FICHTNER

Consulting Engineers Limited

DUNBAR ENERGY RECOVERY FACILITY

Viridor Dunbar Waste Services Ltd

Heat and Power Plan

ENGINEERING CONSULTING

Document approval

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Management Summary

Viridor engaged a joint venture comprising Babcock and Wilcox Volund (BWV) and Interserve Construction Limited (Interserve), to construct the Dunbar Energy Recovery Facility (ERF, the Facility) in Dunbar, East Lothian, Scotland. Construction of the Facility began in 2014. Main construction of the plant finished on 31st July 2018 and the commissioning end date was agreed with SEPA as the 28th June 2019. The Facility is designed with a nominal design capacity of 300,435 tonnes per annum (tpa) of waste, assuming 7,800 hours operation per annum with a net calorific value (NCV) of 10 MJ/kg. However, allowing for variations in the net calorific value (NCV) of the waste, availability and the maximum hourly tonnage, the maximum annual capacity of the Facility is approximately 325,000 tpa. The PPC Permit allows Dunbar ERF to receive and process up to 325,000 tonnes of waste per year. In 2021, Dunbar ERF processed 307,237tonnes of residual waste. The waste is combusted to produce base-load renewable energy directly to the National Grid via an electricity connection at an onsite substation. The plant is capable of producing up to 36MW of electricity, equivalent to powering circa 70,000 households.

The Facility has been designed with the capability of operating in Combined Heat and Power (CHP) mode and export up to 17 MWth of low-grade heat to local heat consumers, subject to technical and economic viability.

Fichtner Consulting Engineers Ltd (Fichtner) was engaged by Viridor to produce a Heat and Power Plan as an update to the January 2021 Heat and Power Plan for the Facility. Scottish Environmental Protection Agency (SEPA) Thermal Treatment of Waste Guidelines (TTWG) 2014 stipulate that all new thermal treatment plants must ensure that the recovery of energy from waste takes place with a high level of efficiency. Specifically, the Heat and Power Plan should provide details of how the applicant proposes to achieve a Quality Index (QI) of 93 or Indicative overall plant efficiency of 35% for facilities processing over 70,000 tpa of fuel and should give an indication of anticipated progress for each year up to the end of the heat plan period. For the heat network identified, comprising consumers situated in close proximity to Dunbar, the Facility is able to achieve a QI of 94.7. We therefore consider that the TTWG energy recovery targets are met.

An average and diversified peak heat demand of 2.21 MWth and 5.38 MWth respectively has been estimated for consumers which could viably be connected to a district heating network. These consumers comprise a planned industrial development, a planned residential development, and several public buildings. Alternative potential heat consumers within a radius of 10km of the Facility were identified and analysed but were discounted for inclusion in a district heating network on grounds of location, technical feasibility, or the expressed intentions of the owners.

The heat network proposed is based on well proven and highly efficient technology, which can supply heat that meets the requirements of end consumers while minimising the impact on power generation. Steam will be extracted from the steam turbine via dedicated extraction(s) and heat transferred to a closed hot water circuit via a series of condensing heat exchangers. Hot water will be supplied to consumers through a pre insulated buried hot water pipeline, before being returned to the ERF for reheating.

Apart from financial viability, we see no reason (within the scope of our review) that a heat network cannot be implemented within SEPA's recommendation of 5 to 7 years starting on cessation of commissioning of the ERF.

The Facility has qualified for support under the Capacity Market (CM), so any proposed heat network would be reliant on heat sales revenue exclusively (plus any additional grants available). The options for fiscal support from the Scottish Government are being monitored. Viridor has committed to continue to review opportunities for a financially viable heat export scheme in light of new heat consumers and changes to the subsidy landscape.

In December 2021, the management team at Dunbar ERF attended the East Lothian Council (ELC) Energy Transformation Board and gave a presentation to the board of what the ERF plant can offer in terms of heat supply to developments in the area. A follow up meeting was held via Microsoft Teams in January 2022 with plans put in place for a site visit in February 2022 if COVID-19 restrictions allow to allow conversations to continue.

Minutes from the meeting can be found in Appendix C of this report.

Contents

1 Introduction

1.1 Background

This Heat and Power Plan updates the previous reports prepared in January 2021 and January 2020 by Stantec, January 2018 by Fichtner and January 2017 by Viridor. Specifically, it has assessed changes in waste feedstocks (i.e. types and volumes), heat network opportunities (i.e. heat demands in proximity) and energy efficiency of ERF.

Viridor is a recycling, renewable energy and waste management company focused on the waste management sector. Viridor aims to provide new life to the world's resources by collecting waste from British homes and businesses and transforming it into valuable materials, resources and energy.

Viridor has partnerships with public bodies, local authorities and business across the UK, investing £1.5bn in low carbon infrastructure.

Viridor strongly invests in the green economy through investments in recruitment, training programmes, technology and innovation. Viridor is a leader in innovation within the waste management industry, investing in projects including the Department of Energy & Climate Change (DECC), Highview Power energy storage,

Viridor obtained Planning Permission in 2010 and a PPC Permit in 2011 for the Dunbar ERF. The construction of the Dunbar ERF began in 2014. Main construction of the plant finished on 31st July 2018 and the commissioning end date was agreed with SEPA as the 28th June 2019.

The update to this Heat and Power Plan relates to updates in the design of the Dunbar ERF further to construction and design development, variations in recent legislation amendments and the current options for potential heat users. In line with SEPA guidelines, Viridor's ambition is to feed in to the heat network within seven years of cessation of commissioning.

1.2 Objective

Fichtner has been commissioned by Viridor to assess the feasibility of supplying heat from the Facility to local heat users. The principal objectives of this study are as follows.

1. Prepare a Heat and Power Plan in line with the requirements of SEPA's TTWG 2014.
2. Provide a description of the proposed facility and heat export infrastructure.
3. Assess the waste to be treated and its energy value.
4. Identify potential heat users from a desktop survey, as required by SEPA's TTWG.
5. Calculate the heat network capacity based on likely heat users.
6. Provide evidence of compliance with the energy recovery targets provided in Annex 1 of SEPA's TTWG 2014.
7. Produce provisional pipe routing drawing from the Facility to the likely heat users.

1.3 The Location

The Facility is located at the existing Dunbar waste treatment hub, situated on the east coast of Scotland, approximately 30 miles east of Edinburgh.

The site is bound to the south and west by the A1, and to the north by a railway To the east of the site is undeveloped land.

Approximately 500m to the northwest of the site lies a cement production facility which has been operating for over 50 years and is currently owned by Tarmac.

2 Conclusions

2.1 Technical Solution

The Facility includes two waste treatment/energy recovery lines, waste reception, waste storage, water, auxiliary fuel and air supply systems, boiler, facility for the treatment of exhaust gases, on-site facilities for treatment or storage of residues and waste water, flues, stack, devices and systems for controlling operation of the Facility, recording and monitoring conditions.

The Facility has been designed as a CHP plant and has capacity to export heat to heat users and to supply power to the National Grid. The turbine has been designed to generate up to 36 MW_e of electricity. The Facility has an average a parasitic load of 2.8 MW_e. It is proposed to export low grade heat to identified heat users, subject to the export of heat being technically and economic viable.

