Ford energy from waste

FORD ENERGY RECOVERY FACILITY AND WASTE SORTING AND TRANSFER FACILITY, FORD CIRCULAR TECHNOLOGY PARK

COMBINED HEAT AND POWER REPORT

MARCH 2021

TERENCE O'ROURKE · FICHTNER Consulting Engineers Limited · Viridor · GRUNDON

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FORD ENERGY FROM WASTE LTD, GRUNDON WASTE MANAGEMENT LTD, VIRIDOR ENERGY LTD

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Introduction

1.1 The ability to generate both electricity and heat for use in meeting energy demands is known as combined heat and power (CHP). CHP has developed into an established technology and has become a key part of UK government's strategy to reduce CO_2 emissions.

1.2 Ford Energy from Waste Limited, Grundon Waste Management Limited and Viridor Energy Limited (the joint applicants) have submitted a full planning application to West Sussex County Council (WSCC) for the construction and operation of an Energy Recovery Facility (ERF) and Waste Sorting and Transfer Facility (WSTF) on land at Ford Circular Technology Park, Ford, West Sussex.

1.3 The proposal is designed to deliver both electricity and heat and is therefore capable of delivering CHP. It includes boilers and a turbine to generate the steam and electricity required. The turbine is designed with suitable heat off-take points so that the heat can be extracted from the system. Space is provided for the necessary equipment so that heat taken from the turbine can be transferred off site for use. The planning application also provides for a pipeline route that will take heat to the public road at Ford Road.

1.4 It is relatively straightforward to distribute the electricity produced via the national electricity grid, and the proposals will provide about 28MW of electricity in this way. The ERF will connect to the Crockerhill substation. The local electricity distribution company will be responsible for connecting the ERF to the national grid. It will be responsible for obtaining any permissions or permits required to develop the necessary connection infrastructure.

1.5 The ability to use the heat generated by the ERF depends on having identified and secured local heat users (customers) and an off site heat distribution network.

1.6 The proposals in the planning application take this as far as possible by ensuring that the heat will be produced, that it can be captured, and that it can be taken to the public road. Other agencies will need to be involved to pick up the reins in providing infrastructure connections from these points to heat users, when these are confirmed.

1.7 The applicants will therefore provide a significant opportunity for district heating, and are committed to working with others to see this opportunity realised.

The applicants CHP experience

1.8 Of the three joint applicants, Viridor has an existing fleet of nine ERFs and has experience of delivering CHP and district heating relating to a number of its existing facilities in the UK. This includes the following.

1.9 Viridor already generates 51 MW of heat at its two Runcorn ERFs (Runcorn I and II) for exclusive use by the nearby INOVYN chemical manufacturing site and has recently (February 2021) agreed proposals to supply a new heat network in Exeter from its existing Exeter ERF. This will support the Exeter Local Plan’s mixed-use development at South West Exeter that will see up to 2,500 new homes in the area plus a new school campus, shops and community facilities.

1.10 Viridor is also participating in a new £26.5m district-heating network in Cardiff and will provide heat generated at its Trident Park ERF to the network. The first phase of the heat network will initially provide heating to a number of large buildings in the city and could be operational within two years of installation works beginning. The first £15 m of funding to secure the first phase has been confirmed in August 2020, with loans from the Welsh and UK governments.

1.11 Viridor also plans to supply heat from its Beddington ERF in South London to new homes in nearby Hackbridge, where it already supplies heat from landfill gas engines.

1.12 Viridor is also constantly reviewing the potential for heat supply from all of its CHP ready ERFs, including the joint venture with Grundon at Lakeside near Slough, plus at Ardley, Avonmouth, Dunbar, and Peterborough.

1.13 In November 2020 Viridor announced a partnership with low carbon heating provider Vattenfall to work together to capture heat from Viridor's ERFs across the UK. Vattenfall already works with ERF owners and operators in Europe.

1.14 The approach being taken by Viridor and Vattenfall aligns well with UK Government policies that support the roll out of district heating in urban areas. The Government's successful flagship Heat Networks Investment Programme and the proposed Green Heat Networks Fund specifically target collaborations between waste heat sources and heat network operators.

1.15 This demonstrates knowledge, commitment and a track record for the applicants to build on in seeking to secure a heat network that will use the heat from the Ford ERF.

1.16 Against this background, the applicants have carried out a study to identify potential heat customers for district heating related to the Ford ERF.

1.17 This document briefly explains the benefits of CHP, the track record of the applicants in delivery, the initial work on identification of potential heat users, and an initial consideration of future delivery.

2. District heating

2.1 District heating is the supply of heat to a number of buildings or homes from a central heat source through a network of pipes carrying hot water or steam. It can be used for residential and commercial heating requirements such as space heating and water heating. District heating can provide higher efficiencies and better pollution control than localized boilers.

The process

2.2 The applicants intend to build a facility that is CHP enabled, that is to say the turbine will be equipped with the necessary additional facilities for extracting steam and the design includes the provision for the future generation of hot water and for taking hot water and/or steam to the boundary of the site for connection into a heat distribution system.

2.3 The ERF combustion process is used to heat water in a boiler. This water turns to steam, which then drives a turbine to produce electricity for export to the national grid.

2.4 The steam can be extracted from the turbine to heat water which can be piped as part of a district heating scheme, but there is a reduction in electricity output associated with this. The higher the extraction pressure, the greater the loss of power output.

2.5 For this reason, to balance the loss of power generation, steam will be extracted from the lowest pressure bleed points on the turbine. A ‘base load’ of heat can be supplied from the last bleed point on the turbine, with peak heat loads met from the intermediate bleed.

2.6 This source of heat offers the most flexible design for the plant. The steam bleeds can be sized to provide additional steam over and above the plant’s parasitic steam loads.

2.7 The heat station can be retrofitted at a time to suit the demand. The turbine has been designed to be able to deliver up to 10 MW_{th} of thermal energy. The proposed network load based on likely users is anticipated to be 3.56 $MW_{th.}$

2.8 Heat will be distributed via buried pre-insulated steel pipes which will be used to supply pressurised hot water to the customer at about 110 degrees centigrade, and to return cooler water at about 70 degrees centigrade. This technology is well proven and provides an energy distribution system with a 30-year design life.

2.9 The district heating pipework will be sized to allow the future expansion of the scheme and the indicative pipe route provided from the ERF to Ford Road has been optimised with existing and potential users in mind.

2.10 At customer level the heat network is usually connected to the central heating system by heat exchangers. The heat exchanger substation may be provided for individual buildings, blocks, streets or areas.

2.11 The water used in the district heating system is not mixed with the water of the central heating system, which will be no different to other heating systems such as gas boilers, and the same level of control will be available. Heat use will probably be metered.

2.12 The ERF will initially operate in electricity-only mode. Once heat customers and commercial terms are agreed, with contracts signed, and when the on and off-site infrastructure has been provided, the plant can operate in full heat and power mode.

2.13 Further details of the district heating equipment, including plant, pumps and pipework, are included in appendix 1, “CHP Feasibility Report, summary for planning application” prepared by Fichtner.

3. Carbon benefits of CHP

3.1 There is a policy context that seeks to encourage and deliver on the potential for combined heat and power and district heating represented by energy recovery facilities in general.

3.2 National energy policy generally aims for development to be planned to limit carbon dioxide emissions and to make good use of opportunities for the decentralised and renewable production of low carbon energy.

3.3 A proportion of the fuel (residual waste) will be derived from biodegradable materials. Carbon dioxide released from the combustion of biomass is not considered to contribute to global warming, since this carbon has been recently extracted from the atmosphere via photosynthesis. Therefore, there are potential environmental benefits when compared with combustion of fossil fuels.

3.4 The carbon assessment presented in chapter 7 of the ES accompanying the planning application indicates that the ERF is predicted to lead to a net reduction in greenhouse gas emissions of approximately 48,102 tonnes of CO2-equivalent (CO2e) per annum compared to landfill.

3.5 Heat production is not considered in the calculation. The carbon assessment has conservatively assumed that the ERF will not export heat. The ERF is designed as a combined heat and power plant (CHP) and if heat is exported this would significantly increase the carbon benefits of the ERF.

3.6 Therefore, if the net carbon produced is considered to be attributable to the production of electricity, which is the primary energy production operation, then the heat produced from the ERF can be considered not to contribute any carbon dioxide emissions.

3.7 Given that the heat from the ERF plant in CHP mode could be considered as not contributing any carbon emissions, the heat exported from the plant can be considered zero carbon energy and can be used by receiving developments to achieve their carbon target.

3.8 There are difficulties in securing customers up front, as without the certainty of an operational ERF there can be no certainty about delivery of heat. Hence the majority of ERFs are CHP ready, pending the subsequent identification and securing of commercial terms for heat customers.

3.9 There is a significant role for local authorities in providing encouragement and an enabling role in bringing about the desired district heat networks. It is therefore significant that national political will is creating a favourable policy framework for decentralised energy, helping to change the investment environment. The public sector is working to remove barriers and harness the private sector's financing and delivery capability.

3.10 Against this background, Viridor (and with Grundon at Lakeside) is already working with local authorities to maximise the potential for delivery of the district heating opportunity presented by its ERFs in other locations around the UK (see section 1 above) and has a partnership with district heating experts Vattenfall to assist in driving this forward.

3.11 The applicants have carried out studies to show that there are heat customers potentially available in the local area and what demand they may have. This is addressed in the following parts of this document.

4. Finding heat customers

4.1 Securing a suitable and deliverable demand from nearby land uses is fundamental to the success of CHP provision.

4.2 The applicants instructed Fichtner Consulting Engineers Ltd (Fichtner) to undertake a District Heating (DH) study linked to the ERF. This work is included in the CHP Feasibility Report summary for planning application at Appendix 1 and is outlined below.

4.3 The Fichtner report at Appendix 1 shows that potential heat users have been identified close to the ERF:

4.4 A review of the potential heat demand within a 15 km radius of the ERF has been undertaken. Physical constraints imposed by local infrastructure and topology have a significant impact on which consumers can viably be connected. Both river and rail crossings exist in the area surrounding the ERF and may present obstructions to connect some consumers. Engineering a bridge crossing will likely require detailed structural assessments and the consent of the bridge owner. Trenching in road crossings will require traffic management and permission from the highway authority.

4.5 Following screening of potential heat consumers, the identification of potential heat demands has focused on nearby industrial and commercial users, as the benefits of providing heat to large nearby premises is generally more financially viable than supply to multiple smaller consumers at further distances.

