Heat Plan, the average and peak heat loads are expected to be 4.7 $MW_{th}$ and 7.5 $MW_{th}$ respectively.

At the time of writing this report, there are no formal agreements in place for the export of heat from the Facility.

### 4.1.1 Combustion process

Figure 2 is an indicative schematic of the combustion process that will be used in the Facility.

*Figure 2: Facility's process schematic*




## 4.1.2 Energy recovery

The heat released by the combustion of the incoming waste will be recovered by means of a water tube boiler, which is integral to the furnace and will produce (in combination with superheaters) high pressure superheated steam at 47 bar(a) and 380°C. The steam from the boiler will then feed a high-efficiency steam turbine which will generate electricity. The turbine will have a series of extractions at different pressures that will be used for preheating air and water in the steam cycle.

The remainder of the steam left after the turbine will be condensed back to water to generate the pressure drop to drive the turbine. A fraction of the steam will condense at the exhaust of the turbine in the form of wet steam, however the majority will be condensed and cooled using an air-cooled condenser. The condensed steam will be returned as feed water in a closed-circuit pipework system to the boiler.

Depending on the requirements of the heat users, either high pressure steam or hot water could be supplied. High pressure steam could be extracted from the turbine and piped directly to the heat users. Alternatively, low pressure steam exiting the turbine could pass through an onsite heat exchanger to heat up water for use in a heat network. The volume of steam extracted would vary depending on the heat load requirements of the heat users. It should be noted that at the time of writing this report, there are no formal agreements in place for the export of heat from the Facility.

## 4.1.3 Details of input waste

*Table 1: Expected Facility input waste characteristics*

| Parameter | Unit | Value |
|---|---:|---:|
| Nominal waste throughput | tonnes/year | 265,541 |
| Design NCV | MJ/kg | 10.9 |
| Design GCV | MJ/kg | 12.4 |

## 4.2 Details of heat supply system

Heat is typically supplied from the energy recovery process in the form of steam and/or hot water, depending on the grade of heat required by the final heat consumers.

For this section we have just considered heat delivery using hot water, as the Heat Demand Investigation did not identify future steam users. For clarity, heat network schemes typically operate with a water flow temperature of between 90°C and 120°C and return water temperature of between 50°C and 80°C.

The most common options for recovering heat are discussed below.

### 4.2.1 Heat recovery from the condenser

Condensate emerges from the condenser at below atmospheric pressure with a typical temperature of around 40°C. This energy can be recovered in the form of low-grade hot water from the condenser depending on the type of cooling implemented.

An air-cooled condenser (ACC) will be installed at the Facility. Within the ACC steam is condensed rejecting the heat to the induced air flow, which is subsequently dispersed to atmosphere. The resulting condensate returns to the boiler. Cooling this condensate further to extract heat for use in a heat network requires additional steam to be extracted from the turbine for subsequent condensate pre-heating. This additional steam extraction reduces turbine power generation leading to lower Facility power efficiency which adversely impacts electrical revenue.

### 4.2.2 Heat extraction from the flue gas

The temperature of the flue gas exiting the flue gas treatment plant is typically around 140°C and contains water in vapour form. This flue gas can be further cooled using a flue gas condenser to recover latent heat from the moisture. This method of heat extraction does not significantly impact plant power generation.

Condensing of the flue gas is achieved using a flue gas condenser. However, the recovered temperature is typically no more than 80°C, which may restrict the hot water temperature available for the heat consumer to below that which is acceptable. The additional cooling of the flue gas may result in production of a visible plume from the stack. Although the plume consists of water vapour, witnesses may visually misinterpret the plume as pollution. The water condensed from the flue gas needs to be treated and then discharged under a controlled consent.

Furthermore, condensing water vapour from the flue gas reduces the flue gas volume and hence increases the concentration of entrained non-condensable pollutants. The lower volume of cooler gas containing higher concentration of some pollutants may require a different stack height to provide adequate dispersion.

### 4.2.3 Heat extraction from the steam turbine

Steam extracted from the steam turbine can be used to generate hot water for heat networks. Steam is preferably extracted from the turbine at low pressure to optimise turbine electrical power generation. Extracted steam is passed through a condensing primary heat exchanger(s), with condensate recovered back into the feedwater system, and heat transferred to the secondary water circuit. Hot water is pumped to heat consumers for heat delivery before being returned to the primary heat exchanger where it is reheated.

This source of heat offers the most flexible design for a heat network. The steam bleeds can be sized to provide additional steam above the Facility's parasitic steam loads. However, the magnitude of the heat load must be clearly defined during the design phase to allow the steam bleeds and associated pipework to be adequately sized. Bleed capacity cannot be easily increased once the turbine is manufactured and installed.

### 4.2.4 Summary

The best solution to supply heat for the network under consideration is by extracting steam from the turbine. This method for the supply of heat is considered to be favourable for the following reasons.

1. The heat temperature requirements of identified consumers (as described in section 5) are too high for that attainable from the condenser as discussed in 4.2.1.
2. As noted in section 4.2.2, together with temperature limitations, the use of a flue gas condenser would generate a visible plume which would be present for significant periods of the year. This is not desirable as it will significantly add to the visual impact of the Facility.
3. As noted in section 4.2.3, extraction of steam from the turbine offers the most flexibility for varying heat quality and capacity to supply variable current demands or new future demands. In addition, extraction of steam from the turbine, heat transfer to a hot water circuit and delivery of heat to consumers can be provided by proven and highly efficient technology.

# 5 Heat Demand Investigation

## 5.1 Identified heat users

A Heat Demand Investigation was carried out as part of the planning application process. The review considered opportunities from both existing heat loads and planned developments within a 2 km radius of the site.

Given the industrial setting of the Facility, the heat demand investigation has considered the potential heat users identified within the planning application. It is noted that there are other potential heat users outside of this area; however, as these opportunities are 10 km or more from the Facility, the focus of this study has been on the nearby industrial heat users as these present deliverable opportunities for heat export.

The list of potential heat users identified during the investigation can be found in Schedule 3 of the CHP assessment submitted as part of the planning application for the Facility (see Appendix A).

The investigation identified five key heat zones made up of demands that would potentially be appropriate for connection to a heat network. The indicative location of these heat zones (A through E) is shown in Figure 3 below.

*Figure 3: Heating zone map*


*Source: 19.00027.WASFUL - Combined Heat and Power Assessment.pdf (Schedule 1)*

Zone A and zone B are closest to the Facility and businesses within them form the "base case" for the CHP scheme development. Table 2 lists heat users in zone A and B that were found to be potentially suitable for taking part in the heat network scheme and their estimated annual heat demand.