The Facility has been designed to thermally treat residual waste with a range of net calorific values (NCVs). The nominal design capacity of the thermal treatment line is approximately 18.8 tonnes per hour of waste, with an average NCV of 10.0 MJ/kg. The Facility is limited to processing325,000 tpa

A number of arrangements for heat recovery and export are available. Given the requirements of the end users (discussed subsequently), flexibility in terms of export temperatures and capacity, and the associated environmental benefits, steam extraction from the turbine is considered the most favourable solution. Heat will be transferred to a closed hot water circuit via a series of condensing heat exchangers and supplied to users through a pre-insulated buried hot water pipeline, before being returned to the Facility for reheating. This technology is well proven and highly efficient.

2.2 Power export

The Facility exports electricity by connecting to the local electricity distribution network operated by Scottish Power. The electrical connection is via a 33kV substation located at Oxwell Mains, southwest of the Facility. Electricity is exported via an on-site electrical substation and switchgear. Scottish Power granted the Facility a connection capacity of 36 MWe, which is sufficient to accommodate the maximum electrical output of the Facility.

2.3 Waste to be treated

The waste to be treated comprises up to 325,000 tpa of non-hazardous residual municipal waste with a nominal design capacity of approximately 300,435 tpa. In 2021, the waste had an average NCV of 10.28MJ/kg.

2.4 Heat export capacity

Based on knowledge of similar facilities (in terms of capacity and fuel specification) and the outline design proposed, it should be technically possible to export up to approximately 17 MW_{th} from the Facility. A higher heat export capacity will have an adverse impact on power export and power efficiency. Therefore, the heat network will need to be designed to take into account the estimated local demand and economic returns resulting from heat generation.

Steps has been taken during the design phase to ensure that the lower heat network demand seen in the initial stages of network operation can be met with reasonable efficiency, as well as providing scope for increasing the export capacity at later stages if feasible additional demand is identified.

2.5 Potential Heat Users

A review of potential heat demand within a 10km radius of the Facility has been undertaken. Heat demand identified using publicly available data and heat mapping tools has demonstrated insufficient heat demand in close proximity to the Facility to accept the maximum export capacity.

However, the following developments have been identified for their potential to be included in a district heating network.

1. Viridor has commenced discussions with East Lothian Council and Zero Waste Scotland on the best utilisation for the heat in the local area. Further conversations are planned for 2022 and a fuller update on progress will be given in the 2022 version of the Heat & Power Plan.
2. Scottish Power Energy Networks (SPEN) have proposed a convertor station and substation be built to the East of the ERF site as part of the Eastern Links Project. Depending on the final design, construction activities are estimated to take 2 to 3 years to enable the project to be fully up and running by 2027. Viridor plan to commence discussion with SPEN in 2022 to see if there are any heating or cooling requirements for the project where offtake heat from the ERF can be utilised.
3. Hallhill Developments controls a 21-hectare site which has been allocated as an extension to the Spott Road Industrial Estate. The East Lothian Development plan supports this allocation of land, which is proposed for employment uses. Estimates suggest a heat demand of 4,095 MWh/year could be generated from offices built on this site, resulting in an average heat load of 0.47 MWth. No further details are available for this proposed development, but the site location and potential heat load make it a potentially attractive heat consumer although this is not a large enough demand to be financially viable in its own right.
4. Upcoming residential developments, including dwellings in Brodie Road; The estimated heat demand is 8,206 MWh/year, equivalent to an average of 0.94 MWth. Whilst this is not a large enough demand to be financially viable in its own right, the location and stage of this project mean that the Brodie Road development could foreseeably be included in a wider district heating network.
5. Public buildings such as schools, council buildings and leisure centres in Dunbar could technically be connected to a district heating network. Retrofitting heat supply equipment to existing properties is expensive, but public buildings could represent a secure consumer base. Furthermore, the location of public buildings along the main routes in Dunbar encourages the expansion of the proposed heating network to other buildings throughout the town. Public buildings would use an estimated 4,988 MWh/year, equivalent to an average of 0.57 MWth.

The listed developments could all be foreseeably included in a district heating network, supplied by hot water, subject to design verification and commercial agreement. However, the low combined average heat usage of 1.11 MWth is unlikely to be sufficient to offset the capital investment required. The high capital cost of district heating equipment requires a relatively high volumes of heat to be exported in order to provide an attractive rate of return on investment and make the scheme financially viable.

Viridor has secured support under the CM and will continue to pursue future CM contracts, so any proposed heat network would be reliant on heat sales revenue exclusively (plus any additional grants available). The options for fiscal support from the Scottish Government are being monitored. If in the future a large heat consumer could provide a secure and substantial demand for heat, this would support the economic case for the installation of the district heating network, and subsequent smaller heat users could be connected incrementally at a reduced cost.

2.6 Heat Network Profile

The proposed district heating network will serve residential housing and offices for which significant variation in heat demand is typical. A heat demand profile has been derived from the sum of the individual heat load profiles to assess diurnal and seasonal variation in demand. Our analysis indicates that the average and diversified peak heat demand anticipated for the proposed district heating network is 2.21 MW_{th} and 5.38 MW_{th} (diversified) respectively.

Since the Facility has a maximum heat export capacity of 17 MW_{th}, the heat demand profile indicates that peak loads can be met by the Facility, except for periods of downtime. Therefore, peak lopping plant will not be required, but a back-up source of heat will be required.

The Torness Nuclear Power Station is located approximately 3.6 km to the east of the Facility, but is unlikely to offer a viable heat source for a district heating network since the safety case relies on independent and highly robust cooling systems. No alternative heat supply assets have been identified. It is therefore anticipated that oil or gas-fired boilers will supply the proposed district heating network when the Facility is unavailable. The option of using electric boilers may be considered in the future subject to a cost-benefit analysis and the availability of renewable electricity. Back-up boilers will be designed to ensure that the peak heat demand can be met but also provide sufficient turndown to supply smaller summer loads with reasonable efficiency.

2.7 Energy Efficiency Measures

The TTWG[1] 2014 sets out the approach of SEPA to permitting thermal treatment of waste facilities. SEPA expects that new waste thermal treatment plants achieve a minimum level of energy recovery. In order to demonstrate compliance, facilities processing over 70,000 tpa of fuel must meet or exceed a QI of 93 or an indicative overall efficiency of 35%.

Based on a Z factor of 6.6 (assuming steam extraction at a pressure of 2.4 bar(a) which is sufficient to meet the needs of identified consumers), the Facility will achieve a QI of 94.7 when exporting 2.21 MW_{th} when applying SEPA's QI calculation methodology. This arrangement would therefore exceed SEPA's energy recovery targets if implemented and demonstrate best practice in the thermal treatment of waste. To achieve the alternative indicative energy efficiency target of 35%, 4.65 MW_{th} of heat would need to be exported from the Facility.

Operating the Facility in CHP mode to deliver the 2.21 MW_{th} heat load to identified potential heat consumers would reduce the net electrical output of the facility from 30.9 MW_e to 30.6 MW_e.