4.6 Potential heat consumers have been identified using publicly available data in the National Comprehensive Assessment, heat mapping tools and satellite imagery. The identified local heat consumers include:

- HMP Ford
- Rudford Industrial Estate.

4.7 These are located at pipeline distances of between 500 m and 1km south of the ERF.

4.8 Initial discussions have been held with HMP Ford to discuss the feasibility of agreeing to a potential heat export scheme. At this stage, heat users at Rudford Industrial Estate have not been contacted. Until the environment permit has been granted and detailed design has been undertaken the heat export conditions are not known, making it difficult for potential heat users to determine whether they would be interested in importing heat. When detailed design has been undertaken and planning permission and an Environmental Permit for the ERF granted, discussions with potential heat users can take place.

4.9 Four large heat consumers (point heat demands greater than 5 MW_{th} as defined by the UK CHP Development Map) have been identified within the specified 15 km search radius.

4.10 The large consumers are within 8-15 km radius of the ERF that would require a prohibitively costly pipe network to connect. Therefore, it is assumed that these large heat users will be more difficult to secure. However, in the future the feasibility of this option will be investigated when there is more certainty about heat loads.

4.11 A strategic site at Ford Airfield has been allocated for residential mixed-use development in the Arun Ditsrict Plan and the Ford Neighbourhood Plan. The masterplan for the site makes provision for1,500 homes, employment land and a local centre / community hub including retail/commercial and community/leisure facilities.

4.12 The development is close to and surrounds the ERF and would be an ideal potential user of heat. The cost of exporting heat to nearby plots would be lower as less civil work is required to lay pipe over short distances and the development site can be designed to incorporate the required heat exchange equipment and back up boilers, reducing costly retrofit work.

4.13 There is uncertainty over construction timescales, appearance, layout, landscaping and scale of the proposals as the outline planning application for the proposals has not yet been approved.

4.14 However, initial discussions have been held with the developer to highlight the opportunity of a potential heat export scheme.

Potential heat demand

4.15 Based on the selection of preferred heat consumers near the ERF, and generic heat demand profiles, the heat demand of the preferred heat consumers has been estimated. The average and diversified peak heat demand of the proposed heat network has been estimated to be 3.56 MW_{th} and 10.00 MW_{th} respectively, with an annual heat demand of 31,189 MWh/annum.

4.16 A heat demand profile has been developed to assess daily 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 ERF independently, except for periods of downtime when a back-up system will be required. Detailed techno-economic modelling will be undertaken when there is a better understanding of consumer heat demands.

Economic assessment

4.17 Appendix 1 includes an initial economic assessment of the costs and revenues associated with the construction and operation of a district heating network. It takes account of capital and operating costs of the heat supply system, heat sales revenue and lost electricity revenue as a result of diverting energy to the heat network. It does not consider the costs associated with the ERF itself.

4.18 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.

4.19 The ERF will meet the requirements of tests outlined in the Environment Agency's CHP Ready Guidance.

Energy efficiency; R1 calculation

4.20 The R1 efficiency is calculated as 0.83 without any heat export. With 3.56 MW_{th} heat export to the identified heat users, which is the average heat demand required by the identified heat users (see Appendix 1), the R1 efficiency is found to be 0.86.

4.21 Both scenarios are above the threshold for new incineration plants. Therefore, the ERF will meet the definition of recovery with or without any heat export.

5. Delivery

5.1 In addition to the applicants' role in providing a significant CHP opportunity that has potential to feed a district heating network, other organisations and bodies will need to be involved for district heating to be realised.

5.2 Local authorities have played a key role in many successful district heating schemes and are often the key to forming relationships with other public bodies, local communities, developers and contractors. The drive for the development of district heating is significantly enhanced with the commitment and involvement of local authorities, and it is seen in many instances around the UK that the public sector is working to remove barriers and harness the private sector’s financing and delivery capability.

5.3 For example, this is happening in Viridor's partnerships in Exeter, Cardiff and South London (Beddington), where Exeter City Council, Cardiff City Council, and the GLA, Sutton and Croydon are working with Viridor for the establishment of district heating, making use of the heat from Viridor's ERFs.

5.4 Through a partnership with Vattenfall, a district heating provider experienced in working with local authorities in continental Europe, further joint working with both local authorities, and direct supply to potential private users, is being explored at Viridor's other ERFs.

5.5 Local authorities are able to tap into central government funding through grants and loans to assist in the provision of district heating. For example, at Cardiff, the City Council has secured support via a £8.6m loan from the Welsh Government and a £6m grant from the UK Government for the first phase of a heat network, now underway.

5.6 There is clearly potential for a district heating network in the vicinity of the Ford ERF. The applicants are committed to working with West Sussex County Council and Arun District Council to investigate future provision of a district heating scheme that will assist in reducing West Sussex/Arun District's carbon emissions.

5.7 Progress towards delivery includes:

- a planning application has been made for the ERF that will provide a significant amount of heat that can be used for district heating
- an environmental permit application has also been submitted
- the design of the ERF includes the ability to take heat from the turbine, and provides space for the necessary heat exchange and pumping equipment to deliver heat off site
- an indicative route has been identified for pipework to take heat to the public road at Ford Road
- potential heat users have been identified and initial contact made with HMP Ford and the developers of the Landings.

5.8 To achieve delivery, the ERF will first need to achieve a planning permission and an environmental permit. This is essential to allow contracts to supply heat to identified end-users to be secured. Further investment in off-site infrastructure will be required. Other parties will need to invest in, install and manage the network outside the site boundary. The applicants are committed to work together with other parties to assist in the process to secure CHP delivery.

APPENDIX 1

CHP FEASIBILITY REPORT

FICHTNER

Consulting Engineers Limited

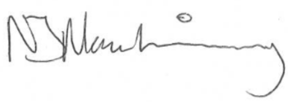
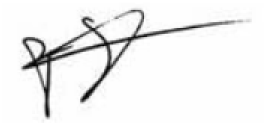
Ford Energy Recovery Facility and Waste Sorting and Transfer Facility, Ford Circular Technology Park

Viridor Energy Limited, Grundon Waste Management and Ford Energy from Waste Ltd

CHP Feasibility Report – Summary for Planning Application

ENGINEERING CONSULTING

Document approval

	Name	Signature	Position	Date
Prepared by:	Noah Mawhinney		Project Engineer	29/03/2021
Checked by:	James Sturman		Lead Consultant	29/03/2021

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Management Summary

Viridor Energy Limited, Grundon Waste Management Limited and Ford Energy from Waste Limited ('Viridor Energy, Grundon and Ford EfW', the Applicants) are developing an Energy Recovery Facility (ERF, the Facility) on the site of an existing waste transfer station in Ford, West Sussex. The Facility will operate as a merchant facility, with fuel sourced primarily from commercial waste contracts.

The Facility will process up to 275,000 tonnes per annum (at the design capacity of 32.5 tph with an NCV of 10.5 MJ/kg and an availability of approximately 8,500 hours).

The Facility has been designed to export power to the National Grid. The Facility will generate approximately 31.2 MW_e of electricity in full condensing mode and with average ambient temperature. The Facility will have a parasitic load of approximately 3.1 MW_e. Therefore, the export capacity of the Facility, with average ambient climatic temperatures, is approximately 28.1 MW_e.

The Facility will have the capacity to export up to 10 MW_{th} of heat, subject to technical and economic feasibility, which is suitable for the identified district heating network. The maximum heat capacity will be subject to the requirements of the heat consumers and confirmed during the detailed design stage of the Facility.

The Environment Agency (EA) Combined Heat and Power (CHP) Ready Guidance requires Best Available Techniques (BAT) to be demonstrated by maximising energy efficiency. Following screening of potential heat consumers and development of a network heat demand profile, it has been established that technically feasible opportunities exist to export an annual average heat load of up to 3.56 MW_{th}, and, when accounting for consumer diversity and heat losses, a peak load of 9.26 MW_{th}.

An 'R1' calculation was performed, in line with the European Commission Waste Framework Directive, to determine if the Facility can be regarded as a 'Recovery' operation. The calculated R1 efficiency for the Facility, both with and without the developed heat network thermal demand, is above the threshold for new incineration plants. Therefore, the Facility will meet the definition of recovery with or without any heat export. The calculation is provided in Appendix D.

In accordance with Article 14 of the Energy Efficiency Directive, a cost-benefit assessment (CBA) of opportunities for CHP is required when applying for an Environmental Permit (EP). An assessment of the costs and revenues associated with the construction and operation of the proposed heating network has been undertaken. This has been inputted into a CBA in accordance with the draft Article 14 guidance document issued by the EA. 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 17.3 % and £0.09 million, respectively. Therefore, it is considered that the proposed heat network yields an economically viable scheme in its current configuration. However, the economic feasibility of the scheme will be reassessed in the future when there is further certainty regarding heat loads and considering any subsidies that might be available at that time that support the export of heat.

It should be noted that the draft EA guidance calculation spreadsheet makes fixed assumptions about a project which are not appropriate for this project. The standard CBA calculation only considers the costs associated with the heat supply infrastructure rather than the full project costs. This has the effect of producing artificially high rates of return. The economic case for the Facility relies on both heat and power revenues to produce a rate of return acceptable to the Applicants for the whole project and not just the heat supply infrastructure.

The Facility will be designed to be CHP-Ready to demonstrate BAT for the Facility, meaning that it will be able to export heat in the future with minimum modification, by virtue of having steam capacity designed into the turbine bleed and safeguarded space within the turbine hall to house CHP equipment. The Applicants appreciate the benefits associated with maximising energy

recovery from the thermal treatment of waste, through the implementation of CHP. The Applicants will continue to explore commercial opportunities to export heat from the Facility and periodically update its position.

Contents

1 Introduction

1.1 Background

Viridor Energy Limited, Grundon Waste Management Limited and Ford Energy from Waste Limited ('Viridor Energy, Grundon and Ford EfW', the Applicants) are developing an Energy Recovery Facility (ERF, the Facility) on land formerly host to the Ford Topblock Concrete Works in Ford, Arundel, West Sussex. The Facility will operate as a merchant facility, with fuel sourced primarily from commercial waste contracts.

1.2 The Location

The Facility is located to the west of the village of Ford, at the former Tarmac blockworks site, which forms part of the former Ford Airfield. Yapton is situated approximately 1 km to the west of the site, Climping approximately 1 km to the south, Littlehampton approximately 2 km to the east, and Arundel approximately 3 km to the north east.

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

2 Conclusions

2.1 Technical Solution

The Facility will generate approximately 31.2 MWe of electricity in full condensing mode and with average ambient temperature. The Facility will have a parasitic load of approximately 3.1 MW_e. Therefore, the export capacity of the Facility, with average ambient climatic temperatures, is approximately 28.1 MW_e.

