Combined Heat and Power (CHP) Assessment

Wheelabrator Kemsley (K3 Generating Station) and Wheelabrator Kemsley North (WKN) Waste to Energy facility Development Consent Order

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K3 Expansion and WKN

Wheelabrator

CHP Assessment

ENGINEERING CONSULTING

Document approval

	Name	Signature	Position	Date
Prepared by:	Vildan Taylor		Associate Senior Consultant	29/08/2019
Checked by:	Nigel Garrod		Principal Consultant	29/08/2019

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Management Summary

Wheelabrator Technologies Inc (WTI) is constructing the Wheelabrator Kemsley (K3) Waste to Energy (WtE) Combined Heat and Power (CHP) Facility, located at Kemsley in Kent. Commissioning and operational takeover of K3 is scheduled for Q4 2019. K3 will be able to process 550,000 tonnes of municipal, commercial and industrial waste per annum, generating up to 49.9 MW_e (gross) of electricity, and will export steam to the adjacent DS Smith Kemsley Paper Mill. K3 is designed and configured only for steam export and it cannot contribute to any future district heating scheme.

WTI has identified that K3 is capable of an increased electrical generation capacity of up to 75 MW_e, through internal upgrade works, and is also capable of having an increased annual throughput of up to 657,000 tonnes per annum. Notwithstanding the fact that K3 is already being built, in order to properly categorise and consent K3 to its increased generation capacity and tonnage throughput an application has been submitted to the Secretary of State, via the Planning Inspectorate, which seeks consent for the construction and operation of K3 to a generating capacity of 75 MW_e and with an annual tonnage throughput of 657,000 tonnes.

WTI also proposes to secure consent to construct a second WtE facility at the development site, Wheelabrator Kemsley North (WKN). WKN will be designed to process annual nominal basethroughput of 351,452 tonnes of municipal, commercial and industrial waste per annum, generating up to 42 MW_e (gross) of electricity, with the potential capability to export steam to the Kemsley Paper Mill, via K3, when K3 is offline. WKN will have a maximum capacity of 390,000 tonnes per annum; however, for the purposes of this report it has been assumed that the WKN will operate at the nominal design capacity.

The export of steam from the permitted K3 when it is brought online will provide an additional source of steam to the Paper Mill. This will replace some of the gas used in an existing gas turbine CHP facility (K1) which is currently required to meet the Paper Mill steam demands. K1 is a more carbon intensive steam source than K3. WKN will further replace some of the gas used in K1, when K3 is offline. WTI therefore will contribute towards maximising the carbon savings for the Paper Mill.

WTI will be making one application to the Secretary of State, via the Planning Inspectorate, for a single Development Consent Order which if granted would give consent for the construction and operation of K3 to its upgraded power generation capacity and with an increased tonnage throughput and for the construction and operation of WKN. Fichtner has been commissioned by WTI to prepare a Combined Heat and Power (CHP) Assessment (herein 'this report') to demonstrate that the supply of additional heat from WKN above supplying Kemsley Paper Mill has been taken into consideration and to confirm its technical and economic feasibility.

WKN will be a CHP facility as it will export steam to the Kemsley Paper Mill, via K3, at an average of 51.9 MW_{th} for approximately 560 hours per year when K3 is offline. This report investigates the additional off-site heat users within 10 km of WKN. Following screening of potential heat consumers over and above the steam export to the paper mill, it has been established that technically feasible opportunities exist to export an annual average heat load of up to 6.5 MW_{th}, and when accounting for consumer diversity, a peak load of 18.6 MW_{th}.

The Environment Agency (EA) requires Environmental Permit applications to demonstrate Best Available Techniques (BAT) for a number of criteria, including energy efficiency. One of the principal ways of improving energy efficiency is through the use of CHP.

A CHP Ready plant is one which is fully capable of exporting heat, with all required on site infrastructure in place. The EA considers this approach Best Available Technique (BAT) for energy efficiency in circumstances where there are technically and economically viable opportunities for the supply of heat from the outset. WKN will already be operating as a CHP from outset to supply steam to Kemsley Paper Mill, via K3, as a minimum. This CHP Assessment has been carried out to demonstrate that WKN is designed to be ready, with minimum modification, to supply additional heat in the future over and above the steam export to the paper mill. WKN therefore exceeds the requirement for 'CHP ready' (i.e. developed with infrastructure in place).

Furthermore, this report demonstrates some of the benefits of operating WKN in CHP mode. WKN already achieves Primary Energy Savings (PES) of 25.6 %, which is in excess of the 10 % technical feasibility threshold in fully condensing (electricity only) mode. Steam export to Kemsley Paper Mill further increases the PES to 25.9 %. Further inclusion of the identified DH network together with steam export to Kemsley Paper Mill increase PES to 28.22 %. Consequently, WKN would always qualify as a high efficiency cogeneration operation when operating in CHP mode, exceeding the Primary Energy Savings threshold of 10 % defined in the draft Article 14 guidance of the Energy Efficiency Directive.

The permitted K3 achieves PES of 27.83 % when operating in normal operating conditions in CHP mode which is in excess of the technical feasibility threshold defined in the draft Article 14 guidance. When operating to its increased 75 MW_e generating capacity K3 would achieve a PES of 26.26 % which is in excess of the technical feasibility threshold.

Under 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). The costs and revenues associated with the construction and operation of the proposed heating network, in the absence of steam export to the paper mill, 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 33 years are 2.8 % and -£14.79 million respectively. Therefore, it is considered that the proposed heat network does not yield an economically viable scheme in its current configuration, but this will be reassessed in the future when there is more certainty over heat loads and considering any subsidies that might be available at that time that support the export of heat.

In summary, WKN will already be built as a CHP facility from outset to supply steam, via K3, at an average of 52 MW_{th} for approximately 560 hours to the Kemsley Paper Mill, when K3 is offline. WKN will be further CHP Ready to allow additional heat export opportunities in the future and include all the on-site infrastructure necessary to connect to a heat distribution network with minimum modification, by virtue of steam capacity designed into the turbine bleeds and safeguarded space within the turbine hall to house CHP equipment. WTI is committed to pursuing additional heat export opportunities by contacting potential heat users and undertaking further development work.

Contents

1 Conclusions

1.1 Technical Solution

In practical terms WTI is proposing to increase electrical export of K3 from its consented 49.9 MW_e to a generation capacity of up to 75 MW_e and increase the throughput from its consented 550,000 tonnes of waste per annum to 657,000 tonnes per annum. WTI also proposes to secure consent to construct a second EfW facility at the development site, Wheelabrator Kemsley North (WKN).

In fully condensing mode, WKN will generate up to 42 MW_e with 38.4 MW_e exported to the local distribution network. A dedicated heat supply system, nominally 51.9 MW_{th} of steam at 11.3 bar(a) + 1 bar, will be supplied to the Kemsley Paper Mill, via K3, when K3 is offline. WKN will therefore be built as CHP from the outset, but the Applicant has identified an opportunity to maximise the benefits associated with heat export by considering a district heating (DH) scheme.

Subject to technical and economic feasibility, a DH scheme will be included to export up to 18.6 MW_{th} of heat to offsite consumers. Based on the heat network identified within this report, the annual average heat load is expected to be 6.5 MW_{th}, resulting in an electrical export capacity of 37.41 MW_e.

The most likely solution for implementing a DH network would be to transfer heat to a closed hot water circuit via a series of condensing heat exchangers. It is typical to supply hot water to consumers through a pre-insulated buried pipeline, before being returned to the plant for reheating. This technology is well proven and highly efficient.

1.2 Heat Demand Investigation

A review of the potential DH heat demand within a 10km radius of WKN has been undertaken in accordance with the requirements set out in Section 4 of the EA's CHP Ready Guidance. The approach to identifying existing heat demands has centred on industrial and commercial users, as the benefits of providing heat to large premises is generally more financially viable than supply to multiple smaller consumers.

Heat consumers have been identified using publicly available data in the National Comprehensive Assessment, heat mapping tools and satellite imagery.

Existing housing stock has not been considered as a potential heat consumer at this stage of the assessment because capital costs are typically excessive and may unfairly skew the financial payback period. No heat supply agreements have been arranged at this stage of the development process.

One large heat consumer (point heat demands greater than 5 MW_{th} as defined by the UK CHP Development Map) was identified within the specified 10 km search radius. The large consumer was within a 6 km radius of WKN that would require a prohibitively costly pipe network to connect. Therefore, this large heat user has been discounted.

1.3 Heat Network Profile

Based on publicly available development proposals, we have estimated the heat demand of the preferred heat consumers. A heat demand profile has been developed to model the seasonal and diurnal variation of the proposed DH network. Accounting for network heat losses and diversity, a heat demand of 56,889 MWh/annum is projected, equating to an average and peak demand of 6.5 MW_{th} and 18.6 MW_{th} respectively.

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 WKN independently, except for periods of downtime when a back-up system will be required. Detailed techno-economic modelling should be undertaken when there is more certainty over consumer heat demands.

1.4 Economic Assessment

We have assessed the costs and revenues associated with the construction and operation of the proposed DH network and input these values into the cost benefit analysis (CBA) template provided by the EA. 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.

The results of the CBA indicate that the estimated circa £25.7 million capital investment will be marginally offset by heat sales revenue. However, the project will require significant de-risking before an investment decision can be made. The nominal project internal rate of return (before financing and tax) over 33 years is projected as 2.8 %, with a net present value of -£14.79 million.

As construction of a district heating network is currently not economically feasible, WKN will be built to be CHP-Ready, discounting the planned steam supply to the adjacent paper mill. As such, WKN will meet the requirements of BAT tests outlined in EA CHP Ready Guidance.

1.5 Energy Efficiency Measures

In order to qualify as high-efficiency cogeneration as defined in the Energy Efficiency Directive (EED), the scheme must achieve at least 10% savings in primary energy usage (PES) compared to the separate generation of heat and power. WKN will already be built as a CHP facility from outset to supply steam to the Kemsley Paper Mill as a minimum. When operating in fully condensing mode (i.e. without heat export) WKN will achieve PES of 25.6 %, which is in excess of the technical feasibility threshold defined in the draft Article 14 guidance. Steam export with an annual average of 3.54 MW_{th} to Kemsley Paper Mill further increases the PES to 25.92 %. The inclusion of heat export at the design case level anticipated for the proposed DH network with an annual average of 6.54 MW_{th} increases PES to 27.64 %. The inclusion of an annual average heat export at 10.08 MW_{th}, including both proposed DH network at 6.54 MW_{th} and DS Smith Kemsley Mill steam supply at 3.54 MW_{th}, increases PES to 28.22%.

The permitted K3 achieves a PES of 27.83 % when operating in normal operating conditions in CHP mode which is in excess of the technical feasibility threshold defined in the draft Article 14 guidance. When operating to its increased 75 MW_e generating capacity K3 would achieve a PES of 26.26 % which is in excess of the technical feasibility threshold.

To be considered 'Good Quality' CHP under the CHPQA scheme, the quantity of heat exported to a heat network must be sufficient to achieve a Quality Index (QI) of at least 105 at the design stage (reducing to 100 at the operational stage). Recent changes to CHPQA guidance (released in December 2018) mean that the proposed heat network would achieve a QI of 67.19 for the Kemsley Paper Mill steam supply at the annual average load of 3.54 MW_{th}. WKN achieves a QI of 69.75 under the annual average heat load of 6.54 MW_{th} exported to the proposed DH network, excluding the steam export to Kemsley Mill. WKN will achieve a QI score of 71.46 for the combined annual average heat load exported to the proposed DH network and annual average steam exported to Kemsley Paper Mill. Therefore, the proposed total heat export scenario would not qualify as Good Quality

CHP. The highly onerous new efficiency criteria set out in the latest CHPQA guidance means that it is unlikely that any waste-to-energy plant will now reach “Good Quality” status.

The permitted K3 has certified as “Good Quality” CHP prior to the publication of this Guidance Note 44 (Issue 7). As the permitted K3 has entered Contracts for Difference contract prior to the publication of this Guidance Note 44 (Issue 7), the X and Y values used for the previous CHPQA certification will be grandfathered. Therefore, K3 will certified as “Good Quality” under the grandfathered X and Y values used for the previous CHPQA certification. The proposed upgraded K3 will also be a “Good Quality” CHP under grandfathered X and Y values.

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. The proposed DH network will achieve PES of 27.64 % and would therefore meet best practice metrics stipulated by the EU.

2 Introduction

2.1 Background

Wheelabrator Technologies Inc (WTI) is constructing Wheelabrator Kemsley (K3) Waste-to-Energy (WtE) CHP Facility, located at Kemsley in Kent. Commissioning and operational takeover of K3 is scheduled for Q4 2019. K3 will be able to process 550,000 tonnes of municipal, commercial and industrial waste per annum, generating up to 49.9 MW_e (gross) of electricity, and export steam to the adjacent DS Smith Kemsley Paper Mill.

WTI has identified that K3 is capable of an increased electrical export capacity of up to 75 MW_e, through internal upgrade works, and is also capable of having an increased annual throughput of up to 657,000 tonnes per annum. Notwithstanding the fact that K3 is already being built, in order to properly categorise and consent K3 to its increased generation capacity and tonnage throughput an application has been submitted to the Secretary of State, via the Planning Inspectorate, which seeks consent for the construction and operation of K3 to a generating capacity of 75 MW_e and with an annual tonnage throughput of 657,000 tonnes.

WTI also proposes to secure consent to construct a second WtE facility at the development site, Wheelabrator Kemsley North (WKN). WKN will be designed to process annual nominal throughput of 351,452 tonnes of municipal, commercial and industrial waste per annum, generating up to 42 MW_e (gross) of electricity, with the capability to export steam to the Kemsley Paper Mill, via K3, when K3 is offline. WKN will have a maximum capacity of 390,000 tonnes per annum; however, for the purposes of this report it has been assumed that the WKN will operate at the nominal design capacity.

The DS Smith Paper Mill is currently supplied with steam by one on-site facility, which is known as the “K1” facility. K1 primarily consists of a gas turbine (GT), two Waste Heat Recovery Boilers (WHRBs), a steam turbine (ST) and some package boilers. DS Smith Paper obtained a Development Consent Order in July 2019 for the “K4” facility; a 73 MW_e combined cycle generating station which would replace K1 and which will provide electricity and steam to the paper mill. Construction of K4 is expected to begin in late 2019.

The Planning Act 2008 states that the construction or extension of an on shore generating station of more than 50MW constitutes a ‘nationally significant infrastructure project’ (NSIP). In those cases an application for a Development Consent Order must be made to the Secretary of State, via the Planning Inspectorate, instead of an application for a planning permission. In order to properly categorise and consent the K3 proposals under the Planning Act 2008 consent will be sought for the construction and operation of the K3 facility to a generating capacity of up to 75 MW_e. The K3 proposal is therefore an NSIP by virtue of being the construction of an onshore generating station with a generating capacity of over 50MW.

WKN is not an NSIP as its generating capacity of 42MW is below the 50MW threshold. However, the Secretary of State has directed under S35 of the Planning Act 2008 that WKN is to be treated as a development for which Development Consent is required.

WTI will therefore be making one application to the Secretary of State, via the Planning Inspectorate, for a single Development Consent Order which if granted would give consent for the construction and operation of K3 to its increased generating capacity and with an increased annual tonnage throughput, and for the construction and operation of WKN.