Aside from financial viability, there is no reason (within the scope of our review) to suggest that the proposed heat network outlined in this Heat and Power Plan cannot be implemented within SEPA's recommendation of 5 to 7 years starting on cessation of commissioning of the Facility. Viridor has therefore committed to continue to review opportunities for a financially viable heat export scheme in light of new heat consumers and changes to the subsidy landscape as per Viridor's recent meeting either ELC Energy Transformation Board.

[1] SEPA Thermal Treatment of Waste Guidelines 2014, May 2014.

3 Legislative Requirements

The TTWG[2] sets out SEPA's approach to permitting facilities that thermally treat waste. The TTWG's state that any permit authorising the combustion of waste contain "conditions necessary to ensure the recovery of energy takes place with a high level of energy efficiency".

SEPA requires that new waste thermal treatment facilities achieve a minimum level of energy recovery. As a consequence, a Heat and Power Plan for a new waste thermal treatment plant is required to demonstrate that it can achieve at least 20 % (gross calorific value basis) energy recovery as electricity only, electricity and heat, heat only or as exported fuel (energy) equivalent on commissioning.

The design and construction of the Facility must provide for the available floor space / infrastructure / facilities to allow for the installation of additional energy recovery equipment, such as heat exchange and / or heat pump systems. A point of connection to allow steam / hot water to be taken to a heat recovery system will be required; for example, in the case of high efficiency electricity generating steam turbines, suitably designed steam off takes should be installed to provide high quality heat for use in an appropriate heat network.

The Heat and Power Plan must be maintained, implemented and reviewed on an annual basis. SEPA has a duty to ensure compliance if these conditions are not met.

The QI value is to be estimated and calculated in accordance with the relevant Combined Heat and Power Quality Assurance (CHPQA) method for the relevant type of thermal treatment facility and fuel type. The calculation must demonstrate that as a minimum the QI or efficiency values meet the energy recovery targets provided in Annex 1 of TTWG.

[2] SEPA Thermal Treatment of Waste Guidelines 2014, May 2014.

4 Description of the Facility Technology and Heat Network

4.1 The Facility

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

The Facility includes two combustion lines, a waste reception hall, main thermal treatment process, a turbine hall, on-site facilities for the treatment or storage of residues and wastewater, flue gas treatment, stack, boiler, systems for controlling operation of the waste combustion plant and recording and monitoring conditions.

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

Construction of the Facility commenced in 2014 and was fully commissioned by 28th June 2019.

The Facility has a nominal design gross electrical output of 33.7 MW_e, (when operating in fully condensing mode), with a parasitic load of 2.8 MW_e with the balance exported to the local grid. Therefore, the Facility exports approximately 30.93 MW_e in full condensing mode at the nominal design mode. However, the turbine has been designed to generate up to 36 MW_e of electricity.

The Facility can technically export up to 17 MW_{th} of heat to local users. The maximum heat capacity was confirmed during the detailed design stage and will be set as a minimum to meet the requirements of the heat users identified.

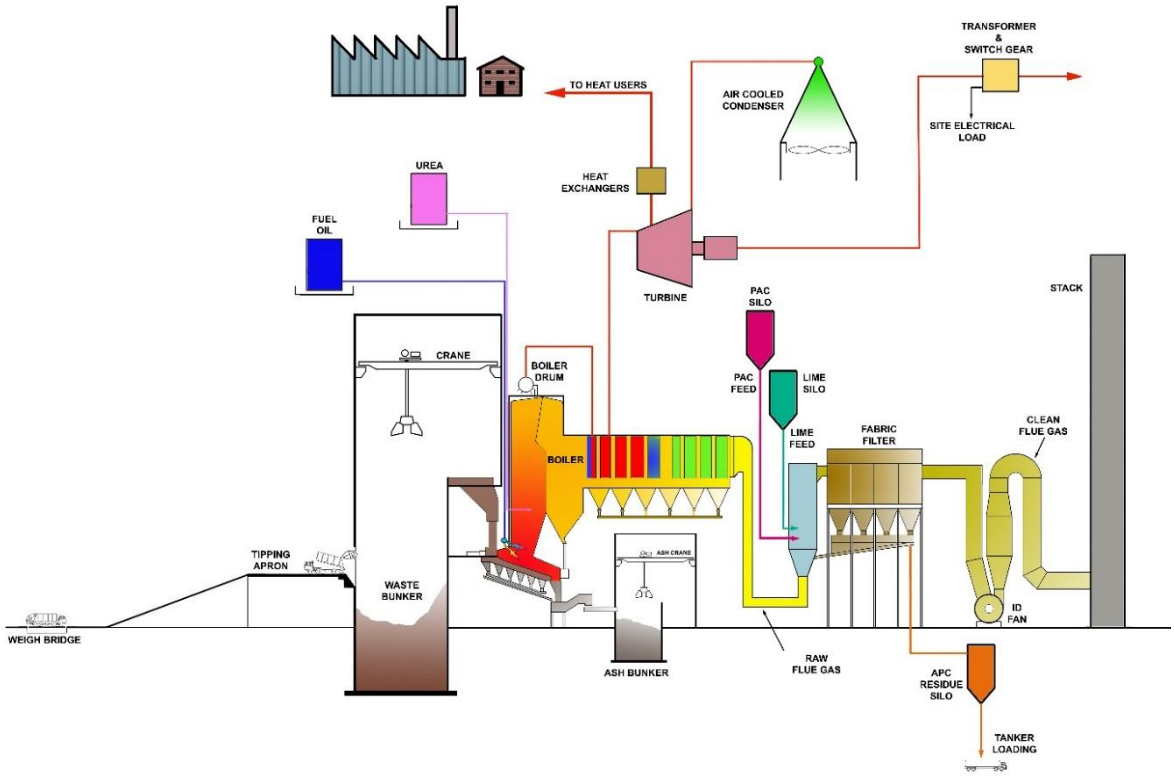
Based on the heat network identified within this Heat and Power Plan, the average heat load is expected to be 2.21 MW_{th}, resulting in electrical export of approximately 30.6 MW_e. However, at the time of writing this report, there are no formal agreements in place for the export of heat from the Facility. The power exported may fluctuate as fuel quality fluctuates, and if heat is exported from the Facility to local heat users in the future.

The nominal capacity of the Facility is approximately 38.52 tonnes per hour of residual waste, with an average net calorific value (NCV) of 10.00 MJ/kg. Therefore, with an estimated availability of 7,800 hours per annum, the Facility has a nominal design capacity of approximately 300,435 tonnes per annum. However, allowing for variations in the NCV of the waste, availability and the maximum hourly tonnage, the maximum capacity of the Facility is approximately 325,000 tpa.

4.1.1 Combustion Process

Figure 1 is an indicative schematic of the combustion process of the Facility.

Figure 1: Process schematic



4.1.2 Energy Recovery

The heat released by the combustion of the incoming waste is recovered by means of a water tube boiler, which is integral to the furnace and produces (in combination with superheaters) high pressure superheated steam. The steam from the boiler is then feed a high-efficiency steam turbine which generates electricity. The turbine has a series of extractions at different pressures that is used for preheating air and water in the steam cycle.

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

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

4.2 Grid connection

To export electricity from the Facility, it is necessary to provide a connection to the local electricity distribution network. Scottish Power is the local distribution network operator for Dunbar. Viridor has obtained and accepted a 36 MW_e connection offer from Scottish Power, which is sufficient to accommodate the maximum electrical output of the facility.