The Facility is designed for the export of up to 10 MW_{th} of heat to local heat consumers, subject to technical and economic viability, which is suitable for the identified district heating network. The maximum heat capacity will be subject to the requirements of the heat consumers and confirmed during detailed design stage. Based on the heat network identified within this CHP Feasibility Report, the average heat load is expected to be 3.56 MW_{th}, resulting in an average electrical export of approximately 27.56 MW_e.

A number of arrangements for heat recovery from the Facility and export are available. Given the requirements of the heat consumers (discussed subsequently), 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 heat exchanger 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

A review of the potential heat demand within a 15 km radius of the Facility has been undertaken in accordance with the requirements set out in Section 2 of the EA's draft Article 14 guidance. Physical constraints imposed by local infrastructure and topology have a significant impact on which consumers can viably be connected. Both river and rail crossings exist in the area surrounding the Facility and may present obstructions to connect some consumers. Engineering a bridge crossing will likely require detailed structural assessments and the consent of the bridge owner. Trenching in road crossings will require traffic management and permission from the highway authority. Following screening of potential heat consumers, the identification of potential heat demands has focused on nearby industrial and commercial users, as the benefits of providing heat to large nearby premises is generally more financially viable than supply to multiple smaller consumers at further distances.

Potential heat consumers have been identified using publicly available data in the National Comprehensive Assessment, heat mapping tools and satellite imagery. The identified local heat consumers include HMP Ford and the Rudford Industrial Estate located at pipeline distances of between 500 m and 1km south of the Facility.

Four large heat consumers (point heat demands greater than 5 MW_{th} as defined by the UK CHP Development Map) have been identified within the specified 15 km search radius. The large consumers are within 8-15 km radius of the Facility that would require a prohibitively costly pipe network to connect. Therefore, these large heat users have been discounted. However, in the future the feasibility of this option will be investigated when there is more certainty in heat loads.

2.3 Heat Network Profile

Based on a selection of preferred heat consumers near the Facility, and generic heat demand profiles, the heat demand of the preferred heat consumers has been estimated. The average and diversified peak heat demand of the proposed heat network has been estimated to be 3.56 MW_{th} and 10.00 MW_{th} respectively, with an annual heat demand of 31,189 MWh/annum.

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, except for periods of downtime when a back-up system will be required. Detailed techno-economic modelling will be undertaken when there is a better understanding of consumer heat demands.

2.4 Economic Assessment

The costs and revenues associated with the construction and operation of the proposed district heating network has been undertaken. This has been inputted into the EA's CBA template. The CBA takes account of heat supply system capital and operating costs, heat sales revenue and lost electricity revenue as a result of diverting energy to the heat network. It does not consider the costs associated with the main CHP plant.

The results of the CBA indicate that the estimated £5.87 million capital investment will be offset by heat sales revenue. The nominal project internal rate of return – IRR – (before financing and tax) over 30 years is projected as 17.3 %, with a net present value – NPV – of £0.09 million. Both IRR and NPV are positive indicating the project would be profitable.

Given the current Renewable Heat Incentive (RHI) scheme is due to end in March 2021, it is not possible that the Facility will qualify for support under the scheme. The economic feasibility of the scheme will be reassessed in the future when there is a better understanding of heat demands considering any subsidies that support the export of heat.

It should be noted that the draft EA guidance calculation spreadsheet makes fixed assumptions about a project which are not appropriate for this project. The standard CBA calculation only considers the costs associated with the heat supply infrastructure rather than the full project costs. This has the effect of producing artificially high rates of return. The economic case for the Facility relies on both heat and power revenues to produce a rate of return acceptable to Ford Energy from Waste Ltd for the whole project and not just the heat supply infrastructure.

As construction of a district heating network is currently economically feasible, the Facility will be design and constructed as CHP-Ready. As such, the Facility will meet the requirements of BAT tests outlined in the EA CHP Ready Guidance.

2.5 Energy Efficiency Measures

In order to qualify as technically feasible under the draft Article 14 guidance, the 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 operating in fully condensing mode (i.e. without heat export) the Facility will achieve a primary energy saving (PES) of 24.05 %, which is in excess of the technical feasibility threshold defined in the draft Article 14 guidance. The proposed heat network will result in PES of 25.46 % which is in excess of the technical feasibility threshold and would therefore be technically feasible to supply.

The R1 efficiency is calculated as 0.83 without any heat export. With 3.56 MW_{th} heat export to the identified heat users which is the average heat demand required by the identified heat users (see

Section 5), the R1 efficiency is found to be 0.86. Both scenarios are above the threshold for new incineration plants. Therefore, the Facility will meet the definition of recovery with or without any heat export.

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], referred to as the CHP-Ready Guidance. The guidance applies to the following facilities, which will be 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 EfW 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 apply.

The CHP-Ready Guidance 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 test 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 there are opportunities for heat use off site.

3.2 Energy Efficiency Directive

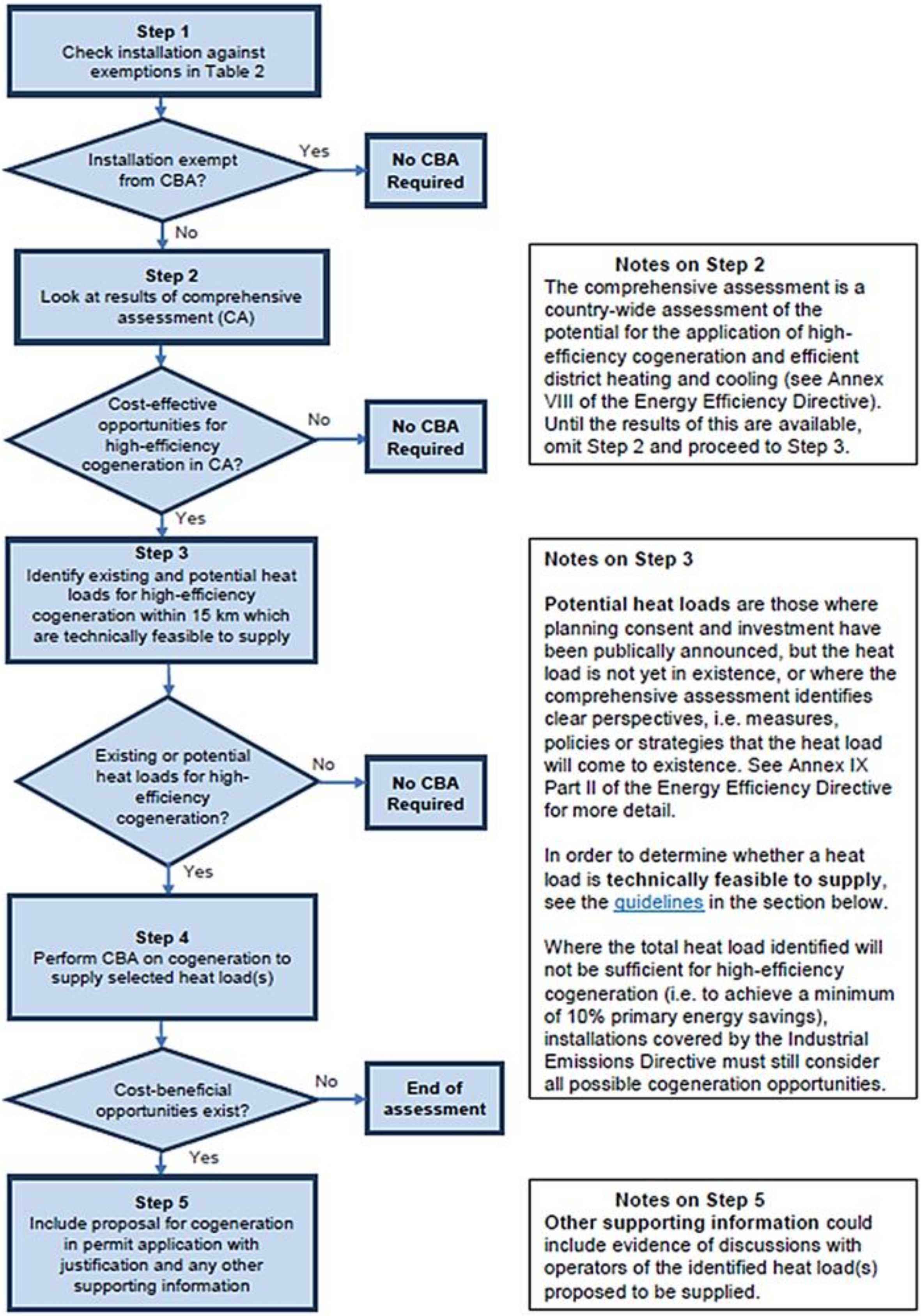
From 21 March 2015, operators of certain types of combustion installations are required to carry out a CBA of opportunities for CHP when applying for an EP. This is a requirement under Article 14 of the Energy Efficiency Directive and applies to a number of combustion installation types. As a new electricity 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, V9.0 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/non-recyclable residual waste to raise steam and the generation of electricity in a steam turbine/generator.

The Facility includes two waste incineration lines, waste reception hall, main thermal treatment process, turbine hall, on-site facilities for the storage of residues and wastewater, flue gas treatment, stack, boiler, devices 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, internal access roads and car parking, transformers, grid connection compound, raw and firewater storage tank, offices, workshop, stores and staff welfare facilities.

The Facility will have a maximum capacity of 275,000 tpa of non-hazardous/non-recyclable residual waste.

The Facility will generate approximately 31.2 MW_e of electricity in full condensing mode and with average ambient temperature. The Facility will have a parasitic load of approximately 3.1 MW_e. Therefore, the export capacity of the Facility, with average ambient climatic temperatures, is approximately 28.1 MW_e.