*Table 2: Screened heat users and their estimated annual heat demands*

| Reference number | Name | Estimated annual heat demand at point of use (MWh/a) |
|---|---|---|
| 1 | Zone A - RCS Logistics Ltd | 6,570 |
| 2 | Zone A - AT Transport Solutions Ltd | 4,380 |
| 3 | Zone A - Premier Galvanizing Ltd | 2,990 |
| 4 | Zone A - Matalan distribution warehouse | 150 |
| 5 | Zone A - Benteler Automotive | 1,580 |
| 6 | Zone A - Ashbury Chocolates/Bluebird Confectionary | 3,924 |
| 7 | Zone A - MFAS/Macemaine and Amstad Ltd | 1,630 |
| 8 | Zone B - Morrison's Distribution Centre | 3,538 |
| 9 | Zone B - Corby Business Academy | 2,465 |
| 10 | Zone B - RS Components | 4,250 |
| 11 | Zone B - Pauley W & Co Ltd | 4,495 |
| 12 | Zone B - Huisman Logistics warehouse | 3,170 |
| **Total** | | **39,142** |

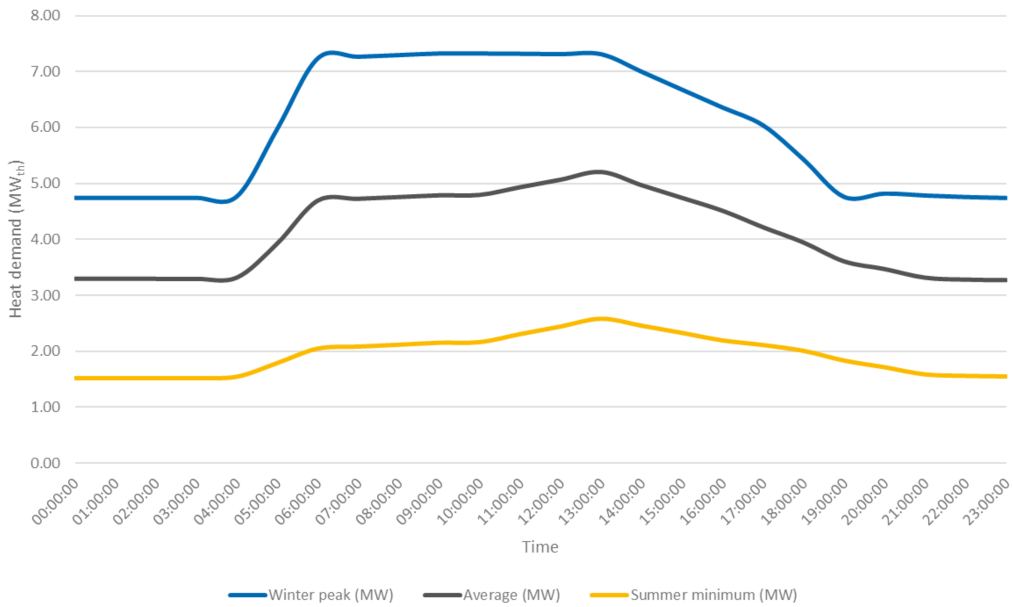
*Source: 19.00027.WASFUL - Combined Heat and Power Assessment.pdf*

## 5.2 Heat network profile

A generic heat demand profile has been developed to model the seasonal and diurnal variation in heat demand for the proposed heat network, by integrating the estimated annual heat demands (in MWh). This has allowed the annual average and peak heat demands (in MW) to be calculated.

The heat profile for the proposed heat network is shown in Figure 4 and illustrates the expected variation in heat demand during a typical day in different seasons. The profile represents heat demand at the point of use and therefore does not include network heat losses.

*Figure 4: Modelled heat network profile*



Daily and seasonal variation in heat demand is typical for heat networks serving industrial, commercial and office consumer types, which form the basis of the proposed heat network. Increasing the number and type of consumers connected to a network diversifies heat demand and helps to reduce the impact of the peak demand of any individual consumer, since it is less likely that peak demands will coincide. In calculating the diversified heat demand, diversity factors of 0.95 and 0.90 have been assumed for summer and winter months respectively, in accordance with CIBSE AM12[3].

The total annual heat export, and average and peak instantaneous network values are projected in Table 3.

*Table 3: Proposed heat network demand*

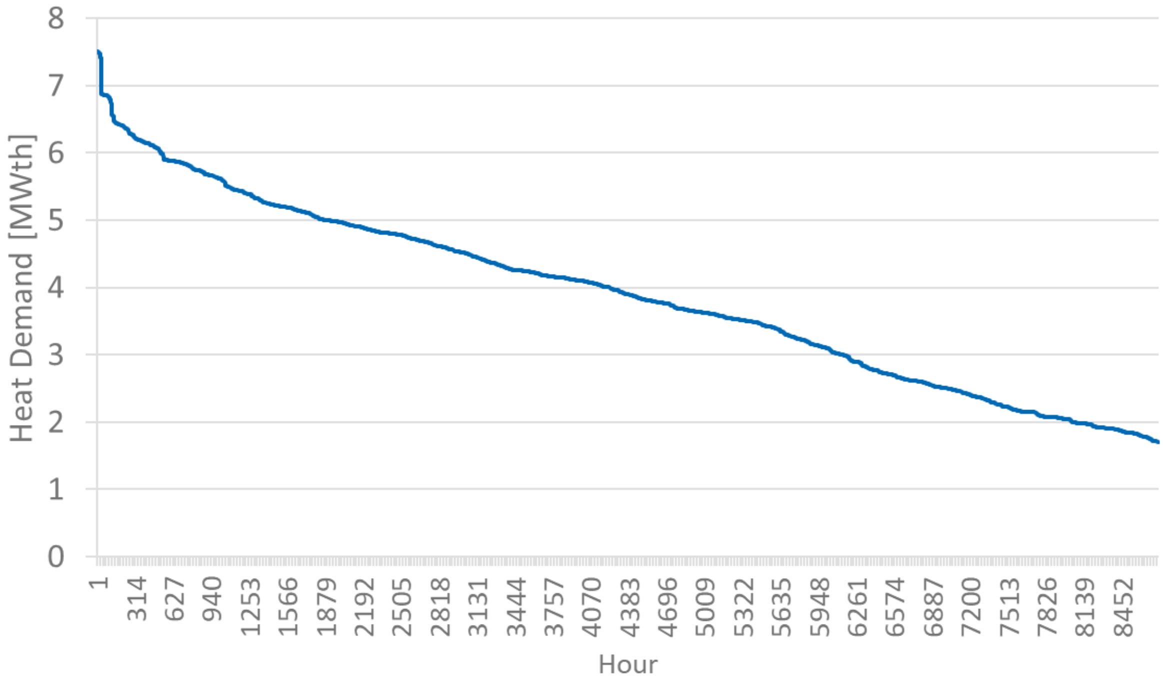
| Annual Heat Load (MWh/a) | | Average heat demand ($MW_{th}$) | | Peak heat demand ($MW_{th}$) | | |
|---|---|---|---|---|---|---|
| At point of use | Accounting for pipe losses | At point of use | Accounting for pipe losses | Combined user loads | Diversified with demand profiles | Diversified with pipe losses |
| 39,142 | 40,755 | 4.47 | 4.65 | 10.04 | 7.32 | 7.51 |

## 5.3 Heat load duration curve

The heat load duration curve presented in Figure 5 displays the instantaneous heat demand for the proposed heat network, arranged in order of decreasing magnitude, across the year.

Since detailed heat demand data is not available at this stage, the heat load duration curve has been developed on the basis of instantaneous heat demand at each hour of the day for each month. This demand data does not account for diversity or heat losses.