The electrical substation on site is complete and the switchgear is installed. The grid connection is completed and in service.

4.3 Details of Heat Supply System

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

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

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

2. Heat extraction from the steam turbine

Steam extracted from the steam turbine can be used to generate hot water for district heating schemes. District heating schemes typically operate with a flow temperature of 90 to 120 °C and return water temperature of 50 to 80 °C. Steam is preferably extracted from the turbine at low pressure to maximise the power generated from the steam. Extraction steam is passed through a condensing heat exchanger(s), with condensate recovered back into the feedwater system. Hot water is pumped to heat users 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 the lowest pressure bleeds on the turbine, depending on the heating requirements of the heat users.

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. The capacity of the bleeds cannot be increased once the turbine has been installed.

3. Heat extraction 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 district heating in the range 90 to 120 °C. This method of heat extraction does not significantly impact the power generation from the plant.

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

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

1. The heat requirements of the identified users (as described in section 6.2) are too high for the temperatures attainable from the turbine exhaust steam.
2. The use of a flue gas condenser would generate a visible plume which would be present for significant periods of the year. This is not desirable as it will significantly add to the visual impact of the Facility and as such has not been included.
3. Extraction of steam from the turbine offers the most flexibility for varying heat quality and capacity to supply variable demands or new future demands.
4. Extraction of steam from the turbine, heat transfer to a hot water circuit and delivery of heat to users can be facilitated by well proven and highly efficient technology.

5 Description of the Waste to be Treated

5.1 Proposed fuel and calorific value

The following table shows the fuel to be processed at the Facility to recover energy.

Table 1: Nominal Design Fuel Profile

	Throughput [1] (tonnes/year)	GCV (MJ/kg)	NCV (MJ/kg)
Waste input	300,435	11.58	10.00
Note 1: Assumed annual design average availability of 7,800 hours per annum.			

The following table shows the fuel that was processed at the Facility through the 2021 calendar year. Average GCV has been derived by Fichtner using the NCV provided by Viridor and adjusting based on Fichtner's experience of reasonable expected hydrogen and moisture content fractions.

Table 2: 2021 operational data

	Throughput (tonnes/year)	Average GCV for 2021 (MJ/kg)	Average NCV for 2021 (MJ/kg)
Waste input	307,237	11.77	10.28

5.2 Energy production

The following table summarises the relevant energy consumption and export design parameters for the Facility.

Table 3: Facility Design Energy Consumption and Export

Parameter	Unit	Value
Operational hours	hours	7,800
Availability	hours/hours	89.04%
Annual throughput (nominal design capacity)	tonnes/year	300,435
Average GCV	MJ/kg	11.6
Gross thermal input - fuel	MWh/year GJ MW_{th}	966,400 3,479,040 123.90
Gross electrical generation (fully condensing)	MWh/year (GJ) MW	262,860 946,296 33.70
Parasitic load (including electrical and support fuel)	MWh/year GJ MW	22,138 79,696 2.77

Parameter	Unit	Value
Heat export capacity[1] from the Facility	MWh/year GJ MW_{th}	132,600 477,360 17.00
Z factor	MW/MW	6.60
Net electrical export (CHP mode at heat export capacity of 17 MW_{th})	MWh/year GJ MW	221,163 796,187 28.35
[1]Calculated in accordance with system boundaries specified in Annex 3 of SEPA's TTWG 2014.		

The following table summarises the relevant energy consumption and export parameters for 2021 operational year.

Table 4: Facility 2021 Energy Consumption and Export

Parameter	Unit	Value
Annual throughput	tonnes/year	307,237
Average GCV[3]	MJ/kg	11.77
Gross thermal input - fuel	MWh/year GJ MW_{th}	1,004,494 3,616,179 128,78
Gross electrical generation (fully condensing)	MWh/year (GJ) MW	260,641 938,308 33.42
Parasitic load (including electrical and support fuel)	MWh/year GJ MW	23,117 83,223 2.89

5.3 Bio-energy content of waste

The Facility will not qualify for support under Contracts for Difference (CfD), since it utilises conventional direct-burn technology.

Viridor has been granted support under the CM, which is the UK Government's principal mechanism for ensuring security of electricity supply. The Facility is therefore not be eligible for alternative renewable subsidies. Consequently, an assessment of the bio-energy content of the fuel is not required for the purposes of determining financial incentives. However, based on our experience of similar projects and fuel supply agreements, we anticipate the pre-treated waste to maintain a bio-energy connect of approximately 50%.

[3] Assumed 1.1 of NCV

6 Heat Demand Investigation

6.1 Wider Heat Export Opportunities

6.1.1 The National Comprehensive Assessment

'National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK'[4] (the NCA), dated 16 December 2015, was published by Ricardo AEA Ltd on behalf of the Department of Energy and Climate Change (now part of the Department for Business, Energy and Industrial Strategy). The report was produced to fulfil the requirement (under Directive 2012/27/EU on energy efficiency) on all EU Member States to undertake a National Comprehensive Assessment (NCA) to establish the technical and socially cost-effective potential for high-efficiency cogeneration. The report also sets out information pertaining to heat policy development in the UK. Due to the low resolution of the data, the results of the NCA can be considered as an overview only.

Table 5 details the heat consumption in 2012 and estimated consumption in 2025 by sector for Scotland as extracted from the NCA. Heat consumption is greatest in the industrial and residential sectors. The estimated heat consumption in 2025 is lower than in 2012, most notably in the commercial and industrial sectors. The energy projections take account of climate change policies where funding has been agreed and where decisions on policy design are sufficiently advanced to allow robust estimates of policy impacts to be made, including measures such as building regulations.

Table 5: Heat consumption in Scotland

Sector	2012 consumption (TWh/annum)	2025 consumption (TWh/annum)
Industry (including agriculture)	22	21
Commercial services	5	3
Public sector	3	2
Residential	31	31
Total	**60**	**57**

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

Current and projected space cooling consumption data is detailed in Table 6. 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.

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

Table 6: Cooling consumption in Scotland

Sector	2012 consumption (TWh/annum)	2025 consumption (TWh/annum)
Industry (including agriculture)	1	1
Commercial services	1	0
Public sector	0	0
Total	**2**	**2**

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

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

6.1.2 UK CHP Development Map

The Department for Business, Energy and Industrial Strategy (BEIS) UK CHP Development Map[5] geographically represents heat demand across various sectors in England, Scotland, Wales and Northern Ireland. A search of heat users within 15 km of the Facility was carried out, as shown in Table 7. This is represented as coloured contour areas in Figure 2, with each colour band representing a range of heat demand density values.

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

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

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

Table 7: Heat demand within 10 km of the Facility

Sector	Heat demand	
	MWh/a	% share
Communications and Transport	-	0%
Commercial Offices	1,006	0.74%
Domestic	95,632	70.49%
Education	1,908	1.41%
Government Buildings	33	0.02%
Hotels	686	0.51%
Large Industrial	32,944	24.28%
Health	742	0.55%
Other	50	0.04%
Small Industrial	180	0.13%
Prisons	-	0%
Retail	1,479	1.09%
Sport and Leisure	984	0.73%
Warehouses	22	0.02%
District Heating	-	0%
Total heat load in area	**135,665**	**100.00%**

Source: UK CHP Development Map

Figure 2: Local heat demand density

Source: UK CHP Development Map

The heat demand in the area surrounding the Facility is predominantly from the domestic and retail sectors. 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 users to a network. In order to secure the most economically viable heat network, the potential heat users which will provide maximum return and carbon saving for the minimum cost have been identified. Therefore, the approach to this study has focused on industrial and commercial heat users and new developments within the search radius.