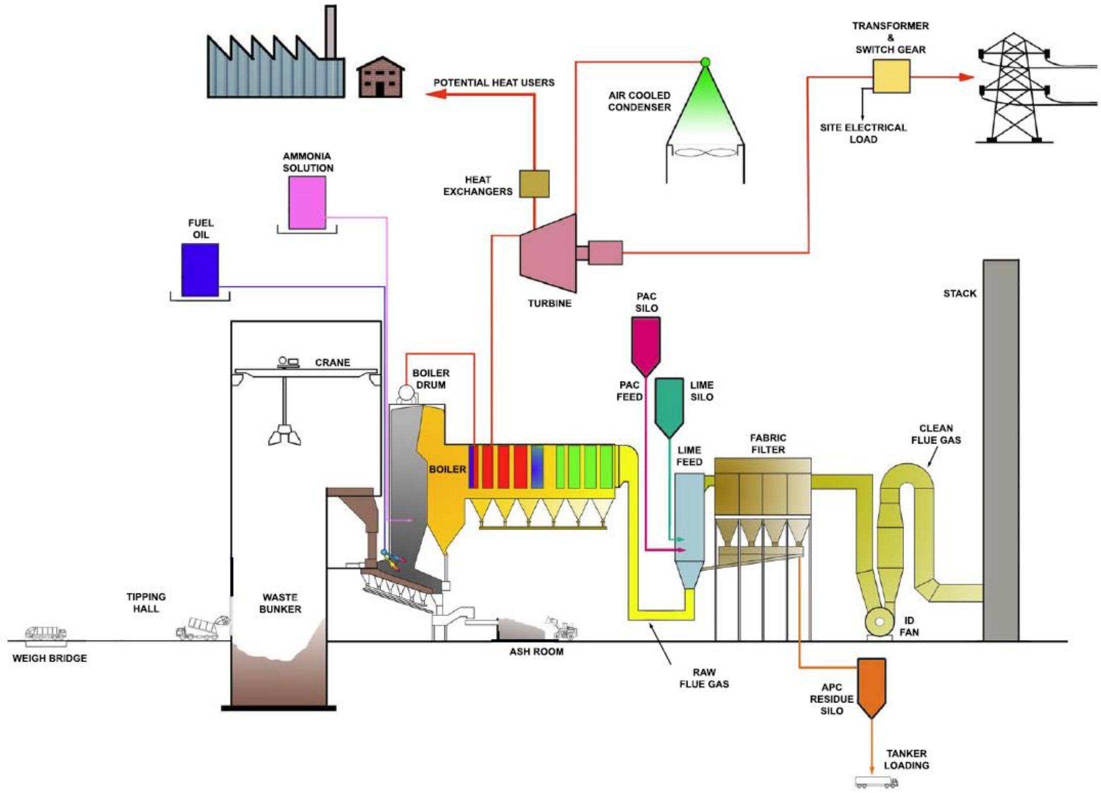
The Facility is designed for the export of up to 10 MW_{th} of heat to local heat consumers, subject to technical and economic viability, which is suitable for the identified district heating network. The maximum heat capacity will be subject to the requirements of the heat consumers and confirmed during detailed design stage.

Based on the heat network identified within this CHP Feasibility Report, the average heat load is expected to be 3.56 MW_{th}, resulting in an electrical export of approximately 27.56 MW_e. However, 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 to local heat users in the future. The power exported fluctuates also depending on the ambient air temperature.

4.1.1 Combustion Process

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

Figure 2: Process schematic



4.1.2 Energy Recovery

The heat released from the combustion of incoming waste will be recovered by means of a steam boiler, which is integral to the furnace and will produce (in combination with superheaters) high pressure superheated steam at approximately 76 bar(a) and 430°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 water/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 of the steam will be condensed and cooled using an air-cooled condenser. The condensed steam will be returned as condensate to the feedwater tank and from there again as feedwater to the closed-circuit pipework system to the boiler.

Depending on the requirements of potential heat users, either low pressure steam or hot water could be supplied. Low pressure steam could be extracted from the turbine and piped directly to the heat users. Alternatively, low pressure steam extracted from 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.

4.2 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 end consumers.

The most commonly considered options for recovering heat are discussed below.

1. Heat recovery from the air-cooled condenser (ACC)

Wet steam emerges from the steam turbine typically at 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 ACC will be installed at the Facility. Steam is condensed in a large air-cooled system which rejects the heat in the steam into the air flow, which is rejected to atmosphere. An ACC generates a similar temperature condensate to mechanical draught or hybrid cooling towers. The condensate then returns back to the boiler. Cooling this condensate further by extracting heat for use in a heat network requires additional steam to be extracted from the turbine to heat the condensate prior to being returned to the boiler. This additional steam extraction reduces the power generation from the plant and therefore reduce the plant power efficiency.

2. Heat extraction from the steam turbine

Steam extracted from the steam turbine can be used to generate hot water for district heating schemes. District heating schemes typically operate with a flow temperature of 90 to 120°C and return water temperature of 50 to 80°C. Steam is preferably extracted from the turbine at low pressure to maximise the power generated from the steam. Extraction steam is passed through a condensing heat exchanger(s), with condensate recovered back into the feedwater system. Hot water is pumped to heat consumers for consumption before being returned to the primary heat exchangers where it is reheated.

Where steam is used for heating hot water, it is normally extracted from a lowest pressure bleeds on the turbine, depending on the heating requirements of the heat consumers.

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 size of the heat load needs to be clearly defined to allow the steam bleeds and associated pipework to be adequately sized. Increasing the capacity of the bleeds once the turbine has been installed can be difficult.

3. Heat extraction from the flue gas

The temperature of cool flue gas from the flue gas treatment plant is around 131°C and contains water in vapour form. This can be cooled further using a flue gas condenser to recover the latent heat from the moisture. This heat can be used to produce hot water for district heating in the range 90 to 120°C. This method of heat extraction does not significantly impact the power generation from the plant.

Condensing the flue gas can be achieved in a wet scrubber. However, the scrubber temperature is typically no more than 80°C, which restricts the hot water temperature available for the consumer. Additionally, condensing water vapour from the flue gas reduces the flue gas volume and hence increases the concentration of non-condensable pollutants within it. The lower volume of cooler gas containing higher concentration of some pollutants would likely require a different stack height to effect adequate dispersion. The additional cooling of the flue gas results in the frequent production of a visible plume from the chimney and although this is only water vapour it can be misinterpreted as pollution. The water condensed from the flue gas needs to be treated and then discharged under a controlled consent.

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 requirements of the identified consumers (as described in section 5.1.4) are suited to the temperatures attainable from the turbine with minimal power loss due to exporting energy to the heat circuit.
2. The use of a flue gas condenser has not been considered as it generates 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. Extraction of steam from the turbine offers the most flexibility for varying heat quality and capacity to supply variable demands or new future demands.
4. Extraction of steam from the turbine, heat transfer to a hot water circuit and delivery of heat to consumers can be facilitated by well proven and highly efficient technology.

4.3 Details of Input Waste

Table 1: Input waste

Parameter	Value
Design waste throughput (NCV 10.5 MJ/kg, 8,000 hours)	275,000 tpa
Proposed NCV	10.5 MJ/kg
Proposed GCV	11.89 MJ/kg

5 Heat Demand Investigation

5.1 Wider Heat Export Opportunities

5.1.1 The National Comprehensive Assessment

'National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK'[3] (the NCA), dated 16 December 2015, was published by Ricardo AEA Ltd on behalf of the Department of Energy and Climate Change (now part of the Department for Business, Energy and Industrial Strategy). The report was produced to fulfil the requirement (under Directive 2012/27/EU on energy efficiency) on all EU Member States to undertake a National Comprehensive Assessment (NCA) to establish the technical and socially cost-effective potential for high-efficiency cogeneration. The report also sets out information pertaining to heat policy development in the UK. Due to the low resolution of the data, the results of the NCA can be considered as an overview only.

Table 2 details the heat consumption in 2012 and estimated consumption in 2025 by sector for the South East of the UK as extracted from the NCA. Heat consumption is greatest in the industrial and residential sectors. Heat demand from the industrial and residential sectors is above the national average. The estimated heat consumption in 2025 is lower than in 2012, most notably in the residential sector. The energy projections take account of climate change policies where funding has been agreed and where decisions on policy design are sufficiently advanced to allow robust estimates of policy impacts to be made, including measures such as building regulations.

Table 2: Heat consumption in the South East of the UK

Sector	2012 consumption (TWh/annum)	2025 consumption (TWh/annum)
Industry (including agriculture)	13	12
Commercial services	3	3
Public sector	2	2
Residential	41	36
Total	**63**	**53**

Source: National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK, Ricardo AEA, December 2015

Current and projected space cooling consumption data detailed in Table 3. Given the paucity of available data on energy consumption for cooling, these figures are estimates based on consumption indicators, building types and floor areas; consequently, they should be considered as indicative.

[3] National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK, Ricardo AEA, December 2015

Table 3: Cooling consumption in the South East of the UK

Sector	2012 consumption (TWh/annum)	2025 consumption (TWh/annum)
Industry (including agriculture)	10	10
Commercial services	3	3
Public sector	1	1
Total	**15**	**13**

Source: National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK, Ricardo AEA, December 2015

It is assumed that the apparent discrepancy in the figures is due to rounding errors. It is not possible to verify this as access to the underlying data is not available.

5.1.2 UK CHP Development Map

The Department for Business, Energy and Industrial Strategy (BEIS) UK CHP Development Map[4] geographically represents heat demand across various sectors in England, Scotland, Wales and Northern Ireland. A search of heat users within 15 km of the Facility was carried out, as shown in Table 4. This is represented as coloured contour areas in Figure 3, with each colour band representing a range of heat demand density values.

The data returned considers the entire regional area into which the search area extends. If a search radius extends marginally into a particular region, the data for the entire region will be included in the results table so there is a possibility that the heat demand can be overestimated.

With the exception of public buildings, the heat map is produced entirely without access to the meter readings or energy bills of individual premises. Therefore, results should be taken as estimates only.