*Figure 5: Heat load duration curve*




3 CIBSE AM12 Combined Heat and Power for Buildings, 2013

## 5.4 Heat network design

As a conventional heat network, heat distribution between the Facility and the identified heat consumers would likely use buried pipework. Pre-insulated steel pipes would be used to supply pressurised hot water to the customer, and to return cooler water. Where pipes are small, two pipes may be integrated within a single insulated sleeve. For larger heat demands, large bore pipes would be installed as a single insulated run. Pipe technology is well proven and can provide a heat distribution system with a 30-year plus design life. Additional pipework can be added retrospectively, and it is reasonably straightforward to add branches to serve new developments.

Modern heat-insulated piping technology enables hot water to be transferred large distances without significant losses. Where the topography creates challenges, heat exchangers and additional pumping systems can be installed to create pressure breaks, enabling the network to be extended.

Heat delivery arriving at a heat consumer's premises usually terminates using a secondary heat exchanger. The heat exchanger is typically arranged to supply heat to a tertiary heating circuit upstream of any boiler plant. The water in the tertiary circuit is boosted to the temperature required to satisfy the heating needs of the building.

Water is pumped continuously around the system. Pumps are operated with 100% standby capacity to maintain heat in the event of a pump fault. Pumps are likely to utilise variable speed drives to minimise energy usage.

The following conservative design criteria relate to a typical hot water network utilising conventional heat extraction (as detailed in section 4.2) and have been used to size the heat transmission pipe diameters. Where possible, the flow temperature will be reduced to minimise heat losses and this will be subject to the requirements of the heat consumers. Flow and return temperatures presented in Table 4 have been selected based on the likely requirements of identified consumers.

*Table 4: District heating network design criteria*

| Parameter | Value |
|---|---|
| Water supply temperature to consumer | 110°C |
| Water return temperature from consumer | 70°C |
| Distance between flow and return pipes | 150 mm |
| Soil temperature | 10°C |
| Depth of soil covering | 600 mm |

Using the above design criteria and allowing for the estimated heat demand for the preferred network, the primary hot water transmission pipe size has been calculated as DN250, reducing along the length of the pipe network to DN65 at the consumer located farthest from the Facility. This is an indicative figure and will be subject to heat demand verification and subsequent network design. Assuming that the difference between the flow and return temperatures (deltaT) remains constant, it will be possible to reduce the flow temperature in the future in line with the CIBSE Code of Practice without impacting the pipe size and thereby reduce system energy losses.

## 5.5 Back-up heat sources

During periods of routine maintenance or unplanned outages the Facility will not be operating, however the heat consumers will still require heat. There is therefore a need, somewhere within the heat distribution system, to provide a back-up source of heat to meet the needs of the heat consumers.

At the heat network scale under consideration, the standby plant will likely comprise oil- or gas-fired hot water heaters (boilers) with a separate dedicated chimney stack. Back-up boilers are typically designed to ensure that the peak heat export capacity can be met but also provide sufficient turndown to supply smaller summer loads with reasonable efficiency.

However, in the case that a majority of heat consumers were to retrofit connections to storage and distribution warehousing, it is possible that existing heating/cooling infrastructure could be retained as back up. The back-up strategy would need to be developed as part of the detailed design phase. Subject to detailed heat demand modelling once heat consumers are known with more certainty, opportunities for installing thermal stores may also be considered to lessen reliance on the back-up plant by storing excess heat generated during off peak periods for use during times of peak heat demand.

Indicative costs of installing and operating back-up plant have been included in the economic assessment in Section 7.3.

## 5.6 Considerations for pipe route

At the present time, no definitive fixed route has been established for the connections from the Facility to the various potential users since no specific agreements have been made. However, an indicative pipe route is presented in Appendix A.

Planning permission, easements and Highways Licenses would need to be obtained for access, construction, and maintenance of the pipeline infrastructure. There is a significant financial implication for obtaining easements, and these would only be progressed once an EP have been granted for the Facility and heat supply agreements put in place. Traffic management requirements would need to be agreed prior to being able to obtain the necessary Highways Licenses granting permission to install the pipework. The projected timetable for the development of the heat mains is detailed in Section 5.7.

Discussion with the various potential heat users will need to be entered into which, if successful, would lead into the production of a heat supply agreement and designs for the pipework. A full economic analysis will need to be undertaken, considering the costs associated with pipe installation and lost electricity revenue in order to determine a suitable heat price per unit. However, without an EP being granted for the Facility, any firm commitment to a supply of heat is difficult to achieve.

## 5.7 Implementation timescale

The start of the construction of the heat system is dependent on the viability of the system and the location of the heat users. For example, planning and gaining consent for installation of the pipework off the site would take a significant amount of time due to the potential impact on local traffic management. Until a core of heat users have been identified and contracted to take heat, pipeline installation will not commence.

# 6 Energy efficiency calculations

## 6.1 Heat and power export

The Z ratio, which is the ratio of reduction in power export for a given increase in heat export, can be used to calculate the effect of variations in heat export on the electrical output of the Facility. A value of 7.05 was obtained following the approach set out in CHPQA Guidance Note 28[4], assuming steam extraction at a pressure of 1.5 bar(a), which is considered sufficient to meet the requirements of the potential heat consumers identified for the Facility.

The heat and power export has been modelled across a range of load cases and the results are presented in Table 5. The results indicate that for the heat consumers identified in section 5.1, load case 2 corresponding to an average heat export of 4.65 $MW_{th}$ will result in a net power export of 27.45 $MW_e$.

*Table 5: Heat and power export*

| Load case | Annual average heat export at turbine | Gross power generated | Net power exported | Z ratio |
|---|---|---|---|---|
| 1. No heat export | - | 30.76 $MW_e$ | 28.11 $MW_e$ | N/A |
| 2. Proposed network heat load | 4.65 $MW_{th}$ | 30.10 $MW_e$ | 27.45 $MW_e$ | 7.05 |
| 3. Maximum heat export capacity | 15.00 $MW_{th}$ | 28.63 $MW_e$ | 25.98 $MW_e$ | 7.05 |

## 6.2 CHPQA Quality Index

CHPQA is an energy efficiency best practice programme introduced by the Government. CHPQA aims to monitor, assess and improve the quality of CHP in the UK. In order to prove that a plant is a 'Good Quality' CHP plant, a QI of at least 105 must be achieved at the design, specification, tendering and approval stages. Under normal operating conditions (i.e. when the scheme is operational) the QI threshold drops to 100. The QI for CHP schemes is a function of their heat efficiency and power efficiency according to the following formula:

$$QI = X\eta_{power} + Y\eta_{heat}$$

where: $\eta_{power}$ = power efficiency; and

$\eta_{heat}$ = heat efficiency.

The power efficiency in the formula is calculated using the gross electrical output and is based on the gross calorific value of the input fuel. The heat efficiency is also based on the gross calorific value of the input fuel. The coefficients X and Y are defined by CHPQA based on the total gross electrical capacity of the scheme and the fuel/technology type used.

In December 2018, the Government released a revised CHPQA Standard (Issue 7). The document sets out revisions to the design and implementation of the CHPQA scheme. These revisions are intended to ensure that schemes which receive Government support are supplying significant quantities of heat and deliver the intended energy savings. The following X and Y coefficients apply to the Facility:

- X value = 220; and

[4] CHPQA Guidance Note 28, 2007

- Y value = 120.

The QI and efficiency values (based on a gross calorific value of 12.4 MJ/kg) have been calculated in accordance with CHPQA methodology for various load cases and the results are presented in Table 6.