Section 6.2 identifies potential heat users that would provide maximum return and carbon saving.

6.1.3 Large Heat Users

One large heat user (point heat demands greater than 5 MW_{th}) was identified within 10 km of the Facility through the BEIS UK CHP Development Map[6] tool.

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

Table 8: Large Heat User

Site	Heat demand (MWh/annum)	Distance from the Facility (m)
Large Cement Works	32,944	500

A cement works, owned by Tarmac, is located approximately 500m to the northwest of the Facility. The production of cement is a heat-intensive process, requiring heat in the crushing, grinding and mixing processes, as well as to fire the kiln.

The kiln requires high grade heat at around 1,400°C which is supplied through direct combustion of high calorific value fuels. The crushing, grinding and mixing processes recover heat from the kiln flue gases for drying and to maintain process temperatures.

Therefore, as it currently operates, the cement works is unlikely to be able to use low-grade heat available from the Facility. If the cement production process changes in the future, the cement works could become an attractive consumer, using large quantities of heat in close proximity to the Facility, subject to technical feasibility and the operator agreeing to any potential process interruptions to connect to the heat network. Viridor has committed to frequently reviewing process heat demands in the area local to the Facility.

6.2 Identified heat consumers

The following section identifies the heat consumers who could foreseeably be included in a district heating network and presents an analysis of their heat loads. Records of stakeholder engagement can be found in Appendix C.

6.2.1 Commercial properties

The January 2017 issue of the Dunbar ERF Heat and Power Plan identified a range of retail and commercial buildings which could be incorporated in a district heating scheme. Whilst several potential developments were identified, Fichtner is unaware of any publicly-available updates to the plans for these developments. Therefore, the expected commercial heat demand remains unchanged from the January 2017 Dunbar ERF Heat and Power Plan, as presented in Table 9.

As these buildings are constructed with gas-fuelled heating systems, incorporating them in a district heating network would require the retrofitting of heat supply equipment, incurring high capital costs. Furthermore, relying on a high number of smaller heat consumers introduces a significant level of commercial uncertainty.

Table 9: Commercial heat demand

Property	Estimated heat demand (MWh/year)	Percentage of gross electrical export (%)
Hotel	296	0.11
Supermarket	650	0.25
Retail units	520	0.20
Pubs	3,240	1.23
Restaurants and cafes	990	0.38
Total	**5,696**	**2.17**

In the January 2017 Dunbar ERF Heat and Power Plan, a 20,000 sq ft retail complex with restaurants was identified as a potential future heat consumer. The presence of a large heat demand in one location would represent a potentially attractive anchor heat load. Furthermore, heat supply equipment could be installed during construction of the development, reducing capital costs.

Discussion between Viridor and local planners indicated that this development was in the pre-planning phase as of January 2017. We understand (from Viridor) that limited progress has been made in respect of this development, so it has not been included in this version of the Heat and Power Plan. However, should this development proceed in the future, it could form a key heat consumer upon which a district heating network could be established.

6.2.2 Residential properties

Construction of the residential housing developments identified in the January 2017 issue of the Dunbar ERF Heat and Power Plan have been completed with conventional gas heating. Therefore, connection of these buildings to a district heating network is likely to be financially prohibitive.

In May 2017, a planning application (reference) was submitted for 73 houses and 8 flats on land south of Brodie Road, Dunbar. This site is located approximately 900m west of the Spott Road industrial estate (discussed in Section 6.2.6), and would be less than 1km from a potential heat distribution pipework corridor between the Facility and Dunbar. East Lothian Council has since been granted planning permission for 68 dwellings. This development is located approximately 4.5 km from Dunbar ERF. Therefore, the development could foreseeably be connected as part of a DHN, assuming a connection is secured Therefore, the development could foreseeably be connected as part of a district heating network.

Additional residential developments, within 6 km from Dunbar ERF, have been identified as potential heat users that could foreseeably connect to the DHN. This list is not exhaustive and there may be more residential developments that may come forward in the future.

The estimated heat demands of the existing residential buildings, along with the new Brodie Road development and new developments that have come forward since January 2020 are presented in Table 10.

Table 10: Residential building heat demands

Buildings	Estimated heat demand (MWh/year)
Existing residential housing	9,549
New developments:	**8,206**
Beveridge Road	586
Brodie Road development	456
Newtonlees Farm	748
9 Bayswell Road Dunbar	130
Hallhill, Dunbar	911
Coastguard Site, Dunbar	97
Assembly Rooms Dunbar	66
"Hallhill Southwest Dunbar Phases 4-7 (Private) "	1,561

Buildings	Estimated heat demand (MWh/year)
"Hallhill Southwest Dunbar Phases 1-3 (Affordable) "	846
Hallhill Southwest Dunbar (82 Private)	520
Hallhill Southwest Dunbar (49 Private)	326
Hallhill Southwest Dunbar (24 Private)	163
Hallhill North Dunbar (25% Affordable)	1,352
Station Road Field Dunbar	130
Pleasance Farm Dunbar	130
Dairy Cottage Thurston Dunbar	66
St Andrews Centre Bayswell Road	118
Total	**17,752**

6.2.3 Public properties

East Lothian Council has previously been consulted in relation to the development of the January 2017 Dunbar ERF Heat and Power Plan with positive response. Whilst public properties exclusively are unlikely to provide sufficient heat demand to make a district heating network economically viable, they would provide a relatively secure base load.

Many of the identified public properties are located along the main routes within Dunbar. However, it is likely that additional heat consumers along the proposed route would have to be connected to the network to secure sufficient heat export capacity.

Public properties which could be included in a district heating network are presented in Table 11.

Table 11: Public property heat demands

Property	Estimated heat demand (MWh/year)
Dunbar Area Office (East Lothian Council)	1
Bleachingfield Community Centre	14
Dunbar Town House	65
Hallhill Leisure Facility	222
Dunbar Primary Lochend Campus	386
Dunbar Primary, John Muir Campus	700

Property	Estimated heat demand (MWh/year)
Dunbar Grammar School	1,100
Dunbar Leisure Pool	2,500
Total	**4,988**

6.2.4 Industry

A cement works, owned by Tarmac, is located approximately 500m to the northwest of the Facility. The production of cement is a heat-intensive process, requiring heat in the crushing, grinding and mixing processes, as well as to fire the kiln.

The kiln requires high grade heat at around 1,400°C which is supplied through direct combustion of high calorific value fuels. The crushing, grinding and mixing processes recover heat from the kiln flue gases for drying and to maintain process temperatures.

Therefore, as it currently operates, the cement works is unlikely to be able to use low-grade heat available from the Facility. If the cement production process changes in the future, the cement works could become an attractive consumer, using large quantities of heat in close proximity to the Facility, subject to technical feasibility and the operator agreeing to any potential process interruptions to connect to the heat network. Viridor has committed to frequently reviewing process heat demands in the area local to the Facility.