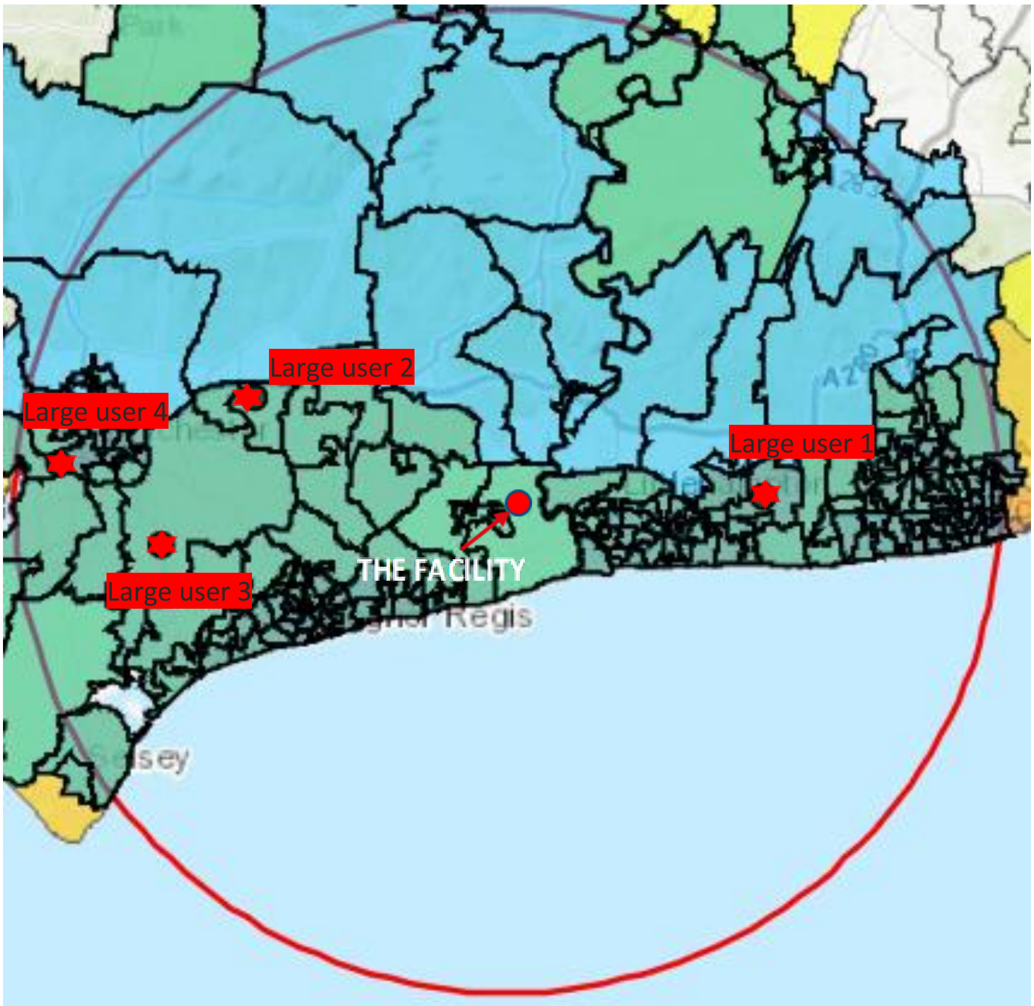
[4] http://chptools.decc.gov.uk/developmentmap/

Table 4: Heat demand within 15 km of the Facility

Sector	Heat demand	
	MWh/a	% share
Communications and Transport		0%
Commercial Offices	5,297	0.31%
Domestic	1,530,283	90.09%
Education		0%
Government Buildings		0%
Hotels		0%
Large Industrial	55,671	3.28%
Health		0%
Other		0%
Small Industrial	105,902	6.23%
Prisons		0%
Retail	467	0.03%
Sport and Leisure	970	0.06%
Warehouses		0%
District Heating		0%
Total heat load in area	**1,698,589**	**100%**

Source: UK CHP Development Map

Figure 3: Local heat demand density. Areas shaded in blue or green are considered within the 15 km. Areas in white/blue have no heat demand. Colour scales with heat demand, with areas in yellow/light green having the lowest demands and areas in red/dark green having the highest



Source: UK CHP Development Map

The heat demand in the area surrounding the Facility is predominantly from the domestic sector and industrial sectors and to a lesser extent, the retail sector. In most cases, existing domestic buildings are unsuitable for inclusion in a heat network as a result of the prohibitive costs of replacing existing heating infrastructure and connecting multiple smaller heat consumers to a network. In order to secure the most economically viable heat network, Fichtner has attempted to identify consumers that will provide maximum return and carbon saving for the minimum cost. Therefore, the approach to this study has focused on industrial and commercial consumers and new developments within the search radius.

Sections 5.1.3 to 5.1.4 identify potential heat users that would provide maximum return and carbon saving.

5.1.3 Large Heat Consumers

Four large heat consumers (point heat demands greater than 5 MW_{th}) were identified within 15km of the Proposed Development using the BEIS UK CHP Development Map[5] tool, as shown as shown in detailed in Table 5 and Figure 3.

It is noted that there are other potential heat users in the local area such as the Binsted Nurseries and Eric Wall Ltd. These are understood to have an individual heat demand of less than 5 MWth and therefore have not been considered within the assessment at this time. However, these potential heat users will be considered in any future heat export opportunities.

Table 5: Large Heat Consumers

Site	Heat demand (MWh/annum)	Distance from the Facility (km)	Postcode
Unknown operator	22,922	8.3 km radius	BN16 4AX
Tangmere Airfield Nurseries Ltd	37,830	8.9 km radius	PO20 2FT
Unknown operator	32,052	11.3 km radius	PO20 1PU
Unknown operator	28,126	14.6 km radius	PO19 8TX

The location of the large heat consumers identified is at a distance that would require a prohibitively costly pipe network to connect. Physical constraints imposed by the local infrastructure and topography have a significant impact on which loads can viably be connected. River and rail crossings are technically challenging and may obstruct the most direct route to the consumers. Connecting the large heat users to a heat network from the Facility would require river and rail crossings. The pipe would also have to be routed around the small towns. This would increase the length of pipe required and consequently increase the cost of the network. The large heat consumers are likely to be steam-users and this adds significantly to the technical challenges of supplying heat. Therefore, these large heat users have been discounted. However, in the future the feasibility of this option should be investigated, when there is more certainty in heat loads.

5.1.4 Visual Assessment

From a review of satellite imagery and aerial photography, additional smaller potential heat consumers have been identified in the area surrounding the Facility and are listed in Table 6. The locations of these heat consumers relative to the Facility are shown in Appendix A. Connecting these users would not require rail, river or major road crossing and there would be no disruption to residential areas.

A list of potential heat consumers identified within 15 km of the Facility, applying engineering judgement to screen out unfavourable routes, is provided in Table 6. The list includes HMP Ford Prison and the Rudford Industrial Estate at the south of the Facility. It is likely that more heat users would be identified at the detailed design phase. The following have been discounted due to their limited heat demand:

- Southern Water Services Limited;
- Ford Materials Recycling Facility;
- Flying Fortress and Arun Sports Arena;

[5] http://chptools.decc.gov.uk/developmentmap/

- Ford Airfield Industrial Estate;
- Bleach of Lavant Ltd;
- Ford Lane Business Park; and
- Wickes Farmhouse.

There is a potential heat demand of approximately 30,652 MWh/year. Initial discussions have been held with HMP Ford to discuss the feasibility of agreeing to a potential heat export scheme. At this stage, heat users at the Rudford Industrial Estate have not been contacted. Until the relevant consents/authorisations have been granted which will enable the Facility to be constructed, and detailed design has been undertaken, the heat export conditions are not known, making it difficult for potential heat users to determine whether they would be interested in importing heat. When the relevant consents/authorisations have been granted and detailed design has been undertaken, potential heat users will be contacted. The potential user's heat consumption has been estimated using the method outlined in Section 5.2.

Table 6: Potential heat users – visual assessment

Map Reference	Business Name/Description	Category	Estimated heat load at point of use (MWh/a)
1	HMP Ford - Prison	Light industrial	24,568
2	Rudford Industrial Estate	Light industrial	6,084
	Total		**30,652**

5.1.5 The Landings development at Ford Airfield

A site "The Landings" at Ford Airfield has been allocated for residential mixed-use development in the Ford Parish Neighbourhood Plan and the Arun Local Plan[6]. The masterplan for the site makes provision for:

- 1,500 homes, including 450 affordable homes;
- employment land;
- a local centre / community hub including retail / commercial and community / leisure facilities;
- primary school and nursery;
- care home;
- public open space and sports facilities;
- reconfiguration of Ford market; and
- associated infrastructure, landscaping and ancillary works.

The Landings development is surrounding the Facility and would be an ideal potential user of heat from the Facility. The cost of exporting heat to nearby plots would be lower as less civil work is required to lay pipe over short distances and the development site can be designed to incorporate the required heat exchange equipment and back up boilers, reducing costly retrofit work. There is uncertainty over construction timescales, appearance, layout, landscaping and scale of the proposals as the planning application for the Landings development has not been approved. However, initial discussions have been held with the developer to highlight the opportunity of a potential heat export scheme.

[6] https://www.arun.gov.uk/download.cfm?doc=docm93jijm4n10651.pdf&ver=10604

An outline planning application is currently lodged and is under consideration by the planning authority (Arun District Council). As the application is outline only, and has not yet been approved, the proposals could be subject to change.

5.2 Estimated Overall Heat Load

Broad assumptions have been made regarding the estimated heat demand from potential heat consumers. Heat demands have been calculated based on benchmark figures from the Chartered Institution of Building Services Engineers (CIBSE) Guide F (Energy Efficiency in Buildings). This document provides good practice benchmark figures based on energy performance of existing buildings. In the CIBSE Guide, loads are expressed in terms of kWh per square metre of floor space per year of fossil fuel use (natural gas is typically assumed). Based on estimates of floor areas and an assessment of the development type, it is possible to estimate annual energy usage. Converting natural gas use to actual heat loads (which can be provided by a hot water distribution system) requires an assumption of gas-fired boiler efficiency; an efficiency of 85% is assumed, based on industry norms.

Based on this benchmark, the potential users identified in section 5.1.4 have a total annual heat consumption of 30,652 MWh/annum.

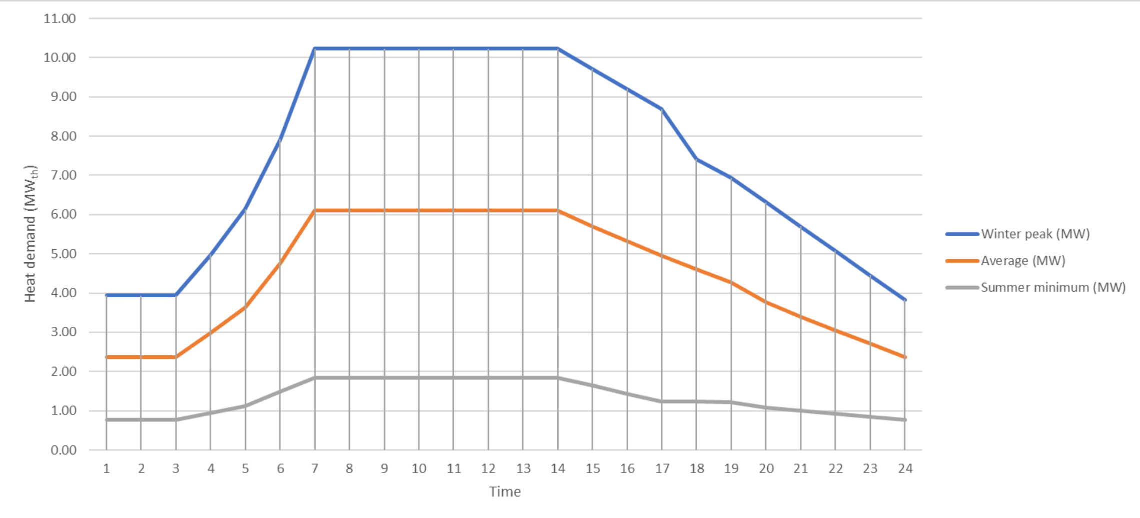
6 Heat Network Technical Solution

6.1 Heat Network Profile

A generic heat demand profile has been developed to model the seasonal and diurnal variation in heat demand for the potential 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 network profile for the proposed heat network is shown in Figure 4 and illustrates the 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: 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 a diversity factor of 0.90 has been assumed, in accordance with CIBSE AM12[7].