*Table 6: QI and efficiency calculations*

| Load case | Gross power efficiency | Heat efficiency | Overall efficiency | CHPQA QI |
|---|---|---|---|---|
| 1. No heat export | 26.90% | - | 26.90% | 59.2 |
| 2. Proposed network heat load (see section 5.1) | 26.33% | 4.07% | 30.39% | 62.8 |
| 3. Maximum heat export capacity | 25.04% | 13.12% | 38.16% | 70.8 |

The results indicate that the Facility will not achieve a QI score in excess of the 'Good Quality' CHP threshold (QI of 105 at the design stage) for the average heat load exported to the proposed heat network. The highly onerous efficiency criteria set out in the latest CHPQA guidance, most notably the underpinning requirement to achieve an overall efficiency (NCV basis) of at least 70%, means that none of the load cases considered will enable heat export from the Facility to be considered Good Quality.

For reference, assuming the same Z ratio as set out in the preceding section, an average heat export of 60 $MW_{th}$ would be required for a heat network to achieve Good Quality status. It is clear that the design proposed for heat recovery is not capable of supplying this quantity of heat at the assumed conditions required by the local network.

# 7 Heat network economic assessment

## 7.1 Fiscal support

The following fiscal incentives are available to energy generation projects and impact the feasibility of delivering a district heating network.

### 7.1.1 Capacity Market for electricity supplied by the Facility

Under the Capacity Market, subsidies are paid to electricity generators (and large electricity consumers who can offer demand-side response) to ensure long-term energy security for the UK. Capacity Agreements are awarded in a competitive auction and new plants (such as the Facility) are eligible for contracts lasting up to 15 years. Based on the eligibility criteria of the mechanism, the Facility will be eligible for Capacity Market support. Since support is based on electrical generation capacity (which would reduce when operating in CHP mode), these payments will act to disincentivise heat export and have therefore not been included in the economic assessment.

### 7.1.2 Renewable Heat Incentive

The Renewable Heat Incentive (RHI) was created by the Government to promote the deployment of heat generated from renewable sources. However, no funding announcements have been published for the RHI post March 2022. Therefore, it is unlikely the Facility will receive incentives under the RHI. In addition, to be eligible, the plant in question must not receive any other support or subsidy from public funds including any support received under the Capacity Market. Therefore, if the Facility qualifies for support under the Capacity Market mechanism, it will not be eligible for the RHI.

### 7.1.3 Contracts for Difference

Contracts for Difference (CfD) replaced the Renewables Obligation (RO) as the mechanism by which the Government has supported low carbon power generation. Launched in 2014, there have been four rounds aimed at incentivising investment in renewable energy. CfD incentivises investment by providing project developers with protection from volatile wholesale prices while protecting consumers from paying increased support costs when electricity prices are high. CfD de-risks investments by guaranteeing a fixed price (the Strike Price) for electricity over a 15-year period.

The fourth CfD allocation round (AR4) was executed on 13th December 2021, with deadline for bids on 14th January 2022, and is now closed. The Government has moved to annual CfD allocation rounds (instead of every two years) with allocation round 5 (AR5) scheduled for March 2023. As of December 2022, the Government has not decided on technologies that will be eligible to participate in the AR5.

Based on AR4's budget allocation, we would not expect that energy from waste with CHP will be considered high priority for AR5. On this basis, for the purpose of this assessment, we have assumed that the Facility will not receive support under the CfD mechanism.

### 7.1.4 Green Heat Networks Fund

The GHNF is a three-year £288 million capital grant fund to support the commercialisation and construction of new low and zero carbon heat networks and the retrofitting and expansion of existing heat networks. The GHNF is open to organisations in the public or private sectors in England.

1. The GHNF opened to applicants in March 2022, Round 4 is open to applications until 24 February 2023. There will be a series of quarterly application rounds until the scheme closes in 2025.
2. Minimum project eligibility metrics include:
   a. 100 g $CO_2$e/kWh thermal energy delivered to consumers; and
   b. minimum demand of 2 GWh/year for urban networks.
3. The GHNF will fund up to 50% of a project's total combined commercialisation and construction costs (with an upper limit of £1 million for commercialisation).
4. The GHNF will provide support for accessing heat sources such as capturing waste heat from an industrial process, energy from waste, wastewater, low carbon generation such as energy centres and low-carbon generation and support for primary heat network distribution including distribution pipework for transmission and distribution of low-carbon heating and cooling.

Whether the Facility would be eligible for GHNF would be investigated in more detail at a later stage. To be conservative, GHNF is not included in the economic assessment at this stage.

Relatively modest grant funding, to assist local authorities in heat network project development, is also available through the Heat Networks Delivery Unit (HNDU), although this could not be received by the Facility directly and is unlikely to be suitable to support project delivery.

## 7.2 Technical feasibility

Step 3 of the CBA methodology requires identification of existing and proposed heat loads which are technically feasible to supply. The draft Article 14 guidance states that the following factors should be accounted for when determining the technical feasibility of a scheme, pertaining to a type 14.5(a) installation.

1. **The compatibility of the heat source(s) and load(s) in terms of temperature and load profiles**

   The CHP scheme has been developed on the basis of delivering heat at typical district heating conditions (refer to Section 5.4). It is reasonable to assume that identified potential heat consumers would be able to utilise hot water at the design conditions. Consumer requirements (in terms of hot water temperature and load profiles) will need to be verified in any subsequent design process prior to the implementation of a heat network. Therefore, the heat source and heat load are considered to be compatible.
2. **Whether thermal stores or other techniques can be used to match heat source(s) and load(s) which will otherwise have incompatible load profiles**

   Conventional thermal stores or back-up boilers (as discussed in section 5.5) will likely be included in the CHP scheme to ensure continuity of supply. The specific arrangement will be selected when there is greater certainty with regards heat loads.
3. **Whether there is enough demand for heat to allow high-efficiency cogeneration**

   High-efficiency cogeneration is cogeneration which achieves at least 10% savings in primary energy usage compared to the separate generation of heat and power. Primary energy savings (PES) are calculated in the following section.

### 7.2.1 Primary energy savings

To be considered high-efficiency cogeneration, the scheme must achieve at least 10% savings in primary energy usage compared to the separate generation of heat and power. PES have been calculated in accordance with European Commission Delegated Regulation (EU) 2015/2402 of 12 October 2015 Annex II part (b), using the following assumptions.

1. Annual nominal throughput capacity of 265,541 tonnes/year based on waste with NCV of 12.4 MJ/kg.
2. Nominal gross electrical output (expected capacity in fully condensing mode) of 30.76 $MW_e$.
3. Parasitic load is 2.66 $MW_e$.
4. Z ratio of 7.05.
5. Efficiency reference values for the separate production of heat and electricity have been taken as 80% and 25% respectively as defined in Commission Delegated Regulation (EU) 2015/2402 of 12 October 2015[5].

When operating in fully condensing mode (i.e. without heat export) the Facility will achieve a PES of 18.32%. This is in excess of the technical feasibility threshold defined in the draft Article 14 guidance. The inclusion of heat export at the design case level anticipated for the proposed heat network increases PES to 20.37%. Therefore, the Facility would qualify as a high-efficiency cogeneration operation when operating in CHP mode.