6.2.5 Heat storage technology

Viridor is exploring a variety of potential heat storage technologies that may support Dunbar ERF's heat generation. Heat storage technologies may be charged with a compatible heat source and transported to a different location where the heat can be utilised by a consumer.

Viridor is exploring opportunities of a traditional heat store utilising hot water. This would be an effective approach that can be readily sized to meet any potential heat outages against heat demand.

Heat storage opportunities will continue to be explored by Viridor and considered in future Heat and Power Plans. There has been no movement on this since the last report was issued in January 2021

6.2.6 Spott Road industrial estate

The extension of the Spott Road industrial estate was identified in the January 2017 revision of the Dunbar ERF Heat and Power Plan. The East Lothian Local Development Plan, submitted to Scottish Ministers in mid-2017, supports the allocation of this land for employment uses, but no further detail on the nature of the proposed development has been made publicly available.

Hallhill Developments, who controls the 21-hectare expansion site, has previously expressed an interest in working with Viridor. As heat network distribution pipework between the Facility and Dunbar would pass within 1km of the expansion site, it could be foreseeably connected as part of a wider district heating network.

Heat estimates remain unchanged from those presented in the January 2017 Dunbar ERF Heat and Power Plan, as shown in Table 12.

Table 12: Industrial extension heat demand

Property	Estimated heat demand (MWh/year)
Extension to Spott Road Industrial Estate	4,095
Total	**4,095**

6.2.7 Agriculture and horticulture

In the previous Heat and Power Plans, Viridor was exploring opportunities to export heat to two local agricultural developments. It has since been confirmed (by Viridor) that these two premises are not interested in undertaking heat-intensive activities (e.g. growing fruit commercially) at this time. Nonetheless, Viridor has committed to continuing to monitor opportunities for export of heat to intensive agricultural developments.

6.3 Estimated Overall Heat Load

Broad assumptions have been made regarding the estimated heat demand from existing potential heat users. Heat demands have been calculated based on benchmark figures from the Chartered Institution of Building Services Engineers (CIBSE) Guide F (Energy Efficiency in Buildings). This document provides good practice benchmark figures based on energy performance of existing buildings. In the CIBSE Guide, loads are expressed in terms of kWh per square metre of floor space per year of fossil fuel use (natural gas is typically assumed). Based on estimates of floor areas and an assessment of the development type, it is possible to estimate annual energy usage. Converting natural gas use to actual heat loads (which can be provided by a hot water distribution system) requires an assumption of gas-fired boiler efficiency. An efficiency of 80 % is assumed, based on industry norms.

Based on the justification presented in section 6.2, the buildings presented Table 13 represent the most favourable solution for a heat network supplied by the Dunbar ERF, including both existing and proposed developments. Whilst all public buildings have been included, this presents a best-case-scenario and it is unlikely that all of these buildings will be connected, due to location and other constraints. The total annual heat export, and average and peak instantaneous network values are projected in Table 13. Adjusted heat demands, taking into account heat transmission losses (calculated using network peak demand as a conservative approach) and consumer diversity, are provided in Table 13, for the proposed district heating network.

Table 13: Proposed heat network demand

	Annual Heat Load (MWh/a)		Average heat demand (MWth)		Peak heat demand (MWth)	
	At point of use	Accounting for pipe losses	At point of use	Accounting for pipe losses	Peak winter value	Accounting pipe losses and diversified
Public buildings	4,988	5,957	0.57	0.68	1.94	1.64
Spott Road Industrial Estate extension	4,095	4,643	0.47	0.53	1.34	1.12
Residential development	8,206	8731.6	0.94	1.00	3.21	2.62
Total	**17,289**	**19,331**	**1.97**	**2.21**	**6.49**	**5.38**

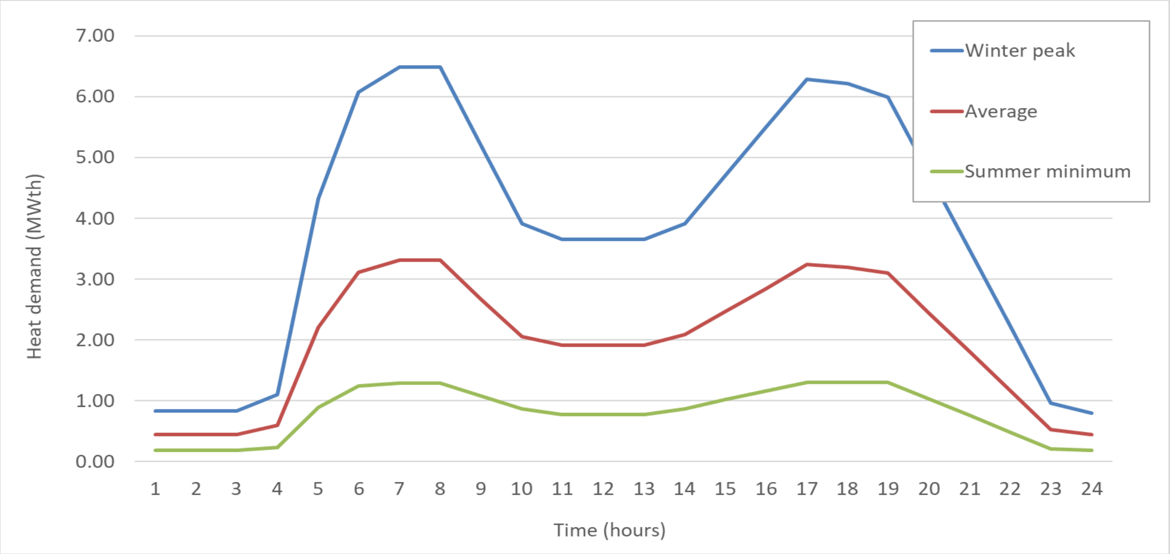
7 Heat Network Technical Solution

7.1 Heat Network Profile

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

The heat network profile for the proposed heat network is shown in Figure 3 and illustrates the variation in heat demand during a typical day in different seasons. The profile represents heat demand at the point of use and therefore does not include network heat losses.