The total annual heat export, and projected average and peak instantaneous network values are presented in Table 7.

Table 7: Proposed heat network demand

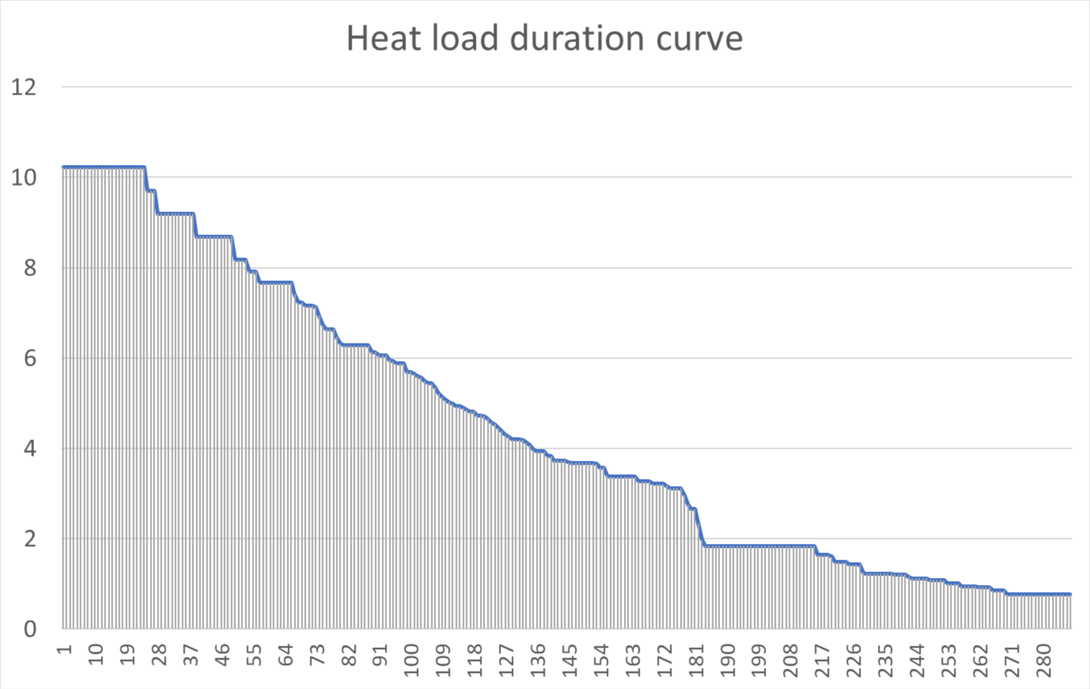
Annual Heat Load (MWh/a)		Average heat demand (MW_{th})		Peak heat demand (MW_{th})	
At the point of use	Including pipe losses (at the Facility boundary)	At the point of use	Including pipe losses (at the Facility boundary)	diversified	diversified + pipe losses (at the Facility boundary)
30,652	31,189	3.50	3.56	9.20	9.26

[7] CIBSE AM12 Combined Heat and Power for Buildings, 2013

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, producing a total of 288 data points (24 hours/day x 12 months/year). This demand data does not account for diversity or heat losses.

Figure 5: Heat load duration curve



6.2 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 pipe work 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 8 have been selected on the basis of the likely requirements of identified consumers.

Table 8: 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 DN20 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 the difference between the flow and return temperatures (ΔT) remains constant, it will be possible to reduce the flow temperature without impacting the pipe size and thereby reduce system energy losses.

6.3 Additional Heat Sources

To maximise the benefits associated with developing a CHP scheme, a review potential heat sources in the area surrounding the Facility has been undertaken, which could increase the capacity of the heat network and associated benefits. However, there is no additional heat sources identified in the area surrounding the Facility.

6.4 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. Therefore, there is a need, somewhere within the heat distribution system, to provide a back-up source of heat to meet the needs of the heat consumers.

With the scale of the proposed heat network, 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 the existing heat consumers were to have existing heating/cooling infrastructure, 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 the heat demand profile of heat users if 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 8.3.

6.5 Considerations for Pipe Route

At the present time, no definitive fixed route has been established for connections from the Facility to the 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 planning permission and an Environmental Permit 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.

Discussion with the potential heat users will be entered into which, if successful, would lead into the production of heat supply agreement and designs for the pipework. A full economic analysis will 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 Planning Permission and Environmental Permit being granted for the Facility it will be difficult to obtain firm commitments for the demand of heat from the Facility.

7 R1 Calculation

The European Commission Waste Framework Directive (WFD), has to be applied by all Member States. In this Directive, incineration facilities for municipal solid waste (MSW) can be regarded as “Recovery” operations if the energy efficiency of the plant is greater than 0.65 (for plants permitted after January 2009). Plants which do not meet this criterion are classed as “Disposal” operations and therefore lie on the same hierarchical level as landfill.

The definition of energy efficiency used in the revised Directive is:

$$\text{Energy Efficiency} = \frac{\left(E_p - \left(E_f + E_i\right)\right)}{\left(0.97 \times \left(E_w + E_f\right)\right)}$$

where:

- E_p means annual energy produced as heat or electricity. It is calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1 (units of GJ/yr)
- E_f means annual energy input to the system from fuels contributing to the production of steam (units of GJ/yr)
- E_w means annual energy contained in the treated waste calculated using the lower calorific value of the waste (units of GJ/yr)
- E_i means annual energy imported excluding Ew and Ef (units of GJ/yr)
- 0.97 is a factor accounting for energy losses due to bottom ash and radiation.

The interpretation of the R1 formula has proved to be difficult. Accordingly, the European Commission set up an expert panel to discuss this. The panel has prepared a guidance note “for the use of the R1 energy efficiency formula for incineration facilities dedicated to the processing of Municipal Solid Waste”, which has now been adopted by the European Commission. The EA has stated in guidance that this guidance should be applied in England and Wales.

Therefore, the formula, interpreted in accordance with the guidance, has been used to assess the energy efficiency of the Facility. The calculation is based on predicted design figures and predicted levels of fuel consumption and electricity usage.

The R1 efficiency is calculated as 0.83 without any heat export. With 3.56 MW_{th} heat export to the identified heat users which is the average heat demand required by the identified heat users (see Section 5), the R1 efficiency is found to be 0.86. Both scenarios are above the threshold for new incineration plants. Therefore, the Facility will meet the definition of recovery with or without any heat export. The calculation is presented in Appendix D.

8 Heat Network Economic Assessment

8.1 Fiscal Support

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

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. The Capacity Market does not prioritise low-carbon energy or specific technologies. Capacity Agreements are awarded in a competitive auction and new plants (such as the Facility) are eligible for contracts lasting up to 15 years.

   The Capacity Market was suspended in November 2018 following a ruling by the European Court of Justice that it constitutes illegal state aid[8]. However, following analysis of the mechanism, the Capacity Market was reinstated by the European Commission in October 2019. The mechanism is expected to operate in a similar manner as prior to the suspension, with the inclusion of a number of improvements proposed by National Grid, which are yet to be finalised.

   Based on eligibility criteria prior to the suspension, the Facility will be eligible for Capacity Market support. Since Capacity Market 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.

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 2021. 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.

3. **Contracts for Difference**

   Contracts for Difference (CfD) has replaced the Renewables Obligation (RO) as the mechanism by which the Government supports low carbon power generation. CfD de-risks investing in low carbon generation projects by guaranteeing a fixed price (the Strike Price) for electricity over a 15 year period. In the second CfD allocation round (executed on 11 September 2017) no funding was allocated for Energy from Waste plants, with or without CHP, on the basis that these are now considered established technologies. The third allocation[9] round was executed in September 2019 with contracts awarded to eligible less established technologies only[10]. The Facility previously bid for CfD as a gasifier, as a less established technology. However, this was unsuccessful and the design of the combustion plant has subsequently been changed to a conventional moving grate incineration technology. On this basis, the Facility would not receive support under the CfD mechanism.

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[8] https://www.gov.uk/government/collections/electricity-market-reform-capacity-market

[9] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/832924/Contracts_for_Difference_CfD_Allocation_Round_3_Results.pdf

[10] https://www.gov.uk/government/collections/contracts-for-difference-cfd-third-allocation-round

4. **Heat Network Investment Project funding**

   The Heat Network Investment Project (HNIP) aims to deliver carbon savings and create a self-sustaining heat network market through the provision of subsidies, in the form of grants and loans, for heat network projects. £320 million has been made available to fund the HNIP between 2019 and 2022. Following a pilot scheme, which ran from October 2016 to March 2017, the Department for Business, Energy and Industrial Strategy (BEIS) has confirmed that funding will be available for both public and private sector applicants, and that there will be no constraints on scheme size.

   The HNIP may be a source of funding that would improve the economic viability of the heat network. The level of funding that the Facility could achieve under this program would depend on the final size of the network and commercial arrangements.

   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 would not serve to support project delivery.

8.2 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 6.2). 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 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 detailed in Section 6.4) 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 saving (PES) is calculated in the following section.

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. Design capacity of 275,000 tonnes per annum (at the design capacity of 32.5 tph with an NCV of 10.5 MJ/kg and an availability of approximately 8,500 hours).
2. Average gross electrical output (expected capacity in fully condensing mode with average ambient air temperature) of 31.2 MW_e.
3. Parasitic load of 3.1 MW_e.

4. Z ratio of 6.85.
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[11].

When operating in fully condensing mode (i.e. without heat export) the Facility will achieve a PES of 24.05 %. 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 25.46 %. On this basis, the Facility will qualify as a high-efficiency cogeneration operation when operating in CHP mode.

8.3 Results of CBA

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 CHP Feasibility Report.

The CBA model considers:

1. the revenue streams (heat sales);
2. the costs 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 (electricity sales and fiscal benefits).