## 7.3 Results of cost benefit analysis

A CBA has been carried out on the selected heat load, in accordance with section 3 of the draft Article 14 guidance. The CBA uses an Excel template, '*Environment Agency Article 14 CBA Template.xlsx*' provided by the EA, with inputs updated to correspond with the specifics of this heat plan.

The CBA model considers:

1. the revenue streams (heat sales);
2. the cost streams for the heat supply infrastructure (construction and operational, including back-up plant); and
3. the lost electricity sales revenue, over the lifetime of the scheme.

The following assumptions have been made:

1. The heat network scheme will commence operation in 2026.
2. The heat export infrastructure required to export heat from the Facility to identified consumers is estimated to have a capital cost of £6.3 million, split over a two-year construction programme.
3. The heat station will cost approx. £1.7 million, split over a two-year construction programme.
4. Back-up boilers will be provided to meet the peak heat demand, at a cost of approximately £0.7 million.
5. Operational costs have been estimated based on similar sized projects.
6. Heat sales revenue will be £45/MWh, current price and index linked for inflation in CBA.
7. Electricity sales revenue will be £84.1/MWh, current price and index linked for inflation in CBA.
8. Standby boiler fuel costs will be £25/MWh[6], current price and index linked for inflation in CBA.
9. Standby boiler(s) will supply 10.7% of annual heat exported.

The results of the CBA indicate that the nominal project internal rate of return and net present value (before financing and tax) over 30 years are 12.9% and -£1.82 million respectively. Therefore, the proposed heat network does not yield an economically viable scheme in its current configuration. Model inputs and key outputs are presented in Appendix D.

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[5] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015R2402

[6] https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2019

Updated using values from Annex M, retail prices, industrial sector, 'reference scenario' tab

# 8 CHP-Ready BAT Assessment

## 8.1 CHP-Ready BAT Assessment

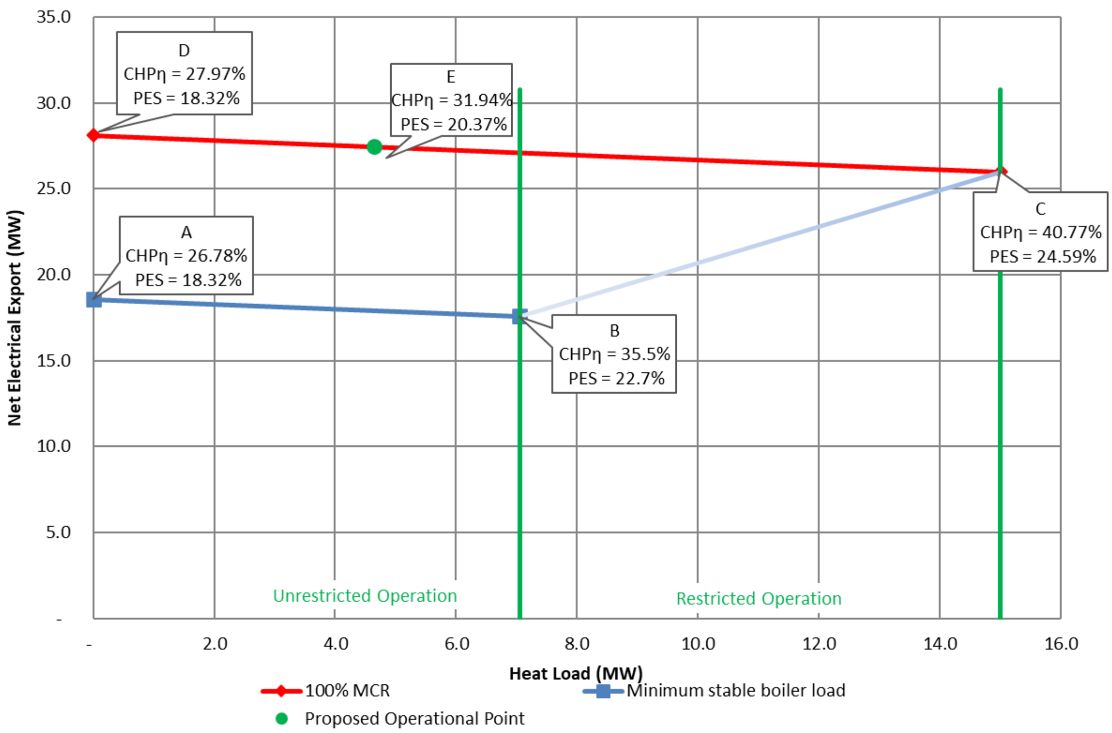
This report includes a CHP-Ready Assessment which considers the requirements of the EA's CHP-Ready Guidance. The completed CHP-Ready Assessment form is provided in Appendix E.

The 'CHP envelope' as outlined under requirement 2 of the CHP-Ready guidance, which identifies the potential operational range of a new plant where it could be technically feasible to operate electrical power generation with heat generation, is provided in Figure 6.

The points defining the CHP envelope are as follows.

- A: minimum stable load (with no heat extraction).
- B: minimum stable load (with maximum heat extraction).
- Line A to B: minimum electrical power output for any given heat load (corresponds to the minimum stable plant load).
- C: 100% load (with maximum heat extraction).
- D: 100% load (with no heat extraction).
- Line D to C: maximum electrical power output for any given heat load (corresponds to 100% plant load).
- E: proposed operational point of the Facility, based on the proposed heat network.
- Unrestricted operation: if a selected heat load is located in this region, the Facility will have the ability to operate at any load between minimum stable plant load and 100% plant load whilst maintaining the selected heat load.
- Restricted operation: if a selected heat load is located in this region, the Facility will not have the ability to operate over its full operational range without a reduction in heat load.