Figure 3: Heat network profile



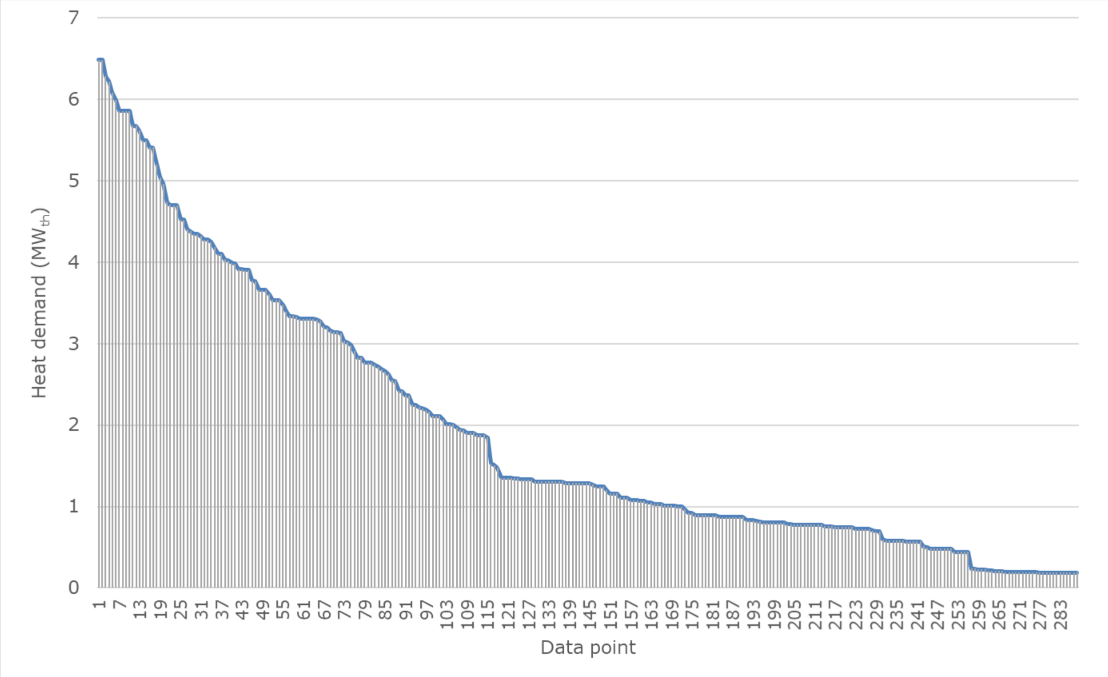
Daily and seasonal variation in heat demand is typical for heat networks serving industrial, commercial and office user types, which form the basis of the proposed heat network. Increasing the number and type of users connected to a network diversifies heat demand and helps to reduce the impact of the peak demand of any individual user, since it is less likely that peak demands will coincide.

7.1.1 Heat Load Duration Curve

The heat load duration curve presented in Figure 4 displays the instantaneous heat demand for the proposed heat network, arranged in order of decreasing magnitude, across the year.

Since detailed heat demand data is not available at this stage, the heat load duration curve has been developed on the basis of instantaneous heat demand at each hour of the day for each month, producing a total of 288 data points (24 hours/day x 12 months/year). This demand data does not account for diversity or heat losses.

Figure 4: Heat load duration curve, plotting heat demand (in MW_{th}) for each data point



7.2 Heat Network Design

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

Modern heat-insulated piping technology enables hot water to be transferred large distances without significant losses, and heavier-duty insulation (plus the addition of a diffusion layer to the pipe) can reduce these losses further. Where the topography creates challenges, heat exchangers and additional pumping systems can be installed to create pressure breaks, enabling the network to be extended.

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

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

The following conservative design criteria relate to a typical hot water network utilising conventional heat extraction (as detailed in section 4.3) supplying existing buildings and have been used to size the heat transmission pipe diameters. Where possible, the flow temperature will be reduced to below 100°C to minimise heat losses and this will be subject to the requirements of the heat users. Flow and return temperatures presented in Table 14 have been selected on the basis of the likely requirements of identified heat users.

Table 14: District heating network design criteria

Parameter	Value
Water supply temperature to user	100°C
Water return temperature from user	70°C
Distance between flow and return pipes	150 mm
Soil temperature	10°C
Depth of soil covering	600 mm

Using the above design criteria and allowing for the estimated heat demand for the preferred network, the primary hot water transmission pipe size has been calculated as DN200, reducing along the length of the pipe network to DN25 at the user located farthest from the Facility. This is an indicative figure and will be subject to heat demand verification and subsequent network design. Assuming the difference between the flow and return temperatures (deltaT) remains constant, it will be possible to reduce the flow temperature without impacting the pipe size and thereby reduce system energy losses. It is noted that current best practice for district heating is to have a water supply temperature of under 100°C to reduce energy losses. The ability to operate at lower supply temperatures whilst still maintaining a high deltaT is governed by the design of the consumers heating system. It is more difficult for consumers with older systems to meet this requirement.

7.3 Additional Heat Sources

To maximise the benefits associated with developing a district heating network, a review of heat sources in the area surrounding the Facility has been undertaken. Additional heat sources could increase the capacity of the heat network and the associated benefits.

According to the National Heat Map[7], there are no point heat sources within a 10km radius of the Facility. However, a manual search reveals that the Torness Nuclear Power Station is situated 3.6km due east of the Facility. Torness Nuclear Power Station is unlikely to offer a viable heat source for a district heating network since the safety case relies on independent and highly robust cooling systems. The operator and Government nuclear regulator are unlikely to consent to a infrastructure interface to an off-site (uncontrolled) location.

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

7.4 Back-up Heat Sources

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

Depending on the heat demands of individual consumers, it could be more efficient to install back-up boilers at the point of use. This would also give consumers direct control over their heating at times when heat from the Facility is not available.

[7] http://nationalheatmap.cse.org.uk/

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

The standby plant will likely comprise oil– or gas-fired hot water heaters (boilers) with a separate dedicated chimney stack. Our analysis of local heat demand indicates that the average and peak heat load anticipated is 2.21 MW_{th} and 5.38 MW_{th} respectively (Section 6.3). The option of using electric boilers may be considered in the future subject to a cost-benefit analysis and the availability of renewable electricity.

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.

Based on the operational availability of the Dunbar ERF, it is anticipated that the back-up boilers will be in operation for approximately 960 hours per year. Based on heat load available, it is anticipated that the boilers will not be required for peak heat demand lopping.

7.5 Considerations for Pipe Route

At the present time, no definitive fixed route has been established for the connections from the Facility to the various potential heat users since no specific agreements have been made. However, an indicative pipe route is presented in Appendix A. Pipework would run west along the A1 towards Dunbar, north up Spott Road and then west on the A1087 through the town of Dunbar. This would result in an indicative pipe length of 7.4km.

Planning permission, easements and Highways Licenses would need to be obtained for access, construction, and maintenance of the pipeline infrastructure. There is a significant financial implication for obtaining easements, and these would only be progressed once heat supply agreements put in place. Traffic management requirements would need to be agreed prior to being able to obtain the necessary Highways Licenses granting permission to install the pipework. The projected timetable for the development of the heat mains is detailed in Section 7.6.

Discussion with the potential heat users will be entered into which, if successful, would lead into the production of heat supply agreement and designs for the pipework. A full economic analysis will be undertaken, considering the costs associated with pipe installation and lost electricity revenue in order to determine a suitable heat price per unit, when there is greater clarity surrounding heat network design.

7.6 Implementation Timescale

Construction of the Facility commenced in 2014 and commissioning was completed on 28th June 2019.It should be noted that Viridor would like the heat export project to be completed well within the recommendation of 5 to 7 years from cessation of commissioning, as stated in the TTWG's. The start of the construction of the heat system will be dependent on the viability of the system and the location of the heat users. For example, planning and gaining consent for installation of the pipework off the site would take a significant amount of time due to the potential impact on local traffic management. Until a core of heat users have been identified and contracted to take heat, pipeline installation will not commence.