Fichtner has been commissioned by the Applicant (WTI) to prepare a Combined Heat and Power (CHP) Assessment (herein 'this report') to demonstrate that the supply of heat from WKN has been taken into consideration and to confirm its technical and economic feasibility.

2.2 The Development Consent Order Process

The Applicant must submit a DCO application to the Planning Inspectorate (PINS), the government body responsible for operating the planning process for NSIPs, who decide whether to accept the application. If accepted, PINS will appoint an Examining Authority to examine the application. Following the examination, the Examining Authority will make a recommendation to the Secretary of State. The Secretary of State must determine the K3 element of the application in accordance with the relevant National Policy Statements (NPSs) for the Proposed Development which are: NPS EN-1 (Overarching Energy Policy), NPS EN-3 (Renewable Energy Supply from Waste) and NPS EN-5 (Electricity Networks Infrastructure). Those NPSs are material considerations in the determination of the WKN element of the application. If the Secretary of State decides to grant development consent then they will make a DCO which will authorise the construction, commissioning and operation of the Proposed Development.

2.3 The Applicant and Study Team

Wheelabrator Technologies Inc. ("the Applicant") is the second largest US waste-to-energy business and is an industry leader in the conversion of everyday municipal, commercial and industrial waste into clean energy. It has a platform of 23 power producing assets across the US and UK comprising 19 waste-to-energy facilities (three under construction), four independent power plants as well as four ash monofills and three transfer stations. The Applicant has an annual waste processing capacity of over 6.8 million tonnes and a total combined electric generating capacity of 853 megawatts.

The company's vision is 'To develop, deliver and realise the potential of clean energy' and defines Wheelabrator's ongoing commitment to the development of clean energy solutions for its customers and local communities.

For more information regarding the Applicant, please visit www.wtienergy.co.uk.

Preparation of this report has been undertaken by Fichtner Consulting Engineers Limited.

2.4 Purpose of this report

The purpose of this report is to demonstrate the CHP opportunity, benefits and feasibility of supplying heat from the Proposed Development to local heat consumers. This report responds to Section 4.6 of NPS EN-1 which requires applications for thermal generating stations, such as the proposed WKN, to consider CHP. The principal objectives of this report are as follows.

1. Provide an overview of the proposed technology, setting out options for additional heat recovery and export, and a justification of site selection.
2. Undertake a heat demand investigation to identify potential off-site heat users within 10km of the development site (as required under the EA's CHP-Ready Guidance) utilising heat mapping tools, satellite imagery, and the findings of any local CHP development strategy reports.
3. The results of the investigation will be used to establish a monthly seasonal heat demand profile and peak heat demand for a limited number of options based on the heat available and the demand of local consumers. Heat demand profiles will account for anticipated network heat losses and demand diversity. This approach will ensure that a robust assessment is delivered.

4. Develop an outline solution for the delivery of heat to the preferred heat consumer (Kemsley Paper Mill) and return of condensate. This will establish the technical feasibility of any options considered. The solution will include a provisional pipeline routing and equipment design, taking into account any known local engineering difficulties. Preliminary pipe sizing will be developed and take into account any reasonable opportunity for future network expansion. The provision of steam to K3 has already been developed via a steam supply Agreement and the necessary infrastructure developed. The only change is to enable the supply of steam from WKN to K3 to facilitate steam supply to DS Smith when K3 is either off line for planned maintenance and or periods of shutdown.
5. Based on this outline solution, review the site layout and take a view on the provision of space for heat export infrastructure. As part of developing the outline solution we will also consider back-up and peak lopping requirements to ensure a resilient solution is offered.
6. Based on the average heat loads anticipated for the outline solution identified, calculate energy efficiency measures to demonstrate legislative compliance, including:
   a. primary energy savings;
   b. Combined Heat and Power Quality Assurance (CHPQA) Quality Index; and
   c. heat, power and overall plant efficiency.
7. Based on the outcome of the technical assessments, carry out an economic assessment of the outline solution. The economic assessment will provide an internal rate of return (IRR) and net present value (NPV). The assessment will confirm if the outline solution is economically viable and will feed into the cost-benefit assessment as required under Article 14 of the Energy Efficiency Directive.
8. Produce a CHP-Ready Assessment as required under the EA CHP-Ready guidance, including a clear statement on best available technique (BAT), CHP envelope and the CHP-Ready Assessment form.

2.5 Project Description

The Proposed Development is described below:

Wheelabrator Kemsley - K3

Planning permission was granted for K3 in 2010 by Kent County Council under reference SW/10/444. As consented and being constructed K3 can process up to 550,000 tonnes of waste each year and has a generation capacity of 49.9 MW. K3 will export electricity to the grid and will supply steam to the DS Smith Kemsley Paper Mill. The construction of K3 began in 2016 and WTI anticipates it being operational in late 2019.

The current gross generating capacity of K3 is 49.9MW_e. Technical advances in design would allow K3 to generate up to 75 MW_e without any change to the design, shape or size of the facility. Separately, WTI has identified opportunities for K3 to process more waste through the plant having increased operational availability.

In order to properly categorise and consent the K3 proposals under the Planning Act 2008 consent will be sought for the construction and operation of the K3 facility to a total generating capacity of up to 75 MW_e and with a total tonnage throughput of 657,000 tonnes of waste per year. In practical terms consent is therefore being sought for the K3 facility, as currently being constructed, to generate an additional 25.1 MW and to process an additional 107,000 tonnes of waste.

Wheelabrator Kemsley North – WKN

WKN would be an entirely new and distinct waste-to-energy facility to the north of K3, which would be operated separately from K3. WKN would provide clean, sustainable electricity to power UK homes and businesses via the National Grid distribution network and would have the ability to export steam to the DS Smith Kemsley Paper Mill via K3 and additional steam to other users in the future.

WKN would have a gross generating capacity of $42MW_e$ and would be a self-contained and fully enclosed facility with its own reception hall, waste fuel bunker, boiler, flue gas treatment, turbine, air-cooled condensers, transformers, office accommodation, weighbridge, administration building, car parking and drainage. WKN would have its own grid connection to allow for the exporting of electricity to the national grid. WKN will be already a CHP facility which will export steam to the Kemsley Paper Mill, via K3 at an average of 51.9 MW_{th} for approximately 560 hours per year when K3 is offline. Any future district heating scheme will be in addition to steam export to the Paper Mill.

2.6 Structure of this report

This report is set out in the following format:

- Section 1: Conclusions;
- Section 2: Introduction;
- Section 3: Legislative Requirements;
- Section 4: Technology Description;
- Section 5: Heat Demand Investigation;
- Section 6: Economic Assessment;
- Section 7: Energy Efficiency Measures; and
- Section 8: EA CHP-Ready Guidance.

3 Legislation Requirements

3.1 CHP-Ready Guidance

In February 2013, the EA produced a guidance note titled '*CHP Ready Guidance for Combustion and Energy from Waste Power Plants*'[1]. This guidance applies to the following facilities, which 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 energy from waste (EfW) plants with a throughput of more than 3 tonnes per hour of non-hazardous waste or 10 tonnes per day of hazardous waste.

WKN will be regulated as a waste incineration facility with a throughput of more than 3 tonnes per hour, so the above guidance applies.

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

3.2 Energy Efficiency Directive

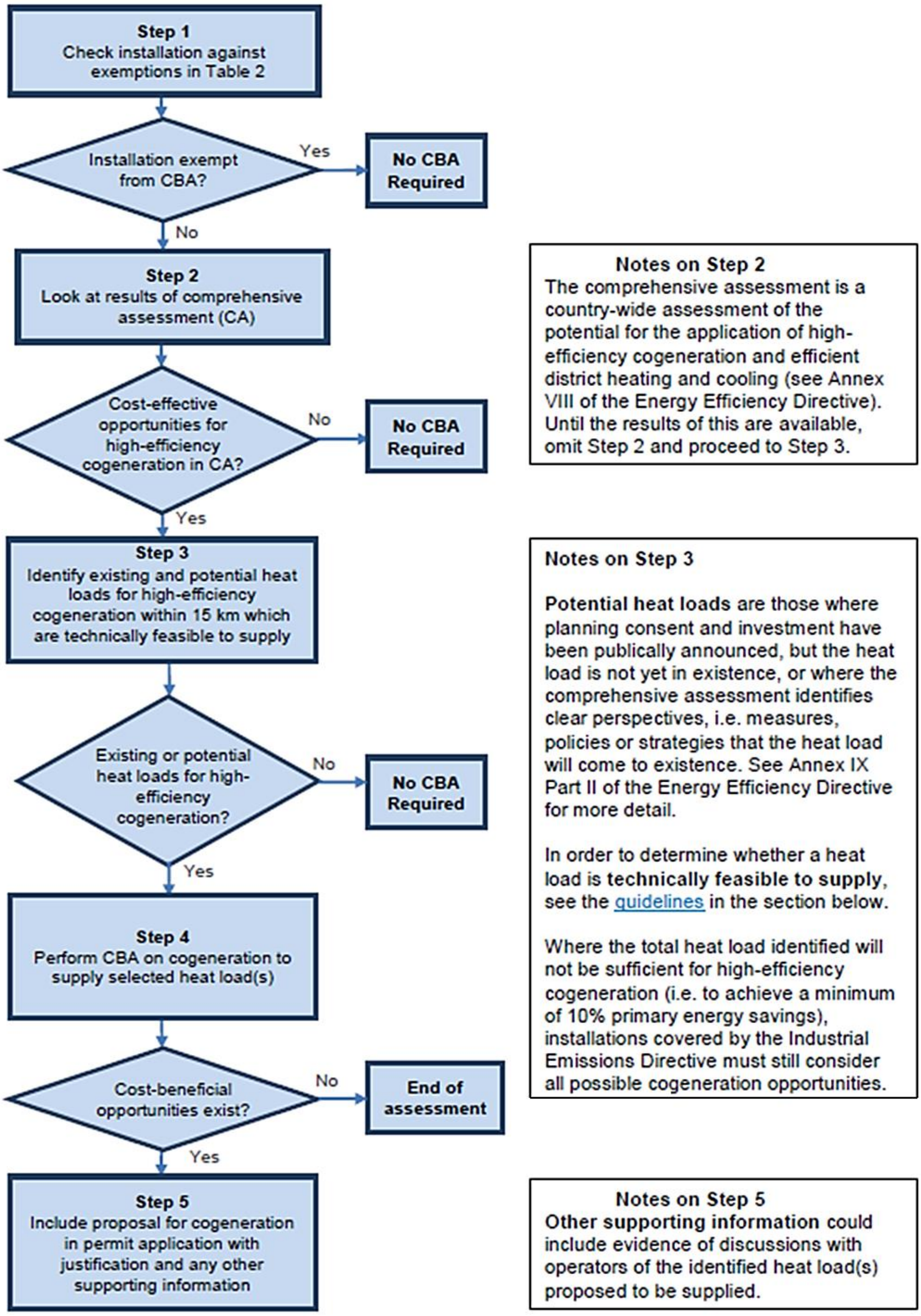
From 21st March 2015, operators of certain types of combustion installations are required to carry out a cost-benefit assessment (CBA) of opportunities for CHP when applying for an Environmental Permit (EP). This is a requirement under Article 14 of the Energy Efficiency Directive and applies to a number of combustion installation types. As 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]. The following methodology describes the process that must be followed for type 14.5(a) and 14.5(b) installations. The CBA is presented in Section E

[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 Technology Description

4.1 Site Selection

The location of the K3 and WKN sites is shown in Appendix A

K3 Site

The K3 site is located on land immediately to the east of the Kemsley Paper Mill, located 0.8 km east of Kemsley, a residential suburb in the north of Sittingbourne in Kent. It lies adjacent to the Swale Estuary to its east, with the Isle of Sheppey beyond and within the administrative areas of Kent County Council (KCC) and Swale Borough Council (SBC). To the south of the K3 Site lies a capped former landfill site which lies adjacent to the confluence between Milton Creek and the Swale Estuary. To the north lies an area of reedbed known as Kemsley Marshes. Access to the K3 Site is obtained from Barge Way to the north via an existing access road forming the eastern boundary of the Kemsley Paper Mill and shared with the mill operator DS Smith Ltd. The K3 Site lies in proximity to A249 which links to both the M2 and M20 motorways to the south and with the Isle of Sheppey to the north.

The consideration of alternative locations is not considered relevant to K3 and subsequently the K3 Proposed Development, as K3 is already being constructed.

WKN Site

The WKN site is located on land immediately north of the permitted K3 facility. The WKN Site is currently being used by the Applicant as a laydown and parking area for the construction of the adjacent K3 facility. It has been cleared of vegetation and laid to concrete or hardcore with a perimeter fence. To the east of the WKN Site lies the Swale Estuary with the Isle of Sheppey beyond. Immediately to the north lie the Kemsley Marshes beyond which lies the Kemsley Paper Mill anaerobic digester treatment works and to the north east a jetty operated by Knauf for the import of gypsum by barge.

Regarding the WKN Proposed Development there is an ongoing national need for energy security and diversity in addition to national targets for the reduction of waste sent to landfill. The Applicant has identified an additional need to increase waste processing capacity in the south-east region for post-recycled waste. The selection of the WKN Site to help meet this need is directly related to the presence of K3 and a number of other reasons as set out below:

- Its location in relation to the waste sources available in the region and access to the strategic road network;
- Availability of existing supporting infrastructure including connection to the grid and water supplies;
- Economies of scale associated with adjoining facilities;
- Location within an existing industrial area; and
- The results of preliminary environmental studies that indicated that there was sufficient environmental carrying capacity in the area to support the development.

It has not therefore been necessary to consider alternative locations for the WKN Proposed Development.

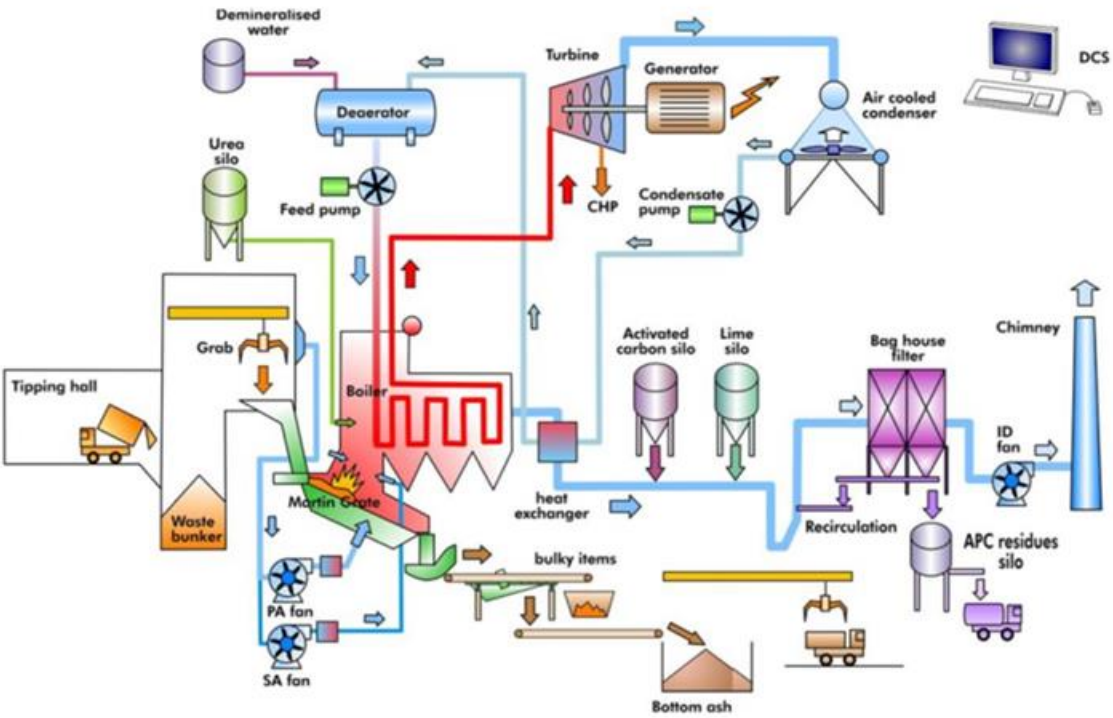
4.2 Proposed Development

Both the K3 and WKN Proposed Developments would be waste to energy facilities.