*Figure 6: Graphical representation of CHP envelope for proposed heat network*



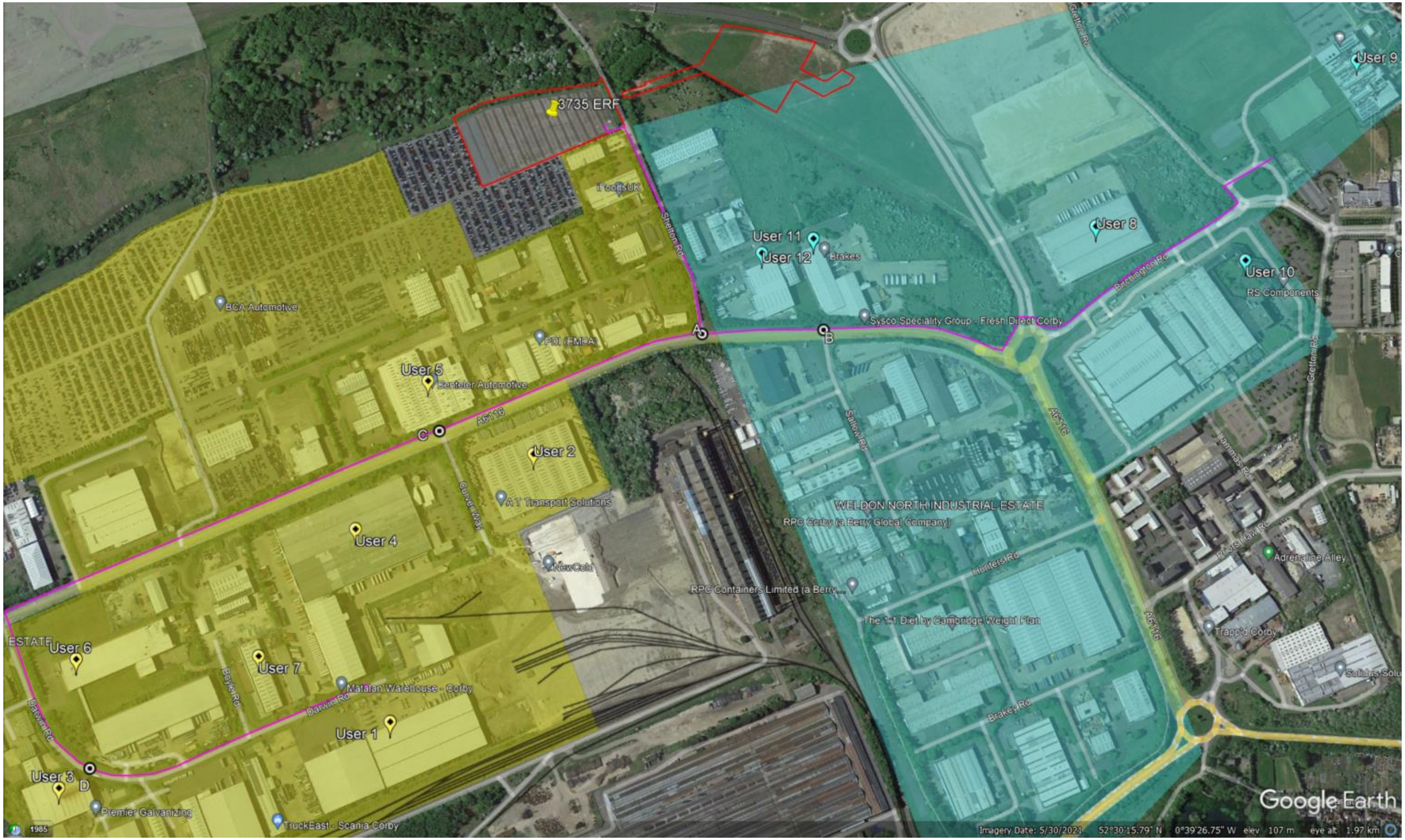
The proposed operational point (point E) represents the annual average heat demand of 4.65 $MW_{th}$ exported to the proposed heat network detailed in section 5. It considers the heat losses and pressure drop in the pipe network and therefore corresponds to the annual average heat demand predicted at the Facility site boundary. The operational range for the Facility will ultimately be subject to the required hot water flow temperature and final steam turbine selection, which are subject to detailed design.

# Appendices

# A Heat Demand Investigation report

19.00027.WASFUL - Combined Heat and Power Assessment.pdf

# B Pipe route and heat users



# C Site Location and Layout Drawings

[To be prepared].

# D CBA Inputs and Key Outputs

# INPUTS

**Version Jan 2015**

## Scenario Choice (dropdown box)

**1** — Power generator (Heat Source) same fuel amount

### Technical solution features

| | |
|---|---|
| Heat carrying medium (hot water, steam or other) (dropdown box) | Hot water |
| Total length of supply pipework (kms) | 3.35 |
| Peak heat demand from Heat User(s) (MWth) | 7.51 |
| Annual quantity of heat supplied from the Heat Source(s) to Heat User(s) (MWh) | *Lines 49 & 79* |

**Key**

| | |
|---|---|
| 2 | Participant to define |
| 2 | Regulatory prescribed |
| 2 | Calculated |
| 2 | Prescribed - but possibility to change if make a case |

### DCF Model Parameters

| | |
|---|---|
| Discount rate (pre-tax pre-financing) (%) - 17% suggested rate | 17% |
| Project lifespan (yrs) | 30 |
| Exceptional shorter lifespan (yrs) | 0 |

### Cost and revenue streams

**Construction costs and build up of operating costs and revenues during construction phase**

| | | % operating costs and revenues during construction phase | Heat Supply Infrastructure - used in Scenarios 1, 2, 3 and 5 | Heat Station - used in Scenarios 1, 2 and 3 | Standby boilers (only if needed for Scenarios 1, 2 and 3) | Industrial CHP - used in Scenario 4 * |
|---|---|---|---|---|---|---|
| Project asset lifespan (yrs) | | | 30 | 30 | 30 | 20 |
| Exceptional reason for shorter lifespan of Heat Supply Infrastructure, Standby Boiler and/ or Heat Station (yrs) | | | | | | |
| Construction length before system operational and at steady state (yrs) | 2 | | | | | |
| Number of years to build | | | 2 | 2 | 2 | 0 |
| | | % (ONLY IF APPLICABLE) | £m | £m | £m | £m |
| Year 1 costs (£m) and build up of operating costs and revenues (%) | | 0% | 3.1554091 | 0.86605549 | 0.33630523 | |
| Year 2 costs (£m) and build up of operating costs and revenues (%) | | 0% | 3.1554091 | 0.86605549 | 0.33630523 | |
| Year 3 costs (£m) and build up of operating costs and revenues (%) | | | | | | |
| Year 4 costs (£m) and build up of operating costs and revenues (%) | | | | | | |
| Year 5 costs (£m) and build up of operating costs and revenues (%) | | | | | | |

**Non-power related operations**

| | |
|---|---|
| OPEX for full steady state Heat Supply Infrastructure on price basis of first year of operations (partial or steady state) (£m) | 0.1 |
| OPEX for full steady state Heat Station on price basis of first year of operations (partial or steady state) (£m) | 0.1 |
| OPEX for full steady state Standby Boilers on price basis of first year of operations (partial or steady state) (£m) | 0.0 |
| OPEX for full steady state Industrial CHP on price basis of first year of operations (partial or steady state) (£m) * | |
| Additional equivalent OPEX to pay for a major Industrial CHP overall spread over the life of the asset (£m) on price basis of first year of operations (partial or steady state) (£m) * | |
| Other 1 - Participant to define (£m) | |
| Other 2 - Participant to define (£m) | |
| **Total non-power related operations** | **0.2** |
| Annual inflation for all non-power related OPEX from first year of operations (full or partial) (%) | 2.0% |