The following assumptions have been made:

1. The DH scheme will commence operation in 2029.
2. The heat export infrastructure required to export heat from the Facility to the consumers identified is estimated to have a capital cost of approximately £3.6 million, split over a three-year construction programme.
3. The heat station will cost approximately £1.1 million, split over a three-year construction programme.
4. Back-up boilers will be provided to meet the peak heat demand, at a cost of approximately £1.2 million.
5. Operational costs have been estimated based on similar sized projects.
6. Heat sales revenue will be £40 / MWh[12], index linked for inflation.
7. Electricity sales revenue will be £45 / MWh[13], index linked for inflation.
8. Standby boiler fuel costs will be £23 / MWh[14], index linked for inflation.
9. Standby boiler(s) will supply 1.15% of annual heat exported.

The results of the CBA indicate that both the nominal project internal rate of return (IRR) and net present value (NPV) (before financing and tax) over 30 years are 17.3 % and £0.09 million,

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

[12] Typical price for this type of DH network.

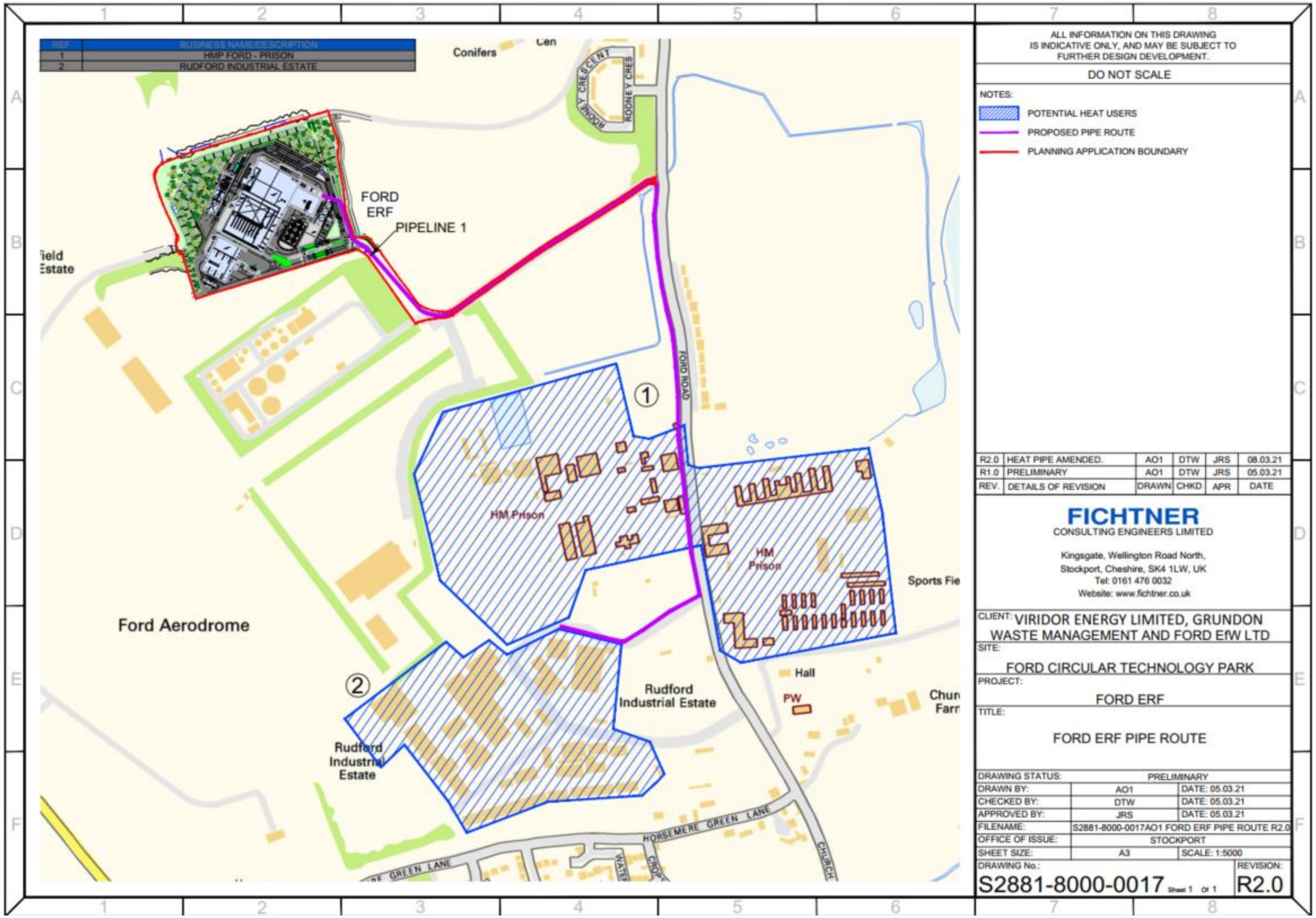
[13] This is based on the data from the Department for Business, Energy & Industrial Strategy website https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018

[14] This is based on the data from the Department for Business, Energy & Industrial Strategy website https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018

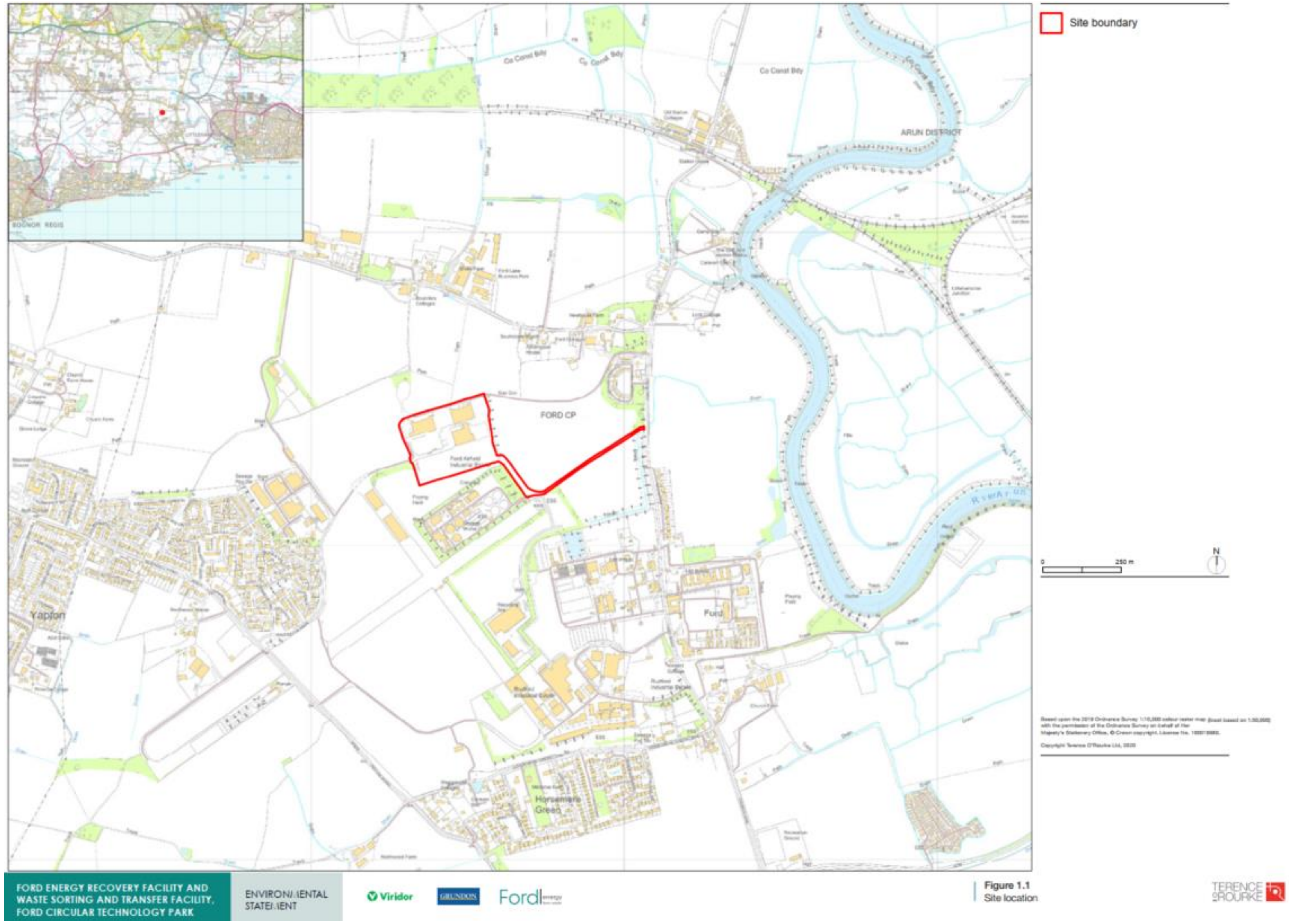
respectively. Therefore, it is considered that the proposed heat network yields an economically viable scheme in its current configuration. The economic case may improve further with HNIP funding. Model inputs and key outputs are presented in Appendix C.