In order to properly categorise and consent the K3 proposed development under the Planning Act 2008 consent will be sought for the construction and operation of K3 to a total generating capacity of 75 MW_e and with a tonnage throughput of 657,000 tonnes of waste per annum. However in practical terms the application for the K3 Proposed Development seeks Development Consent to operate K3 as currently being constructed at an upgraded capacity of up to 75 MW_e (an additional 25.1 MW_e) and to process an additional 107,000 tonnes of waste per annum.

WKN would be an entirely new and distinct waste-to-energy facility, able of operating separately from K3. WKN would be a new single line waste-to-energy plant capable of generating up to 42 MW_e (gross) by processing nominally 351,452 tonnes of municipal, commercial and industrial waste per annum. WKN will have a maximum capacity of 390,000 tonnes per annum; however, for the purposes of this report it has been assumed that the WKN will operate at the nominal design capacity.

The process of WKN is illustrated in the following schematic.



WKN will have one waste incineration line, waste reception, waste storage, water, fuel gas and air supply systems, boilers, steam-turbine-generator, facilities for the treatment of exhaust gases, on-site facilities for treatment and storage of residues and waste water, flues, stack, systems for controlling incineration operations, recording and monitoring conditions.

Post recycled waste will be combusted on an inclined, reciprocating metal grate to ensure continuous mixing of the fuel and hence promote good combustion. The heat released by the combustion of the fuel is recovered in a water tube boiler, which is integral to the furnace and will produce (in combination with superheaters) high pressure superheated steam. The steam from the boiler will feed a steam-turbine generator used to generate electricity. Exhaust steam will be cooled using an air-cooled condenser.

In fully condensing mode, WKN will generate up to 42 MW_e. WKN would have its own grid connection to allow for the exporting of electricity to the national grid. WKN will have the capability to export steam to the Kemsley Paper Mill, via K3, when K3 is offline, at nominally 51.9 MW_{th}.

Subject to technical and economic feasibility, an additional district heating network will be included to export up to 18.6 MW_{th} of heat to offsite consumers, as discussed in the following section.

K3 is configured only for steam export and that it cannot contribute to any future district heating scheme.

4.3 Heat Supply System

Heat is typically supplied from the energy recovery process in the form of steam or hot water, depending on the grade of heat required by the end consumer(s).

Process steam for heat export is usually extracted via a bleed on the turbine and piped to the steam user. Where steam is captured from the user's process and condensed, the condensate can be returned to the power plant. However, care has to be exercised to avoid any contamination being carried in the returned condensate to the power plant boiler.

The most commonly considered options for recovering heat in waste to energy facilities are discussed below.

1. **Heat recovery from the air-cooled condenser**

   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 air-cooled condenser will be installed at WKN. 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 air-cooled condenser generates a similar temperature condensate to mechanical draught or hybrid cooling towers. However, 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 feedwater prior to being returned to the boiler. The additional steam extraction reduces the power generation from the plant.

2. **Heat extraction from the steam-turbine**

   Steam extracted from the steam-turbine can be used to generate hot water for district heating schemes, which 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 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 recovery from the flue gas**

   The temperature of flue gas exiting the flue gas treatment plant is typically around 140°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 DH in the range 90 to 120°C. This method of heat recovery 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 concentrations of some pollutants would likely require a different stack height to effect adequate dispersion. The additional cooling of the flue gas also 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 steam for the Kemsley Paper Mill, supplied via K3, can only be extracted from the turbine of WKN at a given temperature and pressure to suit the requirements of the paper mill. K3 is designed only for steam export and therefore it cannot contribute to any future district heating scheme.

The best solution to supply heat for the district heating scheme for the future possible heat users is by a separate extraction steam from the turbine of WKN at a pressure lower than that required by the paper mill. This method for the supply of heat is considered to be favourable for the following reasons:

1. Extraction of steam from the steam-turbine offers the most flexibility for varying heat quality and capacity to supply variable demands or new future demands, which is particularly relevant for facilities intended to supply district heating networks with a mix of consumers.
2. The heat requirements of the identified consumers (as described in Section 5.2) are suited to the temperatures attainable from the turbine with minimal power loss due to exporting energy to the heat circuit.
3. The use of a flue gas condenser would generate a visible plume which would be present for significant periods of the year. This is not desirable as it will significantly add to the visual impact of WKN.
4. This approach aligns with the design of the adjacent K3.

5 Heat Demand Investigation

A review of the potential heat demand within a 10 km radius of the WKN site has been undertaken to assess potential known or consented future developments that may require heat and to identify any existing major heat consumers. This enabled the initial design of proposed heat network options to be developed. Potential heat consumers have been identified using a review of publicly available datasets on fuel use in the region, heat mapping tools and visual inspection of satellite imagery, as discussed in the following sections.

The approach to identifying existing heat demands has centred on industrial and commercial users, as the benefits of providing heat to large premises is generally more financially viable than supply to multiple smaller consumers. Existing housing stock has not been considered as a potential heat consumer at this stage of the assessment because capital costs are typically excessive and may unfairly skew the financial payback period.

No heat supply agreements have yet been made. Once the DCO have been secured for the Proposed Development, WTI will be able to prepare Heads of Terms with potential heat users, where there it is technically and economically viable for agreements to be made.

The provision of steam from K3 to DS Smith has already been developed via a steam supply Agreement and the necessary infrastructure developed. The only change is to enable the supply of steam from WKN to K3 to facilitate steam supply to DS Smith when K3 is either off line for planned maintenance and or periods of shutdown.

WKN will already be built as a CHP facility from outset to supply steam at an average of 51.9 MW_{th} for approximately 560 hours to Kemsley Paper Mill, when K3 is offline. WKN will be further CHP Ready to allow additional heat export opportunities in the future and include provision for all the on-site infrastructure necessary to connect to a heat distribution network.

5.1 Kemsley Paper Mill

K3 will supply steam to the adjacent DS Smith Kemsley Paper Mill. The construction of K3 began in 2016 and WTI anticipates it being operational in late 2019. K3 will send steam to the Kemsley Paper Mill in a closed loop circuit whereby once utilised in the paper making process it is conveyed back to the air-cooled condenser units of the K3.

As defined in the steam supply agreement with DS Smith, the steam is to be supplied from K3 to DS Smith at conditions at pressure of 11.3 bar(a) + 1 bar and temperature of 220°C ± 5°C.

WKN will be able to provide this steam to DS Smith, via K3, when K3 is offline. Estimated heat demand supply to Kemsley Paper Mill from K3 and WKN is shown in the table below.

Table 1: DS Smith supply from K3 and WKN

	Estimated heat demand (MWh/annum)	Estimated design heat export (MW)	Estimated peak heat demand (MW)	Estimated Annual Average heat export (MW)
K3 Steam Export (8200 hours)	425,580	51.9	88	51.9
WKN steam export, when K3 is offline	29,064	51.9	88	3.54

	Estimated heat demand (MWh/annum)	Estimated design heat export (MW)	Estimated peak heat demand (MW)	Estimated Annual Average heat export (MW)
(560 hours)				
Total export to DS Smith Mill	454,644	51.9	88	51.9

5.2 Wider Heat Export Opportunities

5.2.1 The National Comprehensive Assessment

'*National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK*'[3], dated 16th December 2015, was published by Ricardo AEA Ltd on behalf of the Department of Energy and Climate Change (DECC). 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.

Section 3 of the report presents the results of the NCA. WKN is located in Kent, which falls within the South East region of the assessment. Aggregated 2012 heat consumption and equivalent figures projected to 2025, split by sector, are presented in the following table.

Table 2: Heat consumption in the South East

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	**60**	**53**

Evidently there is a downward trend in heating consumption anticipated in subsequent years. 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.

Similarly, current and projected space cooling consumption data is reported as follows. 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

Sector	2012 consumption (TWh/annum)	2025 consumption (TWh/annum)
Industry (including agriculture)	10	10
Commercial services	3	3
Public sector	1	1
Total	**13**	**13**
We assume that the apparent discrepancy in the figures is due to rounding errors. We do not have access to the underlying data to verify this.		

Due to the low resolution of the data, the results of the NCA can be considered as an overview only. While heating and cooling demand does exist in the region under consideration, this is below the average demand across all regions in England.

Higher resolution heat demand data is ascertained from heat mapping, as explained in the following sections.

5.2.2 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 10km of WKN was carried out, as shown in Table 4.

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.

Table 4: Heat demand within 10 km of WKN

Sector	Heat demand (MWh/annum)	Heat demand (%)
Communications and Transport	1,084	0.13%
Commercial Offices	4,414	0.55%
Domestic	612,676	75.68%
Education	27,895	3.45%
Government Buildings	3,062	0.38%
Hotels	4,074	0.50%
Large Industrial	74,986	9.26%
Health	2,477	0.31%
Other	2,115	0.26%

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

Sector	Heat demand (MWh/annum)	Heat demand (%)
Small Industrial	63,052	7.79%
Prisons	0	0.00%
Retail	5,368	0.66%
Sport and Leisure	1,766	0.22%
Warehouses	6,565	0.81%
District Heating	0	0.00%
Total	**809,534**	**100 %**

The area surrounding WKN can be seen to comprise a heat demand predominantly from the domestic 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.

The large and small industrial sectors contribute 9.26 % and 7.79 % of the local heat demand respectively. WKN is located in close proximity of many industrial estate with warehouses and industrial units. An investigation has been focused on the users within these industrial estates in order to secure the most economically viable heat network. The following sections identify potential heat users that would provide maximum return and carbon saving.

5.2.3 Large Heat Consumers

One large heat consumer (point heat demands greater than 5 MW_{th}) were identified within 10km of the Proposed Development using the BEIS UK CHP Development Map[5] tool, as shown as shown in detailed in Table 5 and Figure 2.

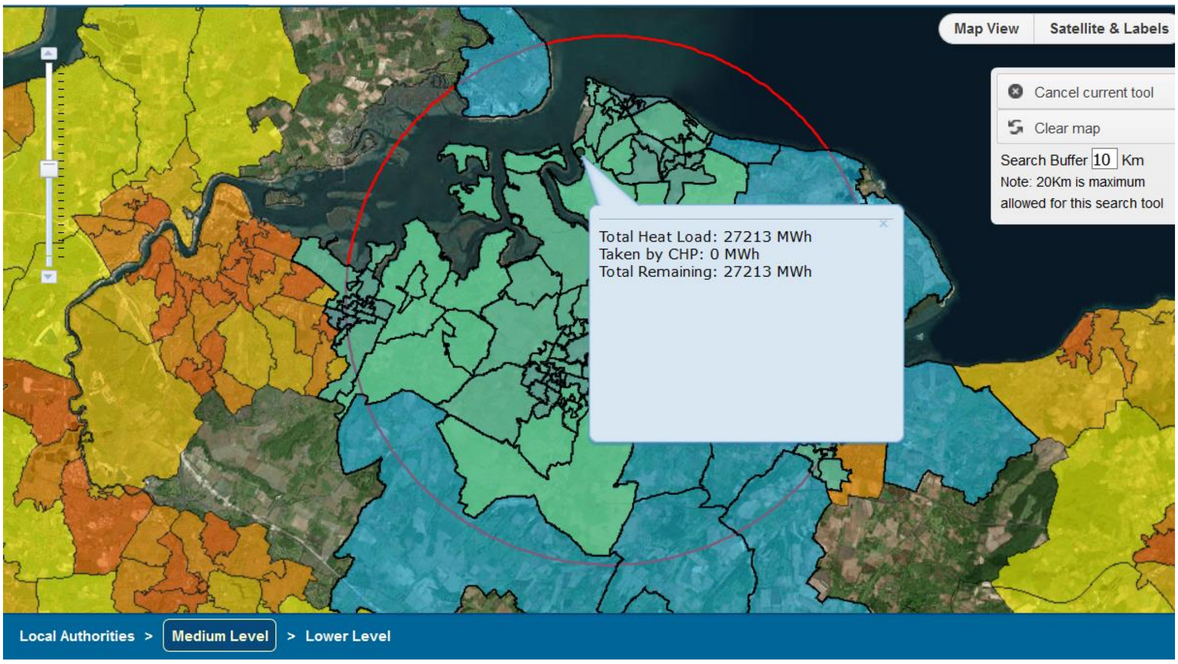
Table 5: Large Heat Consumers

Site	Heat demand (MWh/annum)	Distance from SEC (km)	Postcode
Aesica (pharmaceutical manufacturing company)	27,213	5.8 km	ME11 5EL

The location of the large heat consumer identified is a distance that would require a prohibitively costly pipe network to connect. Physical constraints imposed by the local infrastructure and topology 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 consumer. Connecting either of these locations to a heat network from the Proposed Development would require both river and rail crossings. The pipe would also have to be routed around the small towns near each location. This would increase the length of pipe required and consequently increase the cost of the network. The large heat consumer is likely to be a steam user and this adds significantly to the technical challenges of supplying heat. Therefore, this large heat user has been discounted.

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

Figure 2: CHP development map



5.2.4 Visual Inspection

Broad assumptions were made regarding the estimated heat demand from existing 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)[6]. 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.

A list of potential heat consumers identified within 10 km of the Proposed Development, applying engineering judgement to screen out unfavourable routes, is provided in Section 5.2.5. A corresponding map is provided in Appendix C.

5.2.5 Heat Consumer Screening

The design of any the heat network is the critical component in defining the technical and financial viability of a heating scheme. This section seeks to review the various potential network options

[6] CIBSE Guide F: Energy Efficiency in Buildings

and heat supply considerations that feed into the financial modelling based on the estimated heat demands and physical constraints.

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 Proposed Development and 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. Taking these factors into account, we have identified two potential district heating pipe routes, which are distinguished primarily on the basis of heat consumer location. These routes are described below. A map of these routes is provided in Appendix C.

1. District heating pipe route 1 delivers heat to the north and north west of the Proposed Development to business parks and light industrial users.
2. District heating pipe route 2 delivers heat to the south of the Proposed Development to business parks and light industrial users.

The locations of these heat consumers, relative to the Proposed Development, are shown in Appendix B and listed in Table 6 and Table 7 for pipe route 1 and 2 respectively. Connecting these users would not require rail, river or major road crossing and there would be no disruption to residential areas.