**Unit Energy Prices, Energy Balance, Fuel Related Operational costs and Revenue Stream**

| | Scenario used | 1 Power generator (Heat Source) same fuel amount | 2 Power generator (Heat Source) same electrical output | 3 Industrial installation (Heat Source) - use waste heat | 4 Industrial installation (Heat Source) - CHP set to thermal input | 5 District heating (Heat User) |
|---|---|---|---|---|---|---|
| Heat sale price (£/ MWh) at first year of operations (partial or full) | 45.00 | 45.00 | 50.00 | 50.00 | | |
| Annual quantity of heat supplied from the Heat Source(s) to Heat User(s) at steady state (MWh) | 40,755 | 40,755 | 1,000,000 | 250,000 | | |
| Equivalent heat sales if first year of operations is steady state (£ m) | 1.8 | | | | | |
| Heat sale price inflation from first year of operations (full or partial) (% per year) | 2.0% | 2.0% | 3.0% | 3.0% | | |
| Percentage of heat supplied by Standby Boiler (if relevant) | 11% | 11% | 20% | 20% | | |
| 'Lost' electricity sale price (£/ MWh) at first year of operations | 84.10 | 84.10 | | | | |
| Z-ratio (commonly in the range 3.5 - 8.5) | 7.05 | 7.05 | | | | |
| Power generation lost at steady state (MWh) | 5,162 | 5,162 | | | | |
| Equivalent 'lost' revenue from power generation if first year of operations is steady state (£ m) | 0.43 | | | | | |
| Electricity sale price inflation from first year of operations (full or partial) (% per year) | 2.0% | 2.0% | | | | |
| Industrial CHP electricity sale price (£/ MWh) at first year of operations (full or partial) | 0.00 | | | | 110.00 | |
| Industrial CHP electrical generation in steady state (MWh) | 0 | | | | * 285,714 | |
| Equivalent revenue from power generation if first year of operations is steady state (£ m) | 0.00 | | | | | |
| Industrial CHP electricity price inflation from first year of operations (full or partial) (% per year) | 0.0% | | | | 2.0% | |
| Fuel price for larger power generator/ CHP at first year of operations (full or partial) (£ / MWh) | 0.00 | | 40.00 | | 40.00 | |
| Z-ratio (commonly in the range 3.5 - 8.5) | 0 | | 3.50 | | | |
| Power efficiency in cogeneration mode (%) | 0 | | 30% | | | |
| Additional fuel required per year for larger power generator / CHP in steady state (MWh) | 0 | | 761,905 | | * 300,000 | |
| Equivalent additional fuel costs if first year of operations is steady state (£ m) | 0.00 | | | | | |
| Fuel price inflation from first year of operations (full or partial) (% per year) | 0.0% | | 3.0% | | 5.0% | |
| Fuel price for Standby Boiler at first year of operations (£ / MWh) | 25.00 | 25.00 | 40.00 | 40.00 | | |
| Boiler efficiency of Standby Boiler (%) | 80% | 80% | 80% | 80% | | |
| Additional fuel required per year for Standby Boiler in steady state (MWh) | 5,451 | 5,451 | 250,000 | 62,500 | | |
| Equivalent additional fuel costs if first year of operations is steady state (£m) | 0.14 | | | | | |
| Fuel price inflation for Standby Boiler from first year of operations (full or partial) (% per year) | 2.00% | 2.0% | 3.0% | 3.0% | | |
| Heat purchase price (£/ MWh) at first year of operations (partial or full) | 0.00 | | | | | 35.00 |
| Annual quantity of heat supplied from the Heat Source(s) to Heat User(s) at steady state (MWh) | 0 | | | | | 200,000 |
| Equivalent cost of heat purchased if first year of operations is steady state (£ m) | 0.0 | | | | | |
| Heat purchase price inflation from first year of operations (full or partial) (% per year) | 0.0% | | | | | 3.0% |
| Fuel price (£ / MWh) at first year of operations (partial or full) | 0.00 | | | | | 40.00 |
| Boiler efficiency of district heating plant | 0% | | | | | 80% |
| Fuel avoided per year in steady state (MWh) | 0 | | | | | 250,000 |
| Equivalent fuel savings if first year of operations is steady state (£m) | 0.0 | | | | | |
| Fuel price inflation from first year of operations (full or partial) (% per year) | 0.0% | | | | | 4.0% |
| Fiscal benefits (£m) in first year of operations assuming it is at steady state ** | 0.00 | 0.00 | 2.50 | | 2.50 | |
| Fiscal benefits inflation rate from first year of opeations (full or partial) (%) ** | 0.0% | | 1.0% | | 1.0% | |

* In the case of Industrial CHP a separate model template is available for typical indicative CAPEX, non-power related OPEX, additional equivalent OPEX to pay for a major overall, MWh of electricity generated in the steady state and the additional fuel

** Operator only needs to enter a value for fiscal benefits (£m) and the annual fiscal benefit inflation rate (%) if the NPV without fiscal benefits is negative at the specified discount rate

## OUTPUTS

| | |
|---|---|
| Nominal Project IRR (before financing and tax) over 32 years | 12.9% |
| Nominal NPV (before financing and tax) (£m) over 32 years | -1.82 |

# E CHP-R Assessment Form

| # | Description | Units | Notes / Instructions |
|---|---|---|---|
| **Requirement 1: Plant, Plant location and Potential heat loads** | | | |
| 1.1 | Plant name | | Corby Energy Recovery Facility |
| 1.2 | Plant description | | The main activities associated with the Facility will be the combustion of incoming waste to raise steam and the generation of electricity in a steam turbine/generator.<br>The Facility includes one waste incineration line, waste reception hall, main thermal treatment process, turbine hall, on-site facilities for the treatment or storage of residues and waste water, flue gas treatment, stack, boilers, devices and systems for controlling operation of the waste incineration plant and recording and monitoring conditions.<br>The Facility will also include weighbridges, water, auxiliary fuel and air supply systems, site fencing and security barriers, external hardstanding areas for vehicle manoeuvring, internal access roads and car parking, transformers, grid connection compound, firewater storage tanks, offices, workshop, stores and staff welfare facilities.<br>The Facility has been designed to export power to the National Grid. The Facility will generate approximately 30.8 $MW_e$ of electricity in full condensing mode. The Facility will have a parasitic load of 2.7 $MW_e$. Therefore, the net power export capacity of the Facility is 28.1 $MW_e$.<br>In addition to generating power, the Facility has been designed to be capable of exporting up to 15 $MW_{th}$ heat to local heat users. The maximum heat capacity will be subject to the requirements of the heat consumers and confirmed during detailed design stage.<br>At the time of writing this report, there are no formal agreements in place for the export of heat from the Facility. The power exported may fluctuate as fuel quality fluctuates, and if heat is exported from the Facility to local heat users in the future.<br>The Facility has been designed to thermally treat waste with Net Calorific Value (NCV) between 8 and 14 MJ/kg. The nominal capacity of the Facility is 33.2 tonnes/hour of fuel with an NCV of 10.9 MJ/kg. The expected average availability is 8,000 hours per annum, which is regarded as typical for an energy from waste plant in the UK. Therefore, the nominal capacity for the installation is 265,541 tonnes/annum. The actual annual throughput will vary depending on the plant's availability and the NCV of the waste delivered to the Facility. |

| # | Description | Units | Notes / Instructions |
|---|---|---|---|
| 1.3 | Plant location (Postcode / Grid Ref) | | The site where the Facility will be built is located on the Willowbrook East Industrial Estate, approximately 2.2 km north-east of Corby. The site is centred approximately on National Grid Reference: SP908908 / SP9088190855 |
| 1.4 | Factors influencing selection of plant location | | The site was identified as being suitable for industrial redevelopment and given the nature of the surrounding land uses, the proposed use was considered appropriate. The site is brownfield land, there are no major environmental constraints on the site in relation to the proposed use and there are opportunities to provide heat and steam from the proposed development to nearby facilities.<br>The planning application confirmed the need for an Energy Recovery Facility in the area and selected the site as a potential suitable site for such purposes. A due diligence study was undertaken which confirmed that the site was suitable for its intended use. |
| 1.5 | Operation of plant | | |
| a) | Proposed operational plant load | % | 100 |
| b) | Thermal input at proposed operational plant load | MW | 100.50 |
| c) | Net electrical output at proposed operational plant load | MW | 28.11 |
| d) | Net electrical efficiency at proposed operational plant load | % | 27.97% |
| e) | Maximum plant load | % | 100 |
| f) | Thermal input at maximum plant load | MW | 100.50 |
| g) | Net electrical output at maximum plant load | MW | 28.11 |
| h) | Net electrical efficiency at maximum plant load | % | 27.97% |
| i) | Minimum stable plant load | % | 69% |
| j) | Thermal input at minimum stable plant load | MW | 69.35 |
| k) | Net electrical output at minimum stable plant load | MW | 17.57 |
| l) | Net electrical efficiency at minimum stable plant load | % | 25.34% |
| 1.6 | Identified potential heat loads | | |
| | | | Details of the identified heat loads are in Sections 5.<br>Following consumer screening and accounting for network heat losses and consumer diversity, potential |