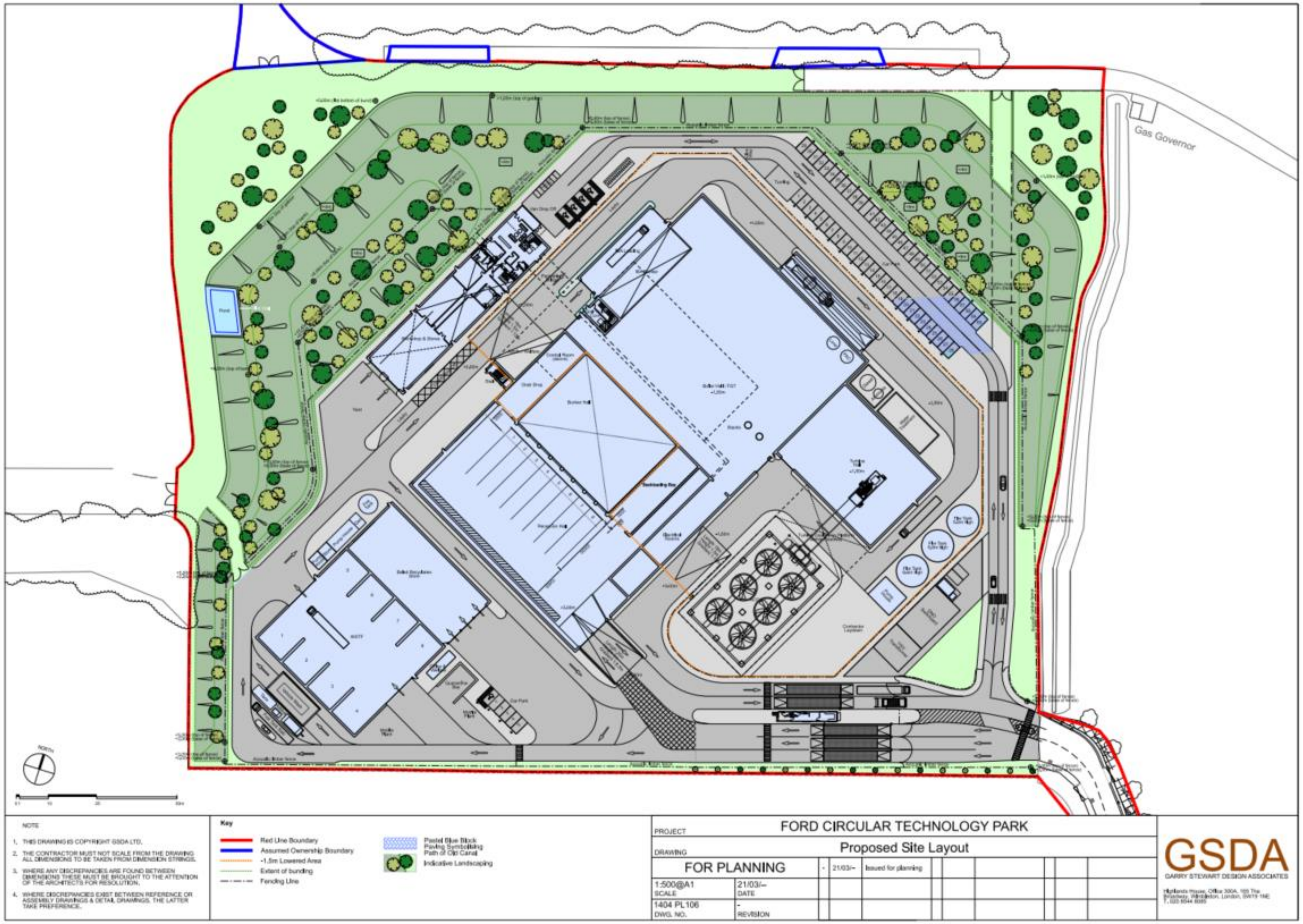
Appendices

A Pipe route and heat users



B Site Location and Layout Drawings




Gas Governor
NOTE
1. THIS DRAWING IS COPYRIGHT GSDA LTD.
2. THE CONTRACTOR MUST NOT SCALE FROM THE DRAWING ALL DIMENSIONS TO BE TAKEN FROM DIMENSION STRINGS.
3. WHERE ANY DISCREPANCIES ARE FOUND BETWEEN DIMENSIONS THESE MUST BE BROUGHT TO THE ATTENTION OF THE ARCHITECTS FOR RESOLUTION.
4. WHERE DISCREPANCIES EXIST BETWEEN REFERENCE OR ASSEMBLY DRAWINGS & DETAIL DRAWINGS, THE LATTER TAKE PREFERENCE.
Key
Red Line Boundary
Assumed Ownership Boundary
-1.5m Lowered Area
Extent of bunding
Fencing Line
Pastel Blue Block Paving Symbolising Path of Old Canal
Indicative Landscaping
PROJECT
FORD CIRCULAR TECHNOLOGY PARK
DRAWING
Proposed Site Layout
FOR PLANNING
- 21/03/- Issued for planning
1:500@A1
SCALE
21/03/–
DATE
1404 PL106
DWG. NO.
-
REVISION
GSDA
GARRY STEWART DESIGN ASSOCIATES

C 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)	1.544
Peak heat demand from Heat User(s) (MWth)	9.26
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	Value	% 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	
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)	3					
Number of years to build			3	3	3	0
		% (ONLY IF APPLICABLE)	£m	£m	£m	£m
Year 1 costs (£m) and build up of operating costs and revenues (%)		0%	1.193110199	0.368594133	0.412447667	
Year 2 costs (£m) and build up of operating costs and revenues (%)		0%	1.193110199	0.368594133	0.412447667	
Year 3 costs (£m) and build up of operating costs and revenues (%)		0%	1.193110199	0.368594133	0.412447667	
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)	0.0
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)	0.1
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)	49.95	49.95				
Annual quantity of heat supplied from the Heat Source(s) to Heat User(s) at steady state (MWh)	31,189	31,189				
Equivalent heat sales if first year of operations is steady state (£ m)	1.6					
Heat sale price inflation from first year of operations (full or partial) (% per year)	2.0%	2.0%				
Percentage of heat supplied by Standby Boiler (if relevant)	1%	1%				
'Lost' electricity sale price (£/ MWh) at first year of operations	56.20	56.20				
Z-ratio (commonly in the range 3.5 - 8.5)	6.85	6.85				
Power generation lost at steady state (MWh)	4,501	4,501				
Equivalent 'lost' revenue from power generation if first year of operations is steady state (£ m)	0.25					
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					
Industrial CHP electrical generation in steady state (MWh)	0					
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%					
Fuel price for larger power generator/ CHP at first year of operations (full or partial) (£ / MWh)	0.00					
Z-ratio (commonly in the range 3.5 - 8.5)	0					
Power efficiency in cogeneration mode (%)	0					
Additional fuel required per year for larger power generator / CHP in steady state (MWh)	0		#DIV/0!			
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%					
Fuel price for Standby Boiler at first year of operations (£ / MWh)	29.22	29.22				
Boiler efficiency of Standby Boiler (%)	80%	80%	80%	80%		
Additional fuel required per year for Standby Boiler in steady state (MWh)	448	448	-	-		
Equivalent additional fuel costs if first year of operations is steady state (£m)	0.01					
Fuel price inflation for Standby Boiler from first year of operations (full or partial) (% per year)	2.00%	2.0%				
Heat purchase price (£/ MWh) at first year of operations (partial or full)	0.00					
Annual quantity of heat supplied from the Heat Source(s) to Heat User(s) at steady state (MWh)	0					
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%					
Fuel price (£ / MWh) at first year of operations (partial or full)	0.00					
Boiler efficiency of district heating plant	0%					80%
Fuel avoided per year in steady state (MWh)	0					-
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				
Fiscal benefits inflation rate from first year of opeations (full or partial) (%) **	0.0%					

* 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 required.

** 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 33 years	17.3%
Nominal NPV (before financing and tax) (£m) over 33 years	0.09

D R1 Calculation

Table 9: Waste Framework Directive energy efficiency calculation

R1 formula	**No heat export**	**3.56 MW heat export**	
Number of streams	1	1	-
Average through-life availability	96.59%	96.59%	%
Equivalent full load operating hours per year	8,461	8,461	h/y
Feed stock calculations			
Waste throughput per boiler	32.50	32.50	tph
Waste NCV	10.50	10.50	MJ/kg
Waste throughput	274,983	274,983	t/y
Waste Energy input	94.79	94.79	MW
Waste Energy input	802,032	802,032	MWh/y
Waste Energy input	2,887,316	2,887,316	GJ/y
Electric exported			
Gross electricity production	31.20	30.68	MW
Gross electrical efficiency	32.91%	32.37%	
Total electricity produced	263,983	259,586	MWh/y
Total electricity produced	950,340	934,509	GJ/y
Parasitic load	3,100	3,100	kW
Parasitic load	26,229	26,229	MWh/y
Parasitic load	94,425	94,425	GJ/y
Net electrical output	28.10	27.58	MW
Net electrical efficiency	29.64%	29.10%	
Heat exported			
Heat exported	-	3.56	MWh/h
Heat efficiency	-	3.76%	
Heat exported	-	30,121	MWh/y
Heat exported	-	108,436	GJ/y
Heat used internally (a)			

R1 formula	No heat export	3.56 MW heat export	
For steam driven turbo pumps for boiler water, backflow as steam	-	-	MWh/y
For heating of flue gas with steam, backflow as condensate	-	-	MWh/y
For concentration of liquid APC residues with steam, backflow as condensate	-	-	MWh/y
For sootblowing without backflow as steam or condensate	-	-	MWh/y
For heating purposes of buildings/instruments/silos, backflow as condensate	-	-	MWh/y
For deaeration - demineralization with condensate as boiler water input	-	-	MWh/y
For ammonia injection without backflow as steam or condensate	-	-	MWh/y
Heat used internally	-	-	MWh/y
Heat used internally	-	-	GJ/y
Total heat produced			
Total heat produced	-	30,121	MWh/y
Total heat produced	-	108,436	GJ/y
Fuel used			
Auxiliary Burner capacity	60%	60%	
Auxiliary Burner capacity per stream	56.88	56.88	MW
Average auxiliary burner duty during start up	50%	50%	
Number of start ups per year per stream	10	10	
Start up time	17	17	hrs
Annual time for start ups	170	170	hrs/y
Total Fuel consumed	4,834	4,834	MWh/y
Energy in fuel consumed by start-up burners	17,404	17,404	GJ/y
Electricity imported			
Electricity consumption during start-up per steam	2,170	2,170	kW
Electricity imported	369	369	MWh/y
Electricity imported	1,328	1,328	GJ/y

R1 formula	No heat export	3.56 MW heat export	
WFD Calculation			
E_w	2,887,316	2,887,316	GJ/y
E_p (electricity)	2,347,339	2,308,238	GJ/y
E_p (heat)	-	119,280	GJ/y
E_p total (electricity + heat)	2,347,339	2,427,518	GJ/y
E_f (1)	8,702	8,702	GJ/y
E_i (electricity)	3,453	3,453	GJ/y
E_i (heat)(2)	8,702	8,702	GJ/y
E_i total (electricity + heat)	12,155	12,155	GJ/y
WFD ratio			
WFD ratio	0.83	0.86	-
Pass or fail?	pass	pass	-
Climate Change Factor			
Heating Degree Days	3,350	3,350	
Old Plant or New Plant	New	New	
CCF	1.000	1.000	
Adjusted WFD ratio	**0.83**	**0.86**	
Pass or fail?	**pass**	**pass**	

1. 0.95 of reduction factor is assumed. If the input data is based on a single design point, a reduction factor of 0.95 is used to include partial load operation, boiler fouling and high air temperature during the summer.
2. assumes only 50% of fossil fuel used by start-up burners generates steam and includes the 50% of fuel energy not contributing to steam generation.

ENGINEERING CONSULTING

FICHTNER

Consulting Engineers Limited

Kingsgate (Floor 3), Wellington Road North,
Stockport, Cheshire, SK4 1LW,
United Kingdom

t: +44 (0)161 476 0032
f: +44 (0)161 474 0618

www.fichtner.co.uk