Table 6: Identified Potential Heat Users -Pipe Route 1

Reference number	Operator	Post code	Distance from WKN (km)	Estimated heat demand (MWh / annum)
1	Countrystyle Recycling Main Office	ME9 8SR	1	2,089
2	Knauf (UK)	ME9 8SR	1.2	2,577
3	Bearsted	ME9 8SR	1.86	784
4	Ballast Phoenix	ME9 8SR	1.72	745
5	Ridham Sea Terminals Ltd	ME9 8SR	1.9	724
6	Hanson Ready-mixed Concrete	ME9 8SR	2.1	1,314
7	Morrisons	ME10 3EX	1.45	13,272
8	LBK	ME10 2FB	1.6	222
9	WG Motorworks and LG Motorsport	ME10 2FB	1.7	275
10	Firmin Recruit	ME10 2FB	1.5	253
11	Nicholls Transport	ME10 2FF	2.4	616

Table 7: Identified Potential Heat Users-Pipe Route 2

Reference number	Operator	Post code	Distance from WKN	Estimated heat demand (MWh / annum)
12	Marshalls plc (Marshalls Mono Ltd) - Sittingbourne	ME10 3NB	2.8	1,889
13	Ace Hydraulics	ME10 3SQ	3.2	337
14	Cravencroft Ltd	ME10 3SQ	3.2	211
15	PowaKaddy International Limited	ME10 3RN	3.2	192
16	Morrells Woodfinishes Sittingborne	ME10 3FB	3.2	96
17	Poly-Tek Ltd	ME10 3FB	3.2	378
18	RTC Ltd	ME10 3RN	3.2	379
19	Flo Plast Ltd	ME10 3FP	3.2	2,903
20	Adam,Rouilly Limited	ME10 3AG	3.2	127
21	Carousel HQ	ME10 3UP	3.2	347
22	Electroquip Ltd	ME10 3GL	3.25	150
23	Besco Industrial Supplies Ltd	ME10 3RZ	3.3	96
24	DDS (International) Ltd	ME10 3RZ	3.4	47
25	Cross and Wells Ltd	ME10 3AG	3.2	1,775
26	All Car Parts	ME10 3EU	2.8	157
27	Tubz Brands Limited	ME10 3AG	3.3	510
28	Aceparts	ME10 3EU	3.3	228
29	Motor Parts Direct - Sittingbourne	ME10 3EU	3.4	87
30	Rumbles Boxing Academy	ME10 3GR	3.4	80
31	Bulgaro Interiors	ME10 3BF	4	471
32	Plalite Ltd	ME10 3BF	4.1	183
33	Q Catering	ME10 3BF	4	370
34	Drakes Plumbing Supplies Ltd	ME10 3BF	4	93
35	Response Envelopes Ltd	ME10 3BF	4	362
36	Tillett Racing Seats	ME10 3BF	3.9	371
37	Hormozi & Co Ltd	ME10 3FZ	3.9	585
38	MK1 Installations	ME10 3SU	3.9	108

Reference number	Operator	Post code	Distance from WKN	Estimated heat demand (MWh / annum)
39	Abbott Laboratories Ltd	ME10 3SU	3.9	1,012
40	Anglian Home Improvements	ME10 3BW	3.9	245
41	Allport	ME10 3BW	3.9	196
42	Window Logic	ME10 3AE	3.5	362
43	Kite Packaging Ltd Sittingbourne	ME10 3AE	3.5	106
44	D & J Motor Services Ltd	ME10 3AE	3.5	230
45	MJ Plastics & Plumbing Ltd	ME10 3RH	3.6	186
46	HM Quickshifter (UK) Ltd	ME10 3RL	3.5	368
47	Tubz Brands Limited	ME10 3AG	3.5	67
48	Magic Mend Trim & Alloy Repairs	ME10 3BG	3.5	80
49	Contracts Engineering Ltd	ME10 3RW	3.5	282
50	Ashbys Cleaning Equipment	ME10 3RW	3.5	301
51	Group Four Glassfibre Co Ltd	ME10 3RS	3.6	110
52	Medway Fibreglass	ME10 3RS	3.6	115
53	Construction Composites	ME10 3RS	3.6	109
54	Vinyl Creations Ltd	ME10 3RS	3.6	165
55	Bale Pak Ltd	ME10 3RS	3.7	320
56	Sittingbourne Commercial Wash	ME10 3SJ	3.8	1,063
57	Turbosat International Ltd	ME10 3RS	3.8	724
58	Woodcoombe Sports & Social Club	ME10 3RT	3.9	244
59	Rees Mechanical Handling	ME10 3RG	3.8	88
60	The Image Corporation	ME10 3RL	3.8	107
61	Southern Components Group Ltd	ME10 3RG	3.7	170
62	Heras Ready Fence	ME10 3RL	3.8	26
63	The Kentish Soap Co.Ltd	ME10 3FX	3.9	187
64	Flowers & Sparkle Wedding Florist	ME10 3FX	3.95	64
65	The Document Warehouse	ME10 3JP	4	770
66	All Vehicle Services	ME10 3RL	3.75	124

Reference number	Operator	Post code	Distance from WKN	Estimated heat demand (MWh / annum)
67	Laminating Service & Supplies	ME10 3EW	3.7	137
68	Tillett Racing Seats	ME10 3BF	3.75	421
69	The Colour Factory Limited	ME10 3RZ	3.8	211
70	Learay	ME10 3RL	3.8	319
71	UK Bespoke Bait Boats Ltd	ME10 3RP	3.8	129
72	Gallery Direct	ME10 3RN	3.95	1,628
73	DPD Local	ME10 3RN	4	242
74	Swale Heating Ltd	ME10 3SA	4.1	252
75	Office Hero Stationery Supplies	ME10 3SA	4.2	135
76	Merry Go Round	ME10 3RY	4.2	146
77	LTH	ME10 3RY	4.5	519
78	Marshall Fleet Solutions (Sittingbourne)	ME10 3RX	4.5	147
79	Network Rail N D S Plant Ltd	ME10 3SY	4.6	222
80	Elm Surfacing Ltd	ME10 3SY	4.4	119
81	LKM Recycling	ME10 3SY	4.4	454
82	Bayford Meadows Kart Circuit	ME10 3RY	4.6	133
83	JAYCREST COACHES	ME10 3SY	4.7	111
84	Chipshield - Paint Protection Film	ME10 3RY	4.3	508
85	DHL Parcel Medway	ME10 3RY	4.3	333
86	Precision Engineering Medway Ltd	ME10 3RY	4.4	268
87	Eurocoils Ltd	ME10 3RY	4.4	332
88	Island Leisure Products Ltd	ME10 3RN	4.2	1,352
89	Swale Skills Centre	ME10 3DZ	4.4	329
90	COLOMBIER (UK) LTD	ME10 3RN	4.6	1,964
91	Dore Metal Services Ltd	ME10 3HB	4.2	1,119
92	US Eurolink Ltd	ME10 3US	4.6	248
93	M & S Hire Ltd	ME10 3HB	4.6	379
94	Carousel Logistics (Warehousing)	ME10 3RN	4.6	907

Reference number	Operator	Post code	Distance from WKN	Estimated heat demand (MWh / annum)
95	Creative Resins International	ME10 3UP	4.6	693
96	Mid Kent Electrical Engineering Co Ltd	ME10 3UP	4.5	718
97	KCS Group	ME10 3UP	4.5	234
98	Maco Door & Window Hardware (UK) Ltd	ME10 3LY	4.4	454
99	Dobbyman	ME10 3UP	4.6	540
100	Sparshatts of Kent Ltd (Sittingbourne)	ME10 3RN	4.8	474
101	Medway Galvanising & Powder Coating Ltd	ME10 3RN	4.8	498
102	Spyder Creative Ltd	ME10 3TB	4.5	158
103	St Georges Business Park	ME10 3TB	4.5	478
104	West Lane Trading Estate, Sittingbourne ME10 3TT	ME10 3TT	4.5	956
105	Constantia Sittingbourne Ltd	ME10 3RY	4.6	790
106	Smeed Dean Centre	ME10 3EW	4.7	538
107	The COOK Kitchen	ME10 3HH	4.8	895
108	Crown Quay Trade Centre	ME10 3DY	5	548
109	Everest Ltd	ME10 3AG	4.7	1,336
110	Aeromet International Ltd	ME10 3RN	4.8	602
111	SMC Ford Sittingbourne	ME10 3HY	5.1	415
112	Sittingbourne Retail Park	ME10 2QD	5.6	2,777
113	Iceland	ME10 4PD	5.5	480
114	Costa Drive Thru	ME10 3DL	5.4	31
115	Morrisons	ME10 3EX	5.7	788
116	Milton Trade Park	ME10 2GZ.	5.9	339
117	Supreme Concrete	ME10 3SL	4.8	1,274
118	Jewson Ltd	ME10 3HX	5.4	442
119	Mervo Trans Parking	ME10 3ST	5.4	50
120	British Chestnut	ME10 3JJ	5.6	315
121	Morrisons	ME10 3EX	5.8	106

Reference number	Operator	Post code	Distance from WKN	Estimated heat demand (MWh / annum)
122	APM Metals Ltd	ME10 3HH	5.1	236
123	Sell My Bike For Cash	ME10 3JQ	5.1	45
124	Odds Timber	ME10 3JB	5.3	905
125	Sittingbourne and Milton Sea Cadets	ME10 3SN	4.9	114
126	FloPlast Ltd	ME10 3FP	3.4	1,496

5.2.6 Heat Network Profile

Generic heat demand profiles were developed to model the seasonal and diurnal variation in heat demand for each of the individual heat consumers identified, by integrating the estimated annual heat demands (in MWh). This allowed the annual average and peak heat demands (in MW_{th}) to be calculated. A combined heat demand profile for the proposed heat pipe routes was then derived from the sum of the individual heat load profiles of the selected consumers.

The heat network profile for the proposed heat pipe routes, shown in Figure 3. The heat network profile illustrates the variation in heat demand during a typical day in different seasons, accounting for network heat losses and demand diversity.

Figure 3 and Figure 4 show how the daily maximum heat capacity requirement changes throughout the year for each pipe route.