| # | Description | Units | Notes / Instructions |
|---|---|---|---|
| | | | consumers were identified with an average heat load of 4.65 $MW_{th.}$ and a peak load of 7.51 $MW_{th}$ for the proposed heat network.<br>The estimated heat use of the identified network is 40,755 MWh/year. |
| | | | |
| 1.7 | Selected heat load(s) | | |
| a) | Category (e.g. industrial / district heating) | | District heating |
| b) | Maximum heat load extraction required | MW | The average and diversified peak heat demand of the proposed heat network has been calculated to be 4.65 $MW_{th}$ and 7.51 $MW_{th}$ respectively. |
| | | | |
| 1.8 | Export and return requirements of heat load | | |
| a) | Description of heat load extraction | | Network to supply hot water at typical district heating temperatures (approximately 110°C) via turbine steam extractions at approximately 1.5 bar(a). |
| b) | Description of heat load profile | | The heat load profile is variable due to mixed use developments (primarily industrial and commercial). A detailed heat load profile can be found in section 5.2 of the Heat Plan. The consumer heat load and profile are subject to verification. |
| c) | Export pressure | bar a | 10 |
| d) | Export temperature | °C | 110 |
| e) | Export flow | t/h | 99.64 (nominal case) |
| f) | Return pressure | bar a | 3 |
| g) | Return temperature | °C | 70 |
| h) | Return flow | t/h | 99.64 (nominal case) |
| **Requirement 2: Identification of CHP Envelope** | | | |
| 2.0 | Comparative efficiency of a standalone boiler for supplying the heat load | % LHV | 85% |
| | | | |
| 2.1 | Heat extraction at 100% plant load | | |
| a) | Maximum heat load extraction at 100% plant load | MW | 15.00 |
| b) | Maximum heat extraction export flow at 100% plant load | t/h | Assuming steam extraction at 1.5 bar(a), export flow rate would be: 2.31 t/h |
| c) | CHP mode net electrical output at 100% plant load | MW | 25.98 |

| # | Description | Units | Notes / Instructions |
|---|---|---|---|
| d) | CHP mode net electrical efficiency at 100% plant load | % | 25.85% |
| e) | CHP mode net CHP efficiency at 100% plant load | % | 40.77% |
| f) | Reduction in primary energy usage for CHP mode at 100% plant load | % | 24.59% |
| | | | |
| 2.2 | Heat extraction at minimum stable plant load | | |
| a) | Maximum heat load extraction at minimum stable plant load | MW | 7.05 |
| b) | Maximum heat extraction export flow at minimum stable plant load | t/h | Assuming steam extraction at 1.5 bar(a), export flow rate would be: 1.1 t/hr |
| c) | CHP mode net electrical output at minimum stable plant load | MW | 17.57 |
| d) | CHP mode net electrical efficiency at minimum stable plant load | % | 25.34% |
| e) | CHP mode net CHP efficiency at minimum stable plant load | % | 35.50% |
| f) | Reduction in primary energy usage for CHP mode at minimum stable plant load | % | 22.70% |
| | | | |
| 2.3 | Can the plant supply the selected identified potential heat load (i.e.is the identified potential heat load within the ‘CHP envelope’)? | | Yes, but not deemed ‘Good Quality’ CHP as detailed in section 6 of the Heat Plan. |
| **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 | 27.45 |
| b) | CHP mode net electrical efficiency at proposed operational plant load | % | 27.31% |
| c) | CHP mode net CHP efficiency at proposed operational plant load | % | 31.94% |
| d) | Reduction in net electrical output for CHP mode at proposed operational plant load | MW | 0.66 |
| e) | Reduction in net electrical efficiency for CHP mode at proposed operational plant load | % | 0.66% |

| # | Description | Units | Notes / Instructions |
|---|---|---|---|
| f) | Reduction in primary energy usage for CHP mode at proposed operational plant load | % | 20.37% |
| g) | Z ratio | | 7.05 |
| **Requirement 4: Technical provisions and space requirements** | | | |
| 4.1 | Description of likely suitable extraction points | | Steam for the district heating system could be supplied via a steam flow extraction from low pressure turbine bleed at approximately 1.5 bar(a). Full details are provided in section 4.2 of the Heat Plan. |
| 4.2 | Description of potential options which could be incorporated in the plant, should a CHP opportunity be realised outside the 'CHP envelope' | | The CHP opportunity lies within the CHP envelope. |
| 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 | | If the scheme were to be implemented, space will be allocated for the CHP equipment within or in the area adjacent to the turbine hall to avoid the cost of building a dedicated heat station at a later date.<br>The turbine design will be selected to maximise electrical efficiency while allowing for the option of heat export to be implemented in the future. This is in line with the EA CHP-Ready Guidance which states that 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. |
| 4.4 | Provision of site layout of the plant, indicating available space which could be made available for CHP-R | | Detailed design of the Facility has not been undertaken at this stage. However, space will be left available on site for heat export infrastructure. Please see the site layout in Appendix C.<br>The heat network will (likely) include steam extraction piping, control and shutoff valves, heat exchangers, district heating supply and return lines, district heating circulation pumps, condensate return piping (to the condensate tank), control and instrumentation / electrical connections, an expansion tank for pressurisation of the district heating pipe network and heat metering.<br>If necessary, a back-up boiler will be located at a suitable location within the installation boundary for ease of connection to the primary hot water circuit. |
| **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** | | |

| # | Description | Units | Notes / Instructions |
|---|---|---|---|
| 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 |

| # | Description | Units | Notes / Instructions |
|---|---|---|---|
| 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 |
| | | | |

| # | Description | Units | Notes / Instructions |
|---|---|---|---|
| 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 |
| | | | |
| 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 | | In order to assess the economic feasibility of the CHP scheme (as required under Article 14 of the Energy Efficiency Directive) a cost benefit assessment has been carried out in accordance with the draft Article 14 guidance.<br>The results of the CBA indicate an internal rate of return of 12.9 % and a net present value of -£1.82 million. The proposed heat network will not yield an economically viable scheme in its current configuration. The economic feasibility of the scheme will be reassessed in the future when there is a better understanding of heat demands and considering any subsidies that support the export of heat. |
| **BAT assessment** | | | |
| | Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)? | | No |
| | If not, is the new plant a CHP-R plant at the outset? | | Yes |
| | Once the new plant is CHP-R, is it BAT? | | Yes |

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