Figure 3: Projected heat network profile showing daily and seasonal variation

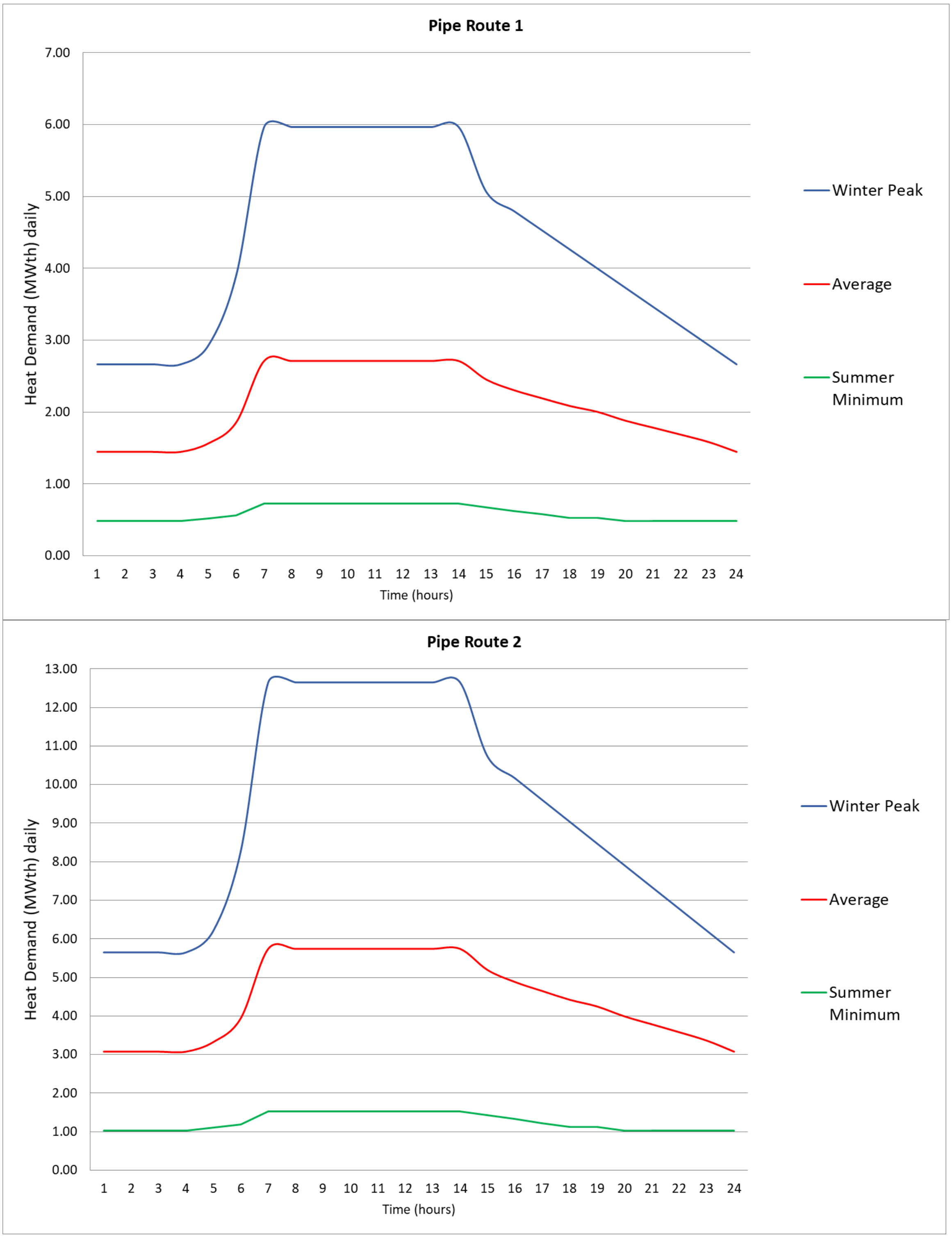
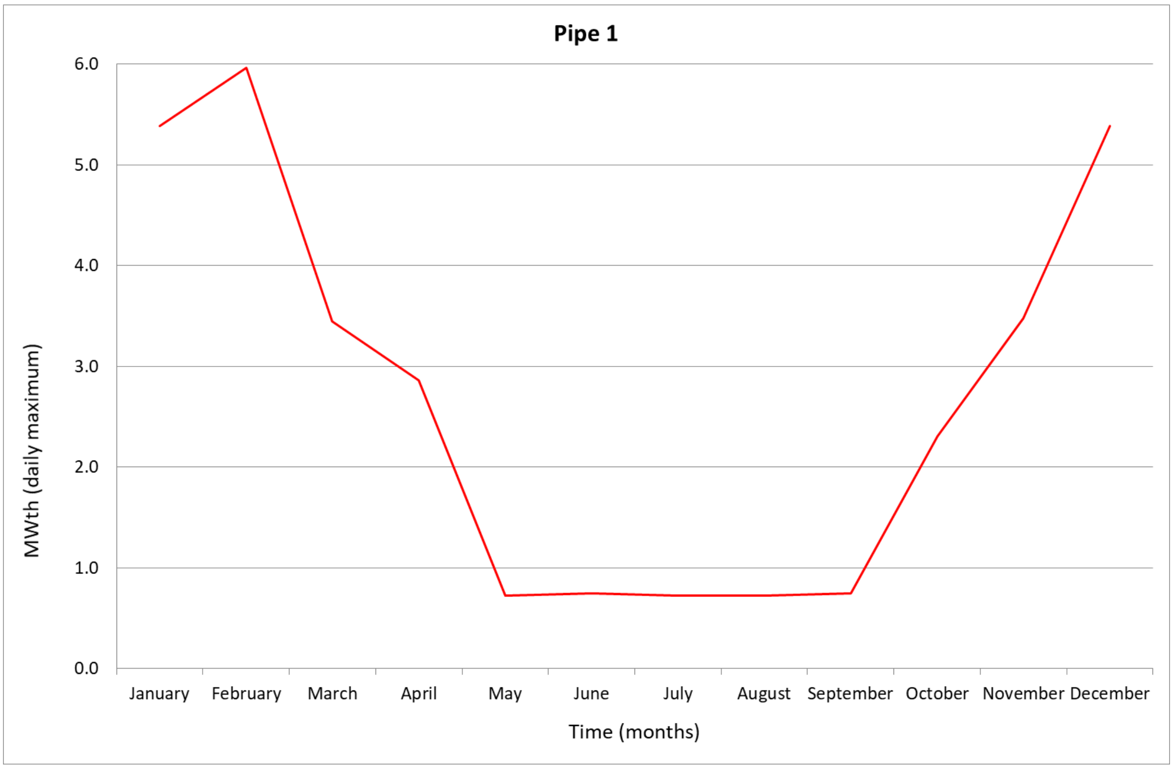
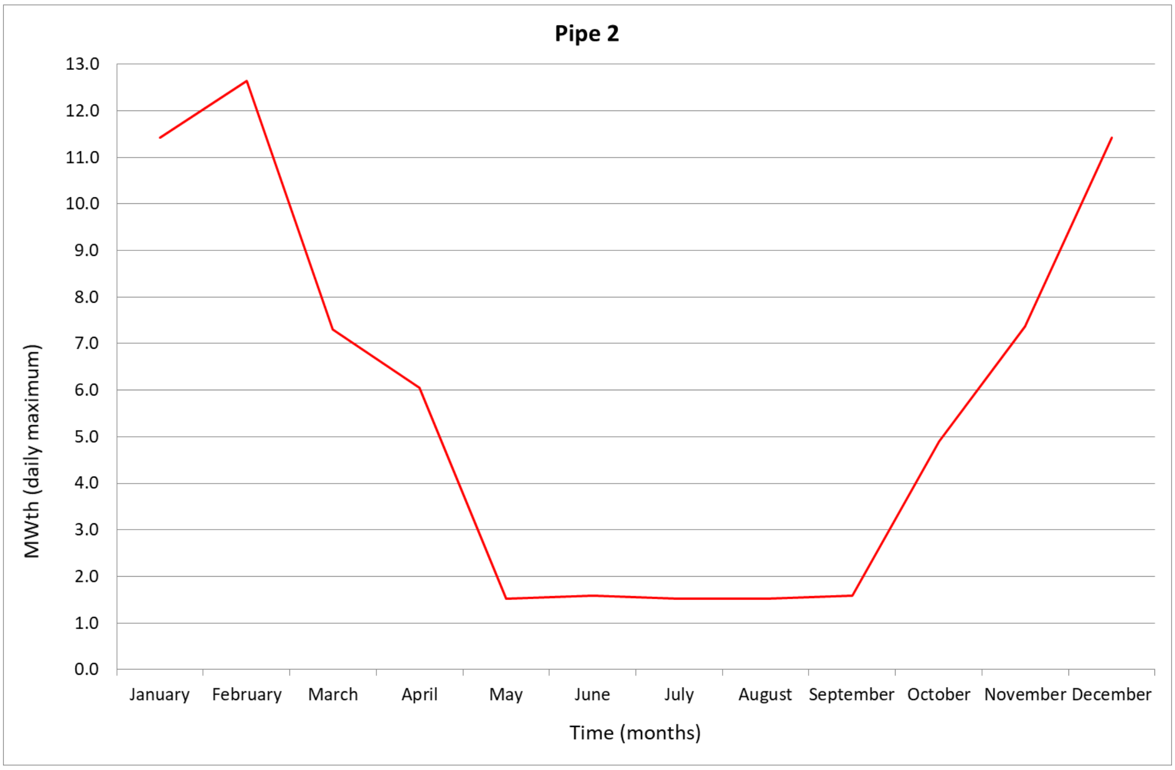
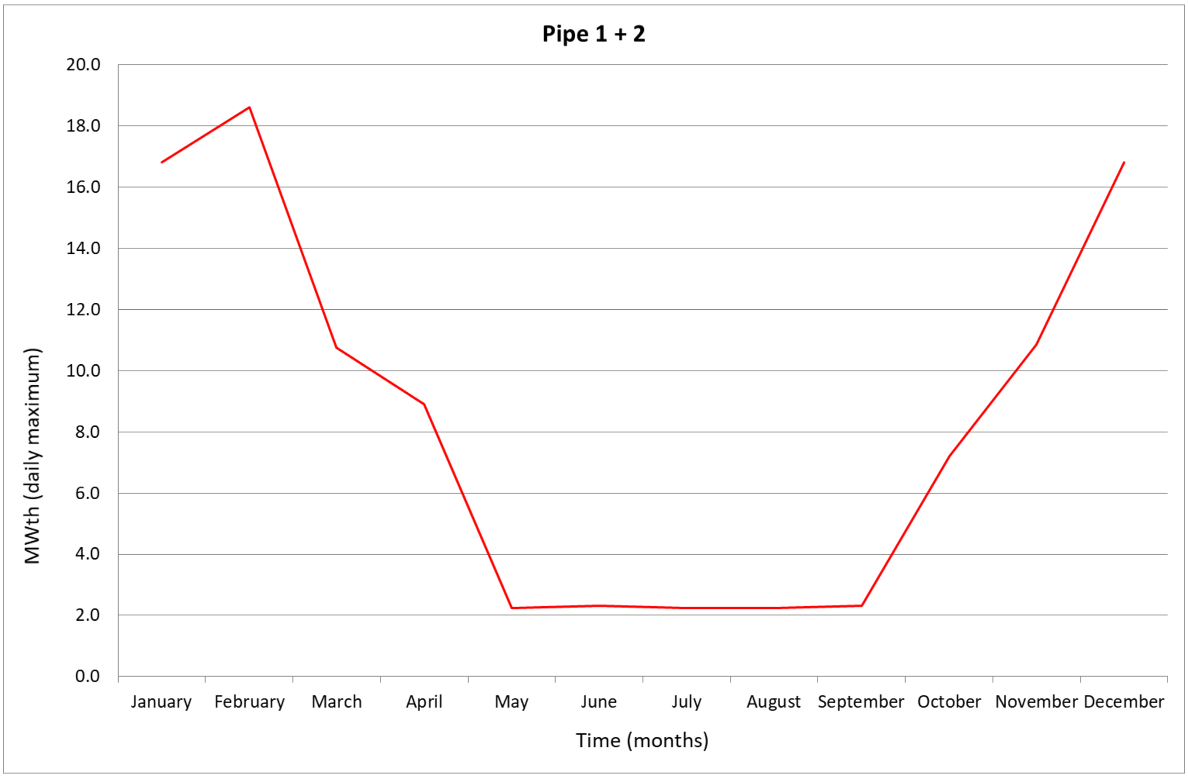


Figure 4: Monthly Heat Demand Profile







From the heat load assessment and the heat profiles outlined above, the estimated heat loads for each pipe route are shown in the table below.

Table 8: Heat network demands

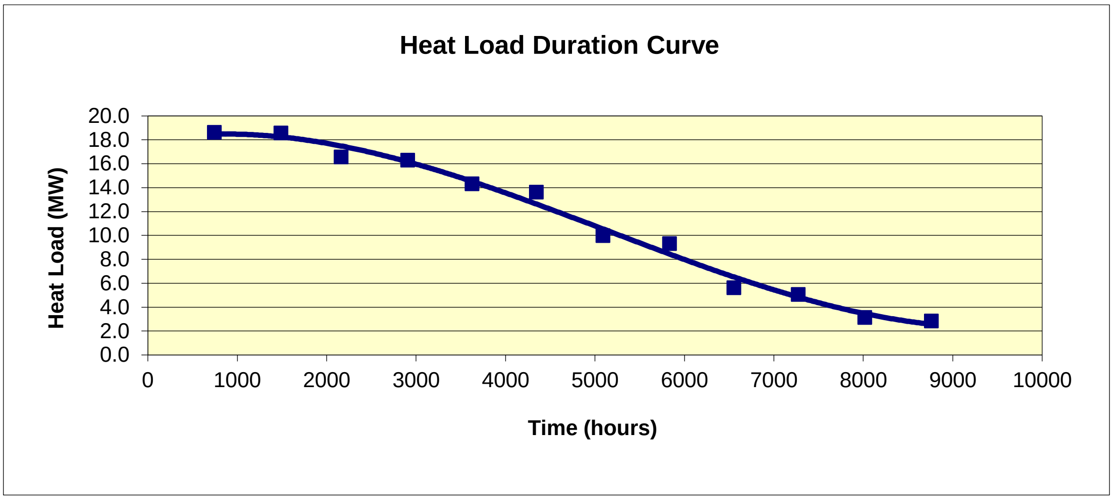
	Estimated heat demand (MWh/annum)	Estimated average heat demand (MW)	Estimated peak heat demand (MW)
Pipe route 1	18,237	2.1	6.0
Pipe route 2	38,652	4.4	12.6
Total	56,889	6.5	18.6

5.2.6.1 Heat Load Duration Curve

Due to the nature of the types of services the heat export will be providing, it is possible that there will be a strong seasonal variation in heat load on the plant. Where a district heating system supplies a large number of buildings with seasonal demand the peak winter load can be as much as ten times higher than the summer load and up to four times the annual average load. A heat load duration curve has been estimated for the scheme. The heat demand for each month has been adjusted based on degree day data for the local area.

The district heating network design will be based on peak heat demand. Peak heat demand can normally be determined from the winter daily heat use profiles. However, no daily heat consumption data is available for the potential heat users. Instead typical daily profiles which represent the heat users have been used.

Figure 5: Heat load duration curve



5.2.7 Heat Network Design

Heat distribution between the Proposed Development and offsite heat consumers would use buried pipework. Pre-insulated steel pipes are 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 are 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 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 design criteria relate to a typical hot water network utilising conventional heat extraction (as detailed in Section 4.3) and have been used to size the heat transmission pipe diameters. Flow and return temperatures have been selected to align with operating temperatures for older heating systems. Once more information on the heat loads is known the flow and return temperatures can be optimised with a view to reducing network heat losses.

Table 9: 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 (minimum)	600 mm

Using the above design criteria and taking into account the estimated heat demand for the identified pipe routes, the primary hot water transmission pipe size has been calculated as DN200 for pipe route 1 and DN 250 pipe route 2. This is an indicative figure and will be subject to heat demand verification and subsequent network design.

As the system is designed as flow and return, a single trench can be used for both the flow pipes to the consumer heat stations and return pipes back to the Proposed Development. The minimum trench sizes are given for the main pipelines in below. It should be noted that trench depths may vary considerably due to the presence of existing utilities and the nature of road construction.

Table 10: Heat Network Pipe Size

	Length of main pipe required (m)	Peak Heat Export at Proposed Development boundary (MW) [7]	Main Pipe Size	Main Pipe Trench Size (mm)
Pipe route 1	500	6.8	DN200	1050 mm wide 1000 mm deep
Pipe route 2	3000	11.8	DN250	1150 mm wide 1050 mm deep

[7] This is the actual peak heat extracted from the WKN turbine which is estimated by taking into consideration the pressure drop and heat loses through the pipe network.

5.2.8 Back-up Heat Source

The Proposed Development will be designed to achieve an availability of over 90 % (i.e. at least c. 8,200 operational hours per year). During periods of routine maintenance or unplanned outages the WKN plant will not be operating, however the district heat consumers will still require heat. There is therefore a need, somewhere within the district heat distribution system, to provide a back-up source of heat to meet the needs of the heat consumers. It is anticipated that the back-up boilers will be in operation for c. 560 hours per year.

The standby plant will likely comprise oil or gas-fired hot water heaters (boilers) with a separate dedicated 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. An indicative arrangement would be the installation of one 15MW_{th} unit and one 5 MW_{th} unit. The location of the back-up boilers has not yet been finalised, but it would be preferential to locate the boilers in close proximity to the heat consumers to minimise heat losses when running on fossil fuel. This would also give consumers direct control over their heating at times when heat from the Proposed Development is not available.

Arrangements for back up boilers should be revisited in the future when there is greater clarity surrounding the heat network design.

Subject to detailed heat demand modelling, once heat consumers are known with more certainty, opportunities for installing thermal stores will 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.

The cost of installing and operating back-up plant has been included in the economic assessment (see Section 6).

5.2.9 Indicative Pipe Route

An indicative layout of the two pipe routes is provided in Appendix C. The routing is indicative; a detailed engineering assessment would be required to determine the optimum route, which is not appropriate for this initial study.

The predominant engineering issue associated with the supply of heat by hot water relates to the installation of the heat supply pipeline. The pipeline required to supply hot water is likely to be a pair of large diameter pipes which must be installed in a trench. Determining a feasible route for such a pipeline is complex as outlined below.

Existing buried services may obstruct the most direct route to end consumers. Infrastructure crossings may be required and the supply and return pipelines would need to be routed along public highways. These issues have a direct bearing on the cost and installation time.

To install heat supply infrastructure, such as pre-insulated district heating pipes, in the public highway, the installer would need to comply with the requirements of the New Roads and Street Works Act 1991 (NRSWA). This lays out the legal obligations that apply to both statutory and non-statutory undertakers wishing to install apparatus in the public highway. Failure to comply can lead to fines and/or an order to remove the apparatus.

The provisions of the NRSWA do not apply to works carried out in private land, which would include the Proposed Development site where consent to install district heating pipes and CHP infrastructure is being secured within this DCO application. Outside of the Proposed Development site, district heating pipes would be brought forward by the associated heat load developer or relevant local authority.

As it may not be possible to fix pipeline routes at this stage the pipelines may be subject to a separate Planning application at a later stage.

6 Economic Assessment

6.1 Fiscal support

The following fiscal incentives are available to energy generation projects, and a number of these could support the delivery of the Proposed Development.

1. **Capacity Market for electricity supplied by WKN**

   Under the Capacity Market, subsidies are paid to generators 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 WKN) are eligible for contracts lasting up to 15 years. The Capacity Market was suspended on 15th November 2018 due to a decision by the European Court of Justice. If the Capacity Market is reinstated WKN may be eligible for these payments. Capacity Market payments have not been included in the economic assessment due the current suspension of the program.

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 WKN 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 WKN 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 generated over a 15-year period. In the second CfD round (executed on 11th September 2017) no funding was allocated for conventional EfW plants, with or without CHP. The third round of allocations under the CfD is scheduled for May 2019. Eligibility for the third round of allocations is focussed on less established renewable technologies. Therefore, this mechanism will not be a source of financial support for WKN.

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 for heat network projects. £320 million has been made available (through grants and loans) to fund the HNIP over the next five years. 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 WKN could achieve under this program would depend on the final size of the network and commercial arrangements.

6.2 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 steam to adjacent DS Smith Mill via the K3 facility, when the K3 is offline. The steam is to be supplied from WKN to DS Smith by K3 at conditions at pressure of 11.3 bar(a) + 1 bar and temperature of 220°C ± 5°C (see section 5.1).

   There are wider potential heat export opportunities identified in Section 5.2. The identified DH network solution is intended to supply heat, in the form of hot water, to industrial and commercial properties, at typical district heating conditions (see section 5.2.6 and 5.2.7). 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 5.2.8) will likely be included in the district heating scheme to ensure continuity of supply. The specific arrangement will be selected when there is more certainty over district 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.

6.3 Primary Energy Savings

In order 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 for the DH scheme in accordance with Directive 2012/27/EU Annex II part (b), using the following assumptions.

1. Annual nominal design throughput of 351,452 tonnes per annum based on a NCV of 10.5 MJ/kg.
2. Gross electrical output (fully condensing mode) of 42 MW_e.
3. Parasitic load of 3.6 MW_e.
4. Z ratio of 3.55 for steam supply to DS Smith Kemsley Mill.
5. Z ratio of 6.6 following the approach set out in CHPQA Guidance Note 28, assuming steam extraction at a pressure of 2.4 bar(a) for the identified DH network.
6. 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[8].

When operating in fully condensing mode (i.e. without heat export) WKN will achieve PES of 25.6 %, which is in excess of the technical feasibility threshold defined in the draft Article 14 guidance. Steam export with an annual average of 3.54 MW_{th} to Kemsley Paper Mill further increases the PES to 25.92 %. The inclusion of heat export at the design case level anticipated for the proposed DH network with an annual average of 6.54 MW_{th} increases PES to 27.64 %. The inclusion of annual

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

average heat export at 10.08 MW_{th}, including both proposed DH network at 6.54 MW_{th} and DS Smith Kemsley Mill at 3.54 MW_{th}, increases PES to 28.22%. On this basis, the proposed WKN will qualify as a high efficiency cogeneration operation when operating in CHP mode and a CBA is therefore required.

The permitted K3 achieves PES of 27.83 % when operating in normal operating conditions in CHP mode which is in excess of the technical feasibility threshold defined in the draft Article 14 guidance. When operating to its increased 75 MW_e generating capacity K3 would achieve a PES of 26.26 % which is in excess of the technical feasibility threshold.

6.4 Cost-benefit Assessment

Under Article 14 of the EED, operators of certain types of combustion installations are required to carry out a CBA of opportunities for CHP when applying for an EP. We have followed the EA's methodology, as outlined in the draft Article 14 guidance, in order to appraise the economic feasibility of implementing the proposed district heating network.

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 Study. The CBA model takes into account:

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

Model inputs and key outputs are provided in Appendix E. The following assumptions have been made.

1. The scheme will commence operation in 2024.
2. The heat export infrastructure required to export heat from WKN to the consumers identified in wider area is estimated to have a capital cost of approximately £22.6 million, split over a three-year construction programme.
3. The heat station will cost approximately £0.75million, split over a three-year construction programme.
4. Back-up boilers will be provided to when WKN is not available, at a cost of approximately £2.34 million.
5. Operational costs have been estimated based on similar sized projects.
6. Heat sales revenue will be £35 / MWh, index linked for inflation.
7. Electricity sales revenue will be £50 / MWh, index linked for inflation.
8. Standby boiler fuel costs will be £20 / MWh, index linked for inflation.
9. Standby boiler(s) will supply 6.4% of annual heat exported.

The results of the CBA indicate that both the nominal project internal rate of return and net present value (before financing and tax) over 33 years are 2.8 % and -£14.79 million respectively. Unattractive returns are a result of large network pipe lengths resulting in higher capital expenditure, combined with a relatively low identified heat demand. Therefore, it is considered that the proposed district heating network does not yield an economically viable scheme in its current configuration, however the economic case may improve with HNIP funding.

7 Energy Efficiency Calculations

7.1 Heat and power export

The Z ratio, which is the ratio of reduction in power export for a given increase in heat export, can be used to calculate the effect of variations in heat export on the electrical output of WKN. There will be two types of heat export from WKN and therefore, two different z ratio was obtained:

1. Steam supply to DS Smith Kemsley Mill:

   The Z ratio of 3.55 was obtained based on heat and mass balance from an EPC contractor proposal, via steam extraction from low pressure turbine bleeds. This extraction pressure is considered enough to meet the requirements of DS Smith Kemsley Mill.

2. Proposed DH network supply:

   A value of 6.6 was obtained following the approach set out in CHPQA Guidance Note 28, assuming steam extraction at a pressure of 2.4 bar(a). This extraction pressure is considered sufficient to meet the requirements of the identified heat users on the proposed DH network.

The heat and power export has been modelled across a range of load cases and the results are presented in Table 11.

Table 11: Heat and power export

Load case	Heat export at turbine (MW_{th})	Net power exported (MW_e)	Z ratio
1. No heat export	0.0	38.4	N/A
2. Proposed DH network annual average heat load (see Section 5.2.6)	6.54	37.41	6.60
3. Kemsley Mill heat supply at design (see Section 5.1)	51.90	23.78	3.55
4. Kemsley Mill heat supply at annual average heat[9] (see Section 5.1)	3.54	37.40	3.55
5. Proposed DH network and Kemsley Mill annual average heat supply (see Section 5)	10.08 (= 6.54 + 3.54)	36.58	5.53

The results indicate that for the DH heat consumers identified in Section 5.1 and Kemsley Mill annual average heat supply, load case 5 corresponding to an average heat export of 10.08 MW_{th} will result in a net power export of 36.58 MW_e.

7.2 CHPQA Quality Index

CHPQA is an energy efficiency best practice programme initiative by the UK Government. CHPQA aims to monitor, assess and improve the quality of CHP in the UK. In order to prove that a plant is a 'Good Quality' CHP plant, a QI of at least 105 must be at the design, specification, tendering and approval stages. Under normal operating conditions (i.e. when the scheme is

[9] WKN will supply steam at circa 51.9 MW_{th} for 560 hours per year, when the K3 is offline. This will be converted to an annual average heat supply of 3.54 MW_{th} (= 51.9 MW_{th} x 560 hours / 8200 hours) from WKN to the Mill.

operational) the QI threshold drops to 100. The QI for CHP schemes is a function of their heat efficiency and power efficiency according to the following formula.

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

where: η_{power} = power efficiency; and

η_{heat} = heat efficiency.

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

In December 2018, the Government released a revised CHPQA Standard Issue 7 and Guidance Note 44 Issue 7. The document sets out revisions to the design and implementation of the CHPQA scheme. These revisions are intended to ensure schemes which receive Government support are supplying significant quantities of heat and delivering intended energy savings. The following X and Y coefficients under the Guidance Note 44 Issue 7 apply to WKN:

X value = 221; and

Y value = 120.

The QI and efficiency values (based on a gross calorific value of 11.9 MJ/kg) have been calculated in accordance with CHPQA methodology for various load cases and the results are presented in Table 12.

Table 12: QI and efficiency calculations

Load case	Gross power efficiency (%)	Heat efficiency (%)	Overall efficiency (%)	CHPQA GN44 QI
1. No heat export	29.75%	0.00%	29.75%	65.74
2. Proposed DH network annual average heat load (see Section 5.2.6)	29.05%	4.63%	33.68%	69.75
3. Kemsley Mill heat supply at design (see Section 5.1)	20.01%	41.52%	61.53%	106.25
4. Kemsley Mill heat supply at annual average heat[10] (see Section 5.1)	29.04%	2.51%	31.55%	67.19
5. Proposed DH network and Kemsley Mill annual average heat supply (see Section 5)	28.46%	7.14%	35.60%	71.46

The results indicate that WKN will not achieve a QI score in excess of the 'Good Quality' CHP threshold (QI of 105 at the design stage) for the average heat load exported to the proposed DH network and Kemsley Paper Mill (Load case 5). The highly onerous efficiency criteria set out in the latest CHPQA guidance, most notably the underpinning requirement to achieve an overall efficiency (NCV basis) of at least 70%, means that none of the load cases considered will enable heat export from WKN to be considered Good Quality.

[10] WKN will supply steam at circa 51.9 MW_{th} for 560 hours per year, when the K3 is offline. This will be converted to an annual average heat supply of 3.54 MW_{th} (= 51.9 MW_{th} x 560 hours / 8200 hours) from WKN to the Mill.

For reference, assuming the same Z ratio as set out in the preceding section for the combination of steam export to Kemsley Paper Mill and the DH network, an annual average heat export of 80 MW_{th} would be required for a heat network to achieve Good Quality status. It is clear that the design proposed for heat recovery is not capable of supplying a sufficient quantity of heat at the design heat conditions.

The permitted K3 has certified as “Good Quality” CHP prior to the publication of this Guidance Note 44 (Issue 7). As the permitted K3 has entered Contracts for Difference contract prior to the publication of this Guidance Note 44 (Issue 7), the X and Y values used for the previous CHPQA certification will be grandfathered. Therefore, K3 will certified as “Good Quality” under the grandfathered X and Y values used for the previous CHPQA certification. The proposed K3 extension will also be a “Good Quality” CHP under grandfathered X and Y values.

8 CHP-Ready BAT Assessment

The EA has published detailed guidance on CHP Assessments as part of the Environmental Permitting regime.

The EA requires EP applications 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. The EA therefore requires developers to satisfy three BAT tests in relation to CHP. The first involves considering and identifying opportunities for the use of heat off-site, as demonstrated in this CHP study. Where this is not technically or economically possible and there are no immediate opportunities, the second test involves ensuring that the plant is built to be CHP Ready. The third test involves carrying out periodic reviews to determine whether the situation has changed and there are opportunities for heat use off site.

Since WKN will export heat to support the DS Smith Kemsley Paper Mill, which is considered an eligible heat use, WKN will operate as a CHP plant and a CHP-Ready assessment is not required. However, since opportunities have been identified to increase the heat export capacity through implementation of a DH network, a CHP-Ready Assessment has been carried out to demonstrate that WKN is designed to be ready, with minimum modification, to supply additional heat in the future.

8.1 CHP Envelope

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

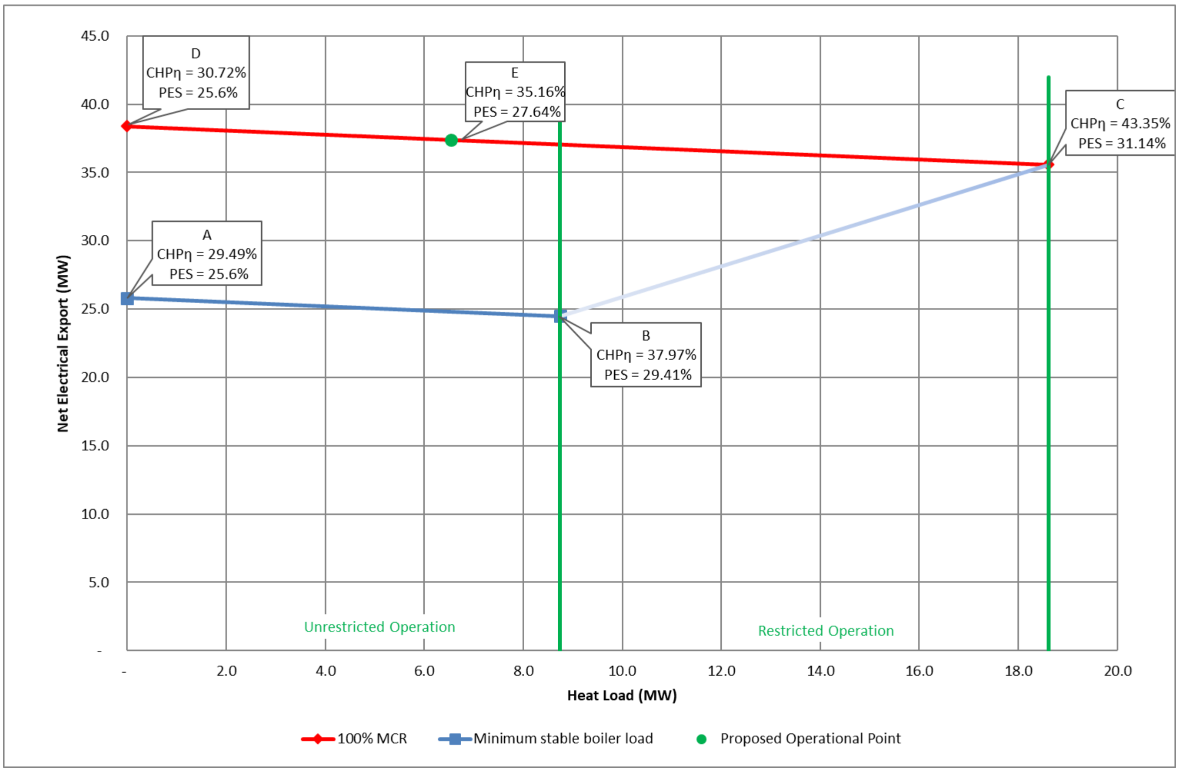
The points defining the CHP envelope are as follows.

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

In this context, the CHP efficiency (ηCHP) is defined as:

$$\eta\text{CHP} = \frac{\text{Net heat output} + \text{Net power output}}{\textit{Thermal input}}$$

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



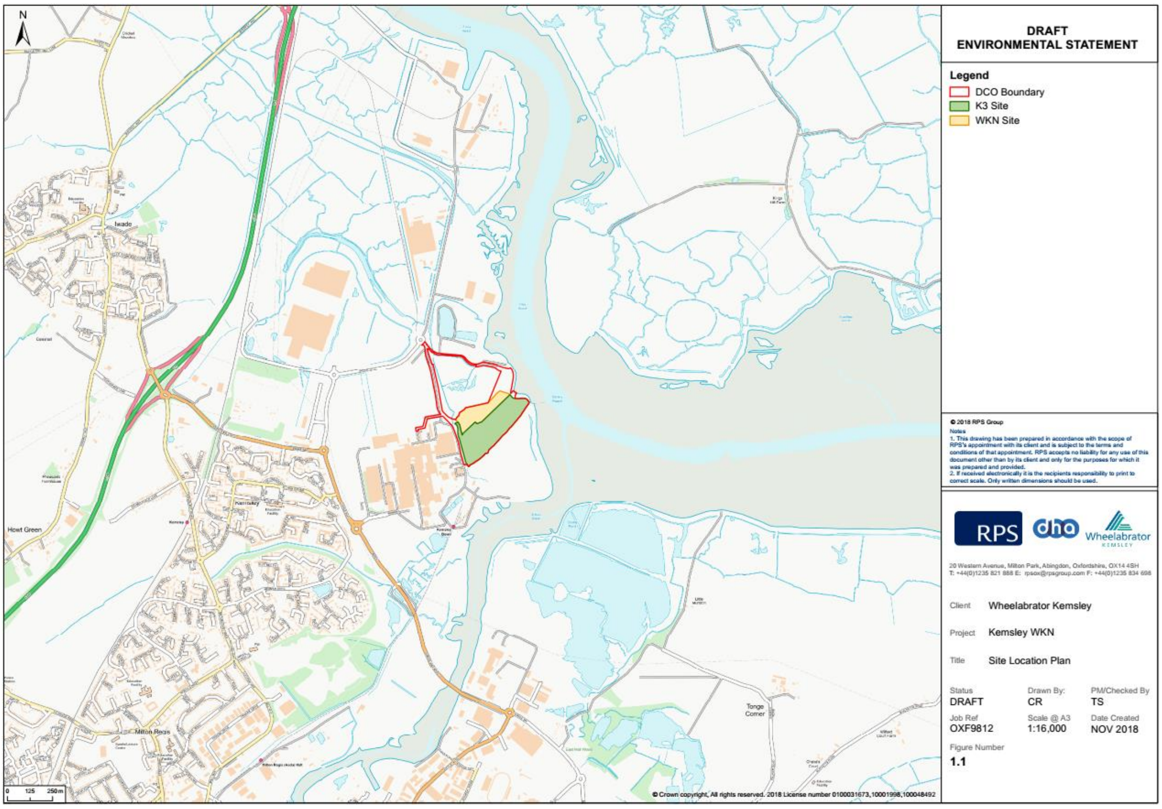
The proposed operational point (point E) represents the design heat demand exported to the proposed DH network.

8.2 CHP-Ready Assessment

A CHP-Ready Assessment form has been prepared for the proposed DH network and is provided in Appendix F.

Appendices

A Site Location Plan



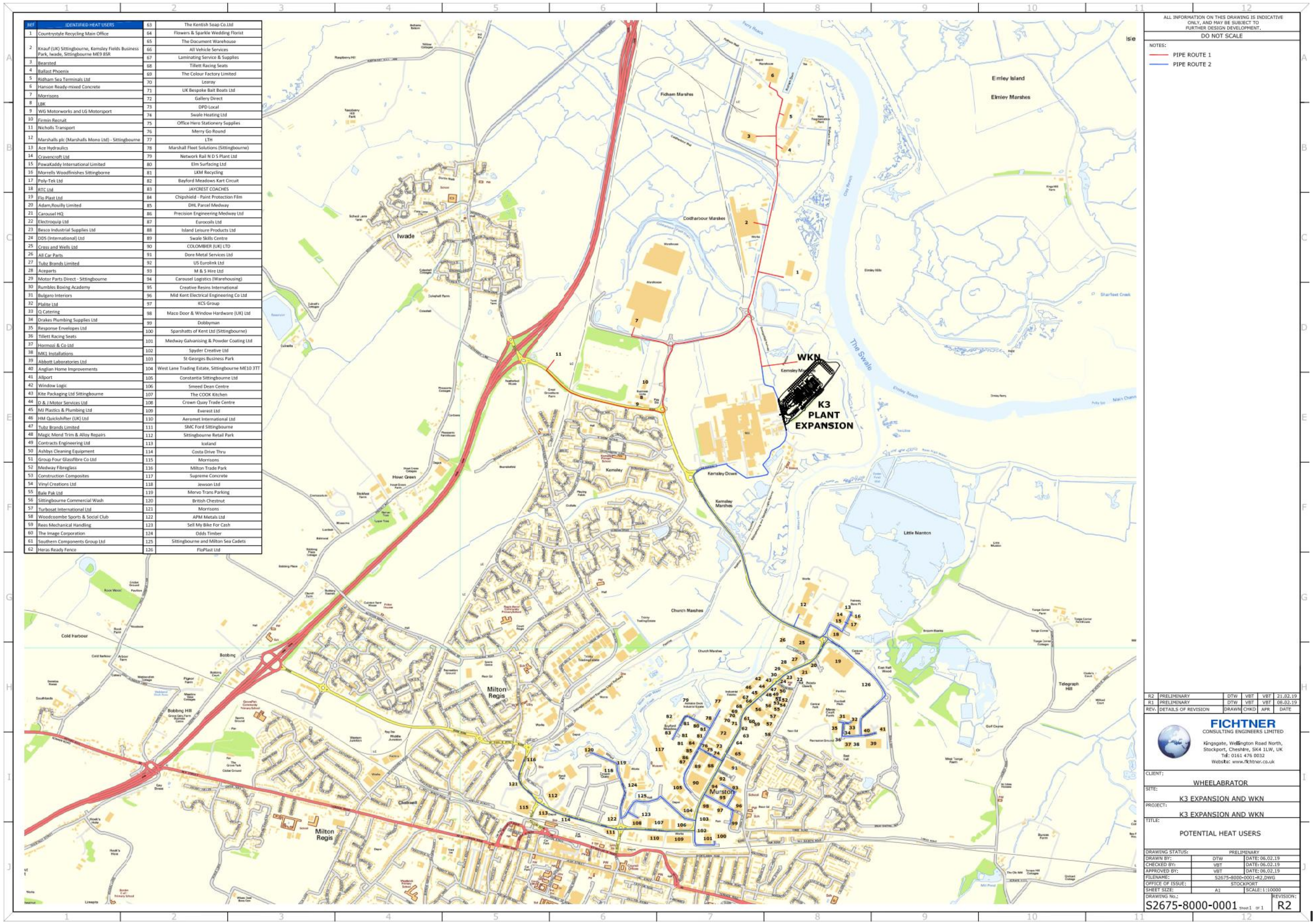
B Potential Heat Consumers

Ref	Identified Heat Users	Distance from Plant (km)	Post Code
	Pipe route 1		
1	Countrystyle Recycling Main Office	1	ME9 8SR
2	Knauf (UK) Sittingbourne	1.2	ME9 8SR
3	Bearsted	1.86	ME9 8SR
4	Ballast Phoenix	1.72	ME9 8SR
5	Ridham Sea Terminals Ltd	1.9	ME9 8SR
6	Hanson Ready-mixed Concrete	2.1	ME9 8SR
7	Morrisons	1.45	ME10 3EX
8	LBK	1.6	ME10 2FB
9	WG Motorworks and LG Motorsport	1.7	ME10 2FB
10	Firmin Recruit	1.5	ME10 2FB
11	Nicholls Transport	2.4	ME10 2FF
	Pipe route 2		
12	Marshalls plc (Marshalls Mono Ltd)	2.8	ME10 3NB
13	Ace Hydraulics	3.2	ME10 3SQ
14	Cravencroft Ltd	3.2	ME10 3SQ
15	PowaKaddy International Limited	3.2	ME10 3RN
16	Morrells Woodfinishes Sittingborne	3.2	ME10 3FB
17	Poly-Tek Ltd	3.2	ME10 3FB
18	RTC Ltd	3.2	ME10 3RN
19	Flo Plast Ltd	3.2	ME10 3FP
20	Adam,Rouilly Limited	3.2	ME10 3AG
21	Carousel HQ	3.2	ME10 3UP
22	Electroquip Ltd	3.25	ME10 3GL
23	Besco Industrial Supplies Ltd	3.3	ME10 3RZ
24	DDS (International) Ltd	3.4	ME10 3RZ
25	Cross and Wells Ltd	3.2	ME10 3AG
26	All Car Parts	2.8	ME10 3EU
27	Tubz Brands Limited	3.3	ME10 3AG
28	Aceparts	3.3	ME10 3EU
29	Motor Parts Direct - Sittingbourne	3.4	ME10 3EU
30	Rumbles Boxing Academy	3.4	ME10 3GR
31	Bulgaro Interiors	4	ME10 3BF
32	Plalite Ltd	4.1	ME10 3BF
33	Q Catering	4	ME10 3BF
34	Drakes Plumbing Supplies Ltd	4	ME10 3BF
35	Response Envelopes Ltd	4	ME10 3BF
36	Tillett Racing Seats	3.9	ME10 3BF
37	Hormozi & Co Ltd	3.9	ME10 3FZ
38	MK1 Installations	3.9	ME10 3SU

39	Abbott Laboratories Ltd	3.9	ME10 3SU
40	Anglian Home Improvements	3.9	ME10 3BW
41	Allport	3.9	ME10 3BW
42	Window Logic	3.5	ME10 3AE
43	Kite Packaging Ltd Sittingbourne	3.5	ME10 3AE
44	D & J Motor Services Ltd	3.5	ME10 3AE
45	MJ Plastics & Plumbing Ltd	3.6	ME10 3RH
46	HM Quickshifter (UK) Ltd	3.5	ME10 3RL
47	Tubz Brands Limited	3.5	ME10 3AG
48	Magic Mend Trim & Alloy Repairs	3.5	ME10 3BG
49	Contracts Engineering Ltd	3.5	ME10 3RW
50	Ashbys Cleaning Equipment	3.5	ME10 3RW
51	Group Four Glassfibre Co Ltd	3.6	ME10 3RS
52	Medway Fibreglass	3.6	ME10 3RS
53	Construction Composites	3.6	ME10 3RS
54	Vinyl Creations Ltd	3.6	ME10 3RS
55	Bale Pak Ltd	3.7	ME10 3RS
56	Sittingbourne Commercial Wash	3.8	ME10 3SJ
57	Turbosat International Ltd	3.8	ME10 3RS
58	Woodcoombe Sports & Social Club	3.9	ME10 3RT
59	Rees Mechanical Handling	3.8	ME10 3RG
60	The Image Corporation	3.8	ME10 3RL
61	Southern Components Group Ltd	3.7	ME10 3RG
62	Heras Ready Fence	3.8	ME10 3RL
63	The Kentish Soap Co.Ltd	3.9	ME10 3FX
64	Flowers & Sparkle Wedding Florist	3.95	ME10 3FX
65	The Document Warehouse	4	ME10 3JP
66	All Vehicle Services	3.75	ME10 3RL
67	Laminating Service & Supplies	3.7	ME10 3EW
68	Tillett Racing Seats	3.75	ME10 3BF
69	The Colour Factory Limited	3.8	ME10 3RZ
70	Learay	3.8	ME10 3RL
71	UK Bespoke Bait Boats Ltd	3.8	ME10 3RP
72	Gallery Direct	3.95	ME10 3RN
73	DPD Local	4	ME10 3RN
74	Swale Heating Ltd	4.1	ME10 3SA
75	Office Hero Stationery Supplies	4.2	ME10 3SA
76	Merry Go Round	4.2	ME10 3RY
77	LTH	4.5	ME10 3RY
78	Marshall Fleet Solutions (Sittingbourne)	4.5	ME10 3RX
79	Network Rail N D S Plant Ltd	4.6	ME10 3SY
80	Elm Surfacing Ltd	4.4	ME10 3SY
81	LKM Recycling	4.4	ME10 3SY
82	Bayford Meadows Kart Circuit	4.6	ME10 3RY
83	JAYCREST COACHES	4.7	ME10 3SY

84	Chipshield - Paint Protection Film	4.3	ME10 3RY
85	DHL Parcel Medway	4.3	ME10 3RY
86	Precision Engineering Medway Ltd	4.4	ME10 3RY
87	Eurocoils Ltd	4.4	ME10 3RY
88	Island Leisure Products Ltd	4.2	ME10 3RN
89	Swale Skills Centre	4.4	ME10 3DZ
90	COLOMBIER (UK) LTD	4.6	ME10 3RN
91	Dore Metal Services Ltd	4.2	ME10 3HB
92	US Eurolink Ltd	4.6	ME10 3US
93	M & S Hire Ltd	4.6	ME10 3HB
94	Carousel Logistics (Warehousing)	4.6	ME10 3RN
95	Creative Resins International	4.6	ME10 3UP
96	Mid Kent Electrical Engineering Co Ltd	4.5	ME10 3UP
97	KCS Group	4.5	ME10 3UP
98	Maco Door & Window Hardware (UK) Ltd	4.4	ME10 3LY
99	Dobbyman	4.6	ME10 3UP
100	Sparshatts of Kent Ltd (Sittingbourne)	4.8	ME10 3RN
101	Medway Galvanising & Powder Coating Ltd	4.8	ME10 3RN
102	Spyder Creative Ltd	4.5	ME10 3TB
103	St Georges Business Park	4.5	ME10 3TB
104	West Lane Trading Estate	4.5	ME10 3TT
105	Constantia Sittingbourne Ltd	4.6	ME10 3RY
106	Smeed Dean Centre	4.7	ME10 3EW
107	The COOK Kitchen	4.8	ME10 3HH
108	Crown Quay Trade Centre	5	ME10 3DY
109	Everest Ltd	4.7	ME10 3AG
110	Aeromet International Ltd	4.8	ME10 3RN
111	SMC Ford Sittingbourne	5.1	ME10 3HY
112	Sittingbourne Retail Park	5.6	ME10 2QD
113	Iceland	5.5	ME10 4PD
114	Costa Drive Thru	5.4	ME10 3DL
115	Morrisons	5.7	ME10 3EX
116	Milton Trade Park	5.9	ME10 2GZ.
117	Supreme Concrete	4.8	ME10 3SL
118	Jewson Ltd	5.4	ME10 3HX
119	Mervo Trans Parking	5.4	ME10 3ST
120	British Chestnut	5.6	ME10 3JJ
121	Morrisons	5.8	ME10 3EX
122	APM Metals Ltd	5.1	ME10 3HH
123	Sell My Bike For Cash	5.1	ME10 3JQ
124	Odds Timber	5.3	ME10 3JB
125	Sittingbourne and Milton Sea Cadets	4.9	ME10 3SN
126	FloPlast Ltd	3.4	ME10 3FP

C Location of Heat Users and Indicative Pipe Route



REF	IDENTIFIED HEAT USERS		
1	Countrystyle Recycling Main Office	63	The Kentish Soap Co.Ltd
2	Knauf (UK) Sittingbourne, Kemsley Fields Business Park, Iwade, Sittingbourne ME9 8SR	64	Flowers & Sparkle Wedding Florist
		65	The Document Warehouse
		66	All Vehicle Services
		67	Laminating Service & Supplies
3	Bearsted	68	Tillett Racing Seats
4	Ballast Phoenix	69	The Colour Factory Limited
5	Ridham Sea Terminals Ltd	70	Learay
6	Hanson Ready-mixed Concrete	71	UK Bespoke Bait Boats Ltd
7	Morrisons	72	Gallery Direct
8	LBK	73	DPD Local
9	WG Motorworks and LG Motorsport	74	Swale Heating Ltd
10	Firmin Recruit	75	Office Hero Stationery Supplies
11	Nicholls Transport	76	Merry Go Round
12	Marshalls plc (Marshalls Mono Ltd) - Sittingbourne	77	LTH
13	Ace Hydraulics	78	Marshall Fleet Solutions (Sittingbourne)
14	Cravencroft Ltd	79	Network Rail N D S Plant Ltd
15	PowaKaddy International Limited	80	Elm Surfacing Ltd
16	Morrells Woodfinishes Sittingborne	81	LKM Recycling
17	Poly-Tek Ltd	82	Bayford Meadows Kart Circuit
18	RTC Ltd	83	JAYCREST COACHES
19	Flo Plast Ltd	84	Chipshield - Paint Protection Film
20	Adam,Rouilly Limited	85	DHL Parcel Medway
21	Carousel HQ	86	Precision Engineering Medway Ltd
22	Electroquip Ltd	87	Eurocoils Ltd
23	Besco Industrial Supplies Ltd	88	Island Leisure Products Ltd
24	DDS (International) Ltd	89	Swale Skills Centre
25	Cross and Wells Ltd	90	COLOMBIER (UK) LTD
26	All Car Parts	91	Dore Metal Services Ltd
27	Tubz Brands Limited	92	US Eurolink Ltd
28	Aceparts	93	M & S Hire Ltd
29	Motor Parts Direct - Sittingbourne	94	Carousel Logistics (Warehousing)
30	Rumbles Boxing Academy	95	Creative Resins International
31	Bulgaro Interiors	96	Mid Kent Electrical Engineering Co Ltd
32	Plalite Ltd	97	KCS Group
33	Q Catering	98	Maco Door & Window Hardware (UK) Ltd
34	Drakes Plumbing Supplies Ltd	99	Dobbyman
35	Response Envelopes Ltd	100	Sparshatts of Kent Ltd (Sittingbourne)
36	Tillett Racing Seats	101	Medway Galvanising & Powder Coating Ltd
37	Hormozi & Co Ltd	102	Spyder Creative Ltd
38	MK1 Installations	103	St Georges Business Park
39	Abbott Laboratories Ltd	104	West Lane Trading Estate, Sittingbourne ME10 3TT
40	Anglian Home Improvements	105	Constantia Sittingbourne Ltd
41	Allport	106	Smeed Dean Centre
42	Window Logic	107	The COOK Kitchen
43	Kite Packaging Ltd Sittingbourne	108	Crown Quay Trade Centre
44	D & J Motor Services Ltd	109	Everest Ltd
45	MJ Plastics & Plumbing Ltd	110	Aeromet International Ltd
46	HM Quickshifter (UK) Ltd	111	SMC Ford Sittingbourne
47	Tubz Brands Limited	112	Sittingbourne Retail Park
48	Magic Mend Trim & Alloy Repairs	113	Iceland
49	Contracts Engineering Ltd	114	Costa Drive Thru
50	Ashbys Cleaning Equipment	115	Morrisons
51	Group Four Glassfibre Co Ltd	116	Milton Trade Park
52	Medway Fibreglass	117	Supreme Concrete
53	Construction Composites	118	Jewson Ltd
54	Vinyl Creations Ltd	119	Mervo Trans Parking
55	Bale Pak Ltd	120	British Chestnut
56	Sittingbourne Commercial Wash	121	Morrisons
57	Turbosat International Ltd	122	APM Metals Ltd
58	Woodcoombe Sports & Social Club	123	Sell My Bike For Cash
59	Rees Mechanical Handling	124	Odds Timber
60	The Image Corporation	125	Sittingbourne and Milton Sea Cadets
61	Southern Components Group Ltd	126	FloPlast Ltd
62	Heras Ready Fence		

Instructions:

D The WKN Site Layout

E Cost-Benefit Assessment Inputs and Key Outputs

INPUTS — Version Jan 2015

Scenario Choice (dropdown box) | 1 | Power generator (Heat Source) same fuel amount

Key

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

Technical solution features

Heat carrying medium (hot water, steam or other) (dropdown box)	Hot water
Total length of supply pipework (kms)	13.1
Peak heat demand from Heat User(s) (MWth)	18.62
Annual quantity of heat supplied from the Heat Source(s) to Heat User(s) (MWh)	*Lines 49 & 79*

DCF Model Parameters

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

Cost and revenue streams

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

	% operating costs and revenues during construction phase	Heat Supply Infrastructure - used in Scenarios 1, 2, 3 and 5	Heat Station - used in Scenarios 1, 2 and 3	Standby boilers (only if needed for Scenarios 1, 2 and 3)	Industrial CHP - used in Scenario 4 *
Project asset lifespan (yrs)		30	30	30	
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%	7.534046667	0.250741333	0.780025	
Year 2 costs (£m) and build up of operating costs and revenues (%)	0%	7.534046667	0.250741333	0.780025	
Year 3 costs (£m) and build up of operating costs and revenues (%)	0%	7.534046667	0.250741333	0.780025	
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)	0.2
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)	0.2
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	**0.5**
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)	35.00	35.00				
Annual quantity of heat supplied from the Heat Source(s) to Heat User(s) at steady state (MWh)	56,889	56,889				
Equivalent heat sales if first year of operations is steady state (£ m)	2.0					
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)	6%	6%				
'Lost' electricity sale price (£/ MWh) at first year of operations	50.00	50.00				
Z-ratio (commonly in the range 3.5 - 8.5)	6.60	6.60				
Power generation lost at steady state (MWh)	8,069	8,069				
Equivalent 'lost' revenue from power generation if first year of operations is steady state (£ m)	0.40					
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)	23.37	23.37				
Boiler efficiency of Standby Boiler (%)	80%	80%	80%	80%		
Additional fuel required per year for Standby Boiler in steady state (MWh)	4,546	4,546	-	-		
Equivalent additional fuel costs if first year of operations is steady state (£m)	0.11					
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	2.8%
Nominal NPV (before financing and tax) (£m) over 33 years	-14.79

F CHP-R Assessment Form

#	Description	Units	Notes / Instructions
Requirement 1: Plant, Plant location and Potential heat loads			
1.1	Plant name		Wheelabrator Kemsley North (WKN)
1.2	Plant description		WKN will be designed to process annual nominal throughput of 351,452 tonnes of municipal, commercial and industrial waste per annum, generating up to 42 MWe (gross) of electricity, with the capability to export steam to the Kemsley Paper Mill, via K3, when K3 is offline. This is equivalent to 42.86 tonnes per hour, based on an annual operational availability of 8,200 hours. The mixed wastes will have an approximate net calorific value (NCV) in the region of 10.5 MJ/kg and will be processed through one combustion line. The proposed WKN will include fuel reception and storage areas, incineration grate and boilers, water, fuel and air supply systems, a flue gas treatment system, on-site facilities for treatment and storage of residues and waste water, stack, devices and systems for controlling incineration operations, and staff facilities. The gross generation of WKN will be up to 42 MW_e of electricity, but there will be some variation depending on the amount of heat exported at any given time. With changes in calorific value of the fuel, the fuel feed rate to the combustion chambers will be varied to maintain a constant thermal load on the boilers.
1.3	Plant location (Postcode / Grid Ref)		The WKN site is located on land immediately north of the permitted K3 facility. The WKN site is located on land immediately to the east of the Kemsley Paper Mill, located 0.8 km east of Kemsley, a residential suburb in the north of Sittingbourne in Kent. It lies adjacent to the Swale Estuary to its east, with the Isle of Sheppey beyond and within the administrative areas of Kent County Council (KCC) and Swale Borough Council (SBC). To the south of the WKN Site lies a capped former landfill site which lies adjacent to the confluence between Milton Creek and the Swale Estuary. To the north lies an area of reedbed known as Kemsley Marshes. Access to the WKN Site is obtained from Barge Way to the north via an existing access road forming the eastern boundary of the Kemsley Paper Mill and shared with the mill operator DS Smith Ltd and the

#	Description	Units	Notes / Instructions
			permitted K3 facility. The WKN Site lies in proximity to A249 which links to both the M2 and M20 motorways to the south and with the Isle of Sheppey to the north. The Site grid references are Easting 592184, Northing 166682. The postcode is ME10 2FB. A map showing the location of the Facility is in Appendix A.
1.4	Factors influencing selection of plant location		Regarding the WKN Proposed Development there is an ongoing national need for energy security and diversity in addition to national targets for the reduction of waste sent to landfill. The Applicant has identified an additional need to increase waste processing capacity in the south-east region for post-recycled waste. The selection of the WKN Site to help meet this need is directly related to the presence of K3 and a number of other reasons as set out below: • Its location in relation to the waste sources available in the region and access to the strategic road network; • Availability of existing supporting infrastructure including connection to the grid and water supplies; • Economies of scale associated with adjoining facilities; • Location within an existing industrial area; and • The results of preliminary environmental studies that indicated that there was sufficient environmental carrying capacity in the area to support the development. It has not therefore been necessary to consider alternative locations for the WKN Proposed Development.
1.5	Operation of plant		
a)	Proposed operational plant load	%	100
b)	Thermal input at proposed operational plant load	MW	141.2
c)	Net electrical output at proposed operational plant load	MW	38.4
d)	Net electrical efficiency at proposed operational plant load	%	30.7
e)	Maximum plant load	%	100

#	Description	Units	Notes / Instructions
f)	Thermal input at maximum plant load	MW	141.2
g)	Net electrical output at maximum plant load	MW	38.4
h)	Net electrical efficiency at maximum plant load	%	30.7
i)	minimum stable plant load	%	70%
j)	Thermal input at minimum stable plant load	MW	98.8
k)	Net electrical output at minimum stable plant load	MW	25.8
l)	Net electrical efficiency at minimum stable plant load	%	29.5
1.6	Identified potential heat loads		
			Details of the identified heat loads are in section 5.2. Following consumer screening and accounting for network heat losses and consumer diversity, 126 potential consumers were identified with an average heat load of 6.5 MW_{th}. and a peak load of 18.6 MW_{th} for the two proposed district heating routes. The estimated heat use per year of the DH identified loads is 56,889 MWh/year.
1.7	Selected heat load(s)		
a)	Category (e.g. industrial / district heating)		District heating
b)	Maximum heat load extraction required	MW	18.6
1.8	Export and return requirements of heat load		
a)	Description of heat load extraction		Network to supply hot water at typical district heating temperatures (approximately 110°C) via turbine steam extractions at approximately 2.4 bar(a).
b)	Description of heat load profile		The heat load profile is variable due to mixed use developments (primarily industrial and commercial). A detailed heat load profile can be found in section 5.2.6 of the Heat Plan. The consumer heat load and profile is subject to verification.
c)	Export pressure	bar a	10

#	Description	Units	Notes / Instructions
d)	Export temperature	°C	110
e)	Export flow	t/h	399
f)	Return pressure	bar a	3
g)	Return temperature	°C	70
h)	Return flow	t/h	399
Requirement 2: Identification of CHP Envelope			
2.0	Comparative efficiency of a standalone boiler for supplying the heat load	% LHV	80% - updated in accordance with CHPQA Stakeholder Engagement Document, April 2016, Table 1.
2.1	Heat extraction at 100% plant load		
a)	Maximum heat load extraction at 100% plant load	MW	18.6
b)	Maximum heat extraction export flow at 100% plant load	t/h	Assuming steam extraction at 2.4 bar(a), export flow rate would be: 30.3 t/hr
c)	CHP mode net electrical output at 100% plant load	MW	35.6
d)	CHP mode net electrical efficiency at 100% plant load	%	28.5
e)	CHP mode net CHP efficiency at 100% plant load	%	43.4
f)	Reduction in primary energy usage for CHP mode at 100% plant load	%	31.1
2.2	Heat extraction at minimum stable plant load		
a)	Maximum heat load extraction at minimum stable plant load	MW	8.7
b)	Maximum heat extraction export flow at minimum stable plant load	t/h	14.24
c)	CHP mode net electrical output at minimum stable plant load	MW	24.5
d)	CHP mode net electrical efficiency at minimum stable plant load	%	28.0
e)	CHP mode net CHP efficiency at minimum stable plant load	%	38.0
f)	Reduction in primary energy usage for CHP mode at minimum stable plant load	%	29.4

#	Description	Units	Notes / Instructions
2.3	Can the plant supply the selected identified potential heat load (i.e.is the identified potential heat load within the 'CHP envelope')?		Yes
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	Proposed operation of plant with CHP		
a)	CHP mode net electrical output at proposed operational plant load	MW	37.4
b)	CHP mode net electrical efficiency at proposed operational plant load	%	29.9
c)	CHP mode net CHP efficiency at proposed operational plant load	%	35.2
d)	Reduction in net electrical output for CHP mode at proposed operational plant load	MW	0.99
e)	Reduction in net electrical efficiency for CHP mode at proposed operational plant load	%	0.79
f)	Reduction in primary energy usage for CHP mode at proposed operational plant load	%	27.6
g)	Z ratio		6.6
Requirement 4: Technical provisions and space requirements			
4.1	Description of likely suitable extraction points		Steam for the district heating system could be supplied via a controlled steam flow extraction from a low pressure turbine bleed at approximately 2.4 bar(a). Heat would be transferred to a closed hot water circuit for offsite export via a series of condensing heat exchangers.
4.2	Description of potential options which could be incorporated in the plant, should a CHP opportunity be realised outside the 'CHP envelope'		The CHP opportunity lies within the CHP envelope.
4.3	Description of how the future costs and burdens associated with supplying the identified heat load / potential CHP opportunity have been minimised through the implementation of an appropriate CHP-R design		If the scheme were to be implemented, space will be allocated for the CHP equipment within or in the area adjacent to the turbine hall to avoid the cost of building a dedicated heat station at a later date. The turbine design will be selected to maximise electrical efficiency while allowing for the option of heat export to be implemented in the future. This is in line with the EA CHP-Ready Guidance which states

#	Description	Units	Notes / Instructions
			that the initial electrical efficiency of a CHP-R plant (before any opportunities for the supply of heat are realised) should be no less than that of the equivalent non-CHP-R plant.
4.4	Provision of site layout of the plant, indicating available space which could be made available for CHP-R		Please refer to the site layout drawing provided in Appendix D. A space in the turbine hall could be made available for CHP-R. The heat network will (likely) include steam extraction piping, control and shutoff valves, heat exchangers, district heating supply and return lines, district heating circulation pumps, condensate return piping (to the condensate tank), control and instrumentation / electrical connections, an expansion tank for pressurisation of the district heating pipe network and heat metering. If necessary, a back-up boiler will be located on in the turbine hall, for ease of connection to the primary hot water circuit.
Requirement 5: Integration of CHP and carbon capture			
5.1	Is the plant required to be CCR?		No
5.2	Export and return requirements identified for carbon capture		
	100% plant load		
a)	Heat load extraction for carbon capture at 100% plant load	MW	N/A
b)	Description of heat export (e.g. steam / hot water)		N/A
c)	Export pressure	bar a	N/A
d)	Export temperature	°C	N/A
e)	Export flow	t/h	N/A
f)	Return pressure	bar a	N/A
g)	Return temperature	°C	N/A
h)	Return flow	t/h	N/A
i)	Likely suitable extraction points		N/A
	Minimum stable plant load		
j)	Heat load extraction for carbon capture at minimum stable plant load	MW	N/A
k)	Description of heat export (e.g. steam / hot water)		N/A

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

#	Description	Units	Notes / Instructions
e)	Carbon capture and CHP mode net CHP efficiency at 100% plant load	%	N/A
f)	Reduction in primary energy usage for carbon capture and CHP mode at 100% plant load	%	N/A
5.5	Heat extraction at minimum stable plant load with carbon capture		
a)	Maximum heat load extraction at minimum stable plant load with carbon capture	MW	N/A
b)	Maximum heat extraction export flow at minimum stable plant load with carbon capture	t/h	N/A
c)	Carbon capture and CHP mode net electrical output at minimum stable plant load	MW	N/A
d)	Carbon capture and CHP mode net electrical efficiency at minimum stable plant load	%	N/A
e)	Carbon capture and CHP mode net CHP efficiency at minimum stable plant load	%	N/A
f)	reduction in primary energy usage for carbon capture and CHP mode at minimum stable plant load	%	N/A
5.6	Can the plant with carbon capture supply the selected identified potential heat load (i.e. is the identified potential heat load within the 'CHP and carbon capture envelope')?		N/A
5.7	Description of potential options which could be incorporated in the plant for useful integration of any realised CHP system and carbon capture system		N/A
Requirement 6: Economics of CHP-R			
6.1	Economic assessment of CHP-R		In order to assess the economic feasibility of the CHP scheme (as required under Article 14 of the Energy Efficiency Directive) a cost benefit

#	Description	Units	Notes / Instructions
			assessment has been carried out in accordance with the draft Article 14 guidance. The results of the CBA indicate an internal rate of return of 2.8 % and a net present value of -£14.79 million. The proposed heat network will not yield an economically viable scheme in its current configuration. The economic feasibility of the scheme will be reassessed in the future when there is more certainty over heat loads and considering any subsidies that support the export of heat.
BAT assessment			
	Is the new plant a CHP plant at the outset (i.e.are there economically viable CHP opportunities at the outset)?		Yes
	If not, is the new plant a CHP-R plant at the outset?		Yes
	Once the new plant is CHP-R, is it BAT?		Yes

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