The TTWG's requires the relevant energy recovery efficiency targets (as discussed in Section 8) to be achieved within the shortest practicable time. Except for financial viability, there are no reasons (within the scope of this review) to suggest that the heat network outlined in this Heat and Power Plan cannot be implemented within the requirements of the TTWG's.

Additional information regarding the implementation timescales for the heat network are not available at this stage. When the Applicant is in a position to implement a district heating network, this will be agreed with SEPA. However, this will not be possible until there is more certainty over the progress of developments which will be required to implement a scheme.

8 Achievement of Energy Efficiency Threshold

8.1 Heat and power export

The Z ratio, which is the ratio of reduction in power export for a given increase in heat export, can be used to calculate the effect of variations in heat export on the electrical output of the facility. A value of 6.6 was obtained following CHPQA Guidance Note 28[8], assuming steam extraction at a pressure of 2.4 bar(a), which is considered sufficient to meet the requirements of the consumers identified in this Heat and Power Plan.

Fichtner has modelled heat and power export across a range of load cases, for both design data 2021 operational data, and the results are presented in Table 15.

Table 15: Heat and Power Export

Load Case		Annual Heat Export at Turbine (MW)	Gross Power Generation (MW)	Net Power Exported (MW)	Z Ratio
Design case					
1.	No heat export	0.0	33.7	30.9	N/A
2.	Average heat load required for QI value of 93	0.60	33.6	30.8	6.60
3.	Average network heat load	2.21	33.4	30.6	6.60
4.	Heat load required for indicative overall efficiency of 35%	4.65	33.0	30.2	6.60
5.	Maximum heat export capacity	17.00	31.1	28.4	6.60
2021 operational data					
1.	No heat export	0.0	33.4	30.5	N/A
2.	Average heat load required for QI value of 93	4.89	32.7	29.8	6.60
3.	Average network heat load	2.21	33.1	30.2	6.60
4.	Heat load required for indicative overall efficiency of 35%	5.51	32.6	29.7	6.60
5.	Maximum heat export capacity	17.00	30.8	27.9	6.60

An annual average of at least 0.6 MW_{th} must be exported in order to achieve the QI threshold of 93 as demonstrated by load case 2. The results indicate that for the heat users identified in section 6.3, load case 3 corresponding to an average heat export of 2.21 MW_{th} will result in a net power export of 30.6 MW_e.

[8] https://www.chpqa.com/guidance_notes/GUIDANCE_NOTE_28.pdf

8.2 Energy recovery efficiency targets

TTWG:

The TTWG states that the Heat and Power Plan must demonstrate, within a period of seven years from cessation of commissioning, further energy can be recovered over and above the initial operational energy recovery. Specifically, the Heat and Power Plan must provide details of how the Applicant proposes to achieve the relevant the QI value or Indicative Efficiency specified in Annex 1 of the TTWG's and should give an indication of anticipated progress for each year up to the end of the heat plan period.

TTWG states that the QI value is to be estimated and calculated in accordance with the relevant Combined Heat and Power Quality Assurance (CHPQA) method for the relevant type of thermal treatment facility and fuel type. The calculation must demonstrate that as a minimum the QI or efficiency values meet the energy recovery targets provided in Annex 1 of the TTWG.

Annex 1 of the TTWG requires facilities processing over 70,000 tpa of fuel to meet or exceed the following criteria:

- QI value ≥ 93; or
- indicative overall efficiency ≥ 35%, in order to demonstrate best practice for thermal treatment of waste facilities.

CHPQA:

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 achieved at the design, specification, tendering and approval stages. Under normal operating conditions (i.e. when the scheme is operational) the QI threshold drops to 100. The QI for CHP schemes is a function of their heat efficiency and power efficiency according to the following formula.

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

where: 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 (GCV) of the input fuel. The heat efficiency is also based on the GCV 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.

We have used GN 44 Quality Index formulae stated in the original application Heat and Power Plan for the Facility. The following X and Y coefficients apply to the Facility:

X value = 350; and

Y value = 120.

It is noted that there are a number of differences between the CHPQA method and SEPA requirements with regards to efficiency calculations and system boundaries. We have calculated the QI and efficiency values in accordance with the TTWG for various load cases and the results are presented in Table 16.

Table 16: QI and efficiency calculations

Load case		Gross power efficiency (%), GCV	Heat efficiency (%), GCV	Overall efficiency (%), GCV	CHPQA QI
Design case					
1.	No heat export	26.4%	0.0%	26.4%	92.5
2.	Average heat load required for QI value of 93	26.1%	1.5%	27.6%	93.1
3.	Average network heat load	25.1%	5.5%	30.7%	94.7
4.	Heat load required for indicative overall efficiency of 35%	23.9%	11.2%	35.0%	96.9
5.	Maximum heat export capacity	18.6%	33.8%	52.5%	105.8
2021 operational data					
1.	No heat export	25.2%	0.0%	25.2%	88.2
2.	Average heat load required for QI value of 93	22.7%	11.3%	34.0%	93.0
3.	Average network heat load	24.0%	5.3%	29.4%	90.5
4.	Heat load required for indicative overall efficiency of 35%	22.4%	12.6%	35.0%	93.6
5.	Maximum heat export capacity	17.9%	32.8%	50.8%	102.1

Annex 1 of TTWG states that facilities processing over 70,000 tpa of fuel must meet or exceed the following criteria:

- QI value ≥ 93; or
- indicative overall efficiency ≥ 35%, in order to demonstrate best practice for thermal treatment of waste facilities.

As demonstrated in Table 16, the Facility will exceed the QI threshold in all heat export cases, thereby exceeding SEPA's energy recovery targets.

For reference, an average heat export of 4.65 MW_{th} is required to achieve overall efficiency of 35 %, as demonstrated by load case 4. However, as only one of these requirements needs to be met, the Facility will be considered to demonstrate best practice for thermal treatment of waste when exporting heat to the preferred consumers identified in this Heat and Power Plan.

It is estimated that the maximum heat export capacity will exceed the overall efficiency threshold of 35% and that it is technically possible, subject to the detailed design process, for the Facility to export this amount of heat.

8.3 BAT 20 of WI BREF - Gross Electrical Efficiency

The Industrial Emissions Directive (IED), which was adopted on 7 January 2013, is the key European Directive which covers almost all regulation of industrial processes in the EU. Within the IED, the requirements of the relevant sector BREF become binding as BAT Conclusions. The WI BREF[9] was published in 2019. This includes, as section 5, the BAT Conclusions.

BAT 20 states that the BAT-Associated Energy Efficiency Levels (referred to as BAT-AEELs) for Gross Electrical Efficiency for an existing waste incineration plant is 20-35%. The Gross Electrical Efficiency of the Facility has been calculated in accordance with the requirements of BAT 20, refer to Table 17. The methodology for calculating efficiency is different between the TTWG and the Draft WI BATC; therefore, the reported efficiencies are different between Table 16 and Table 17.

For the purposes of the TTWG's, power efficiency is calculated using the gross electrical output based on the gross calorific value (GCV) of the input fuel. The calculation method used in Table 16 in section 8.2 of this Heat and Power Plan is based on the method described in Annex 3 of the TTWG.

However, for the purposes of the Draft WI BATC, gross electrical efficiency is calculated using the gross electrical output based on the net calorific value of the input fuel and shown in Table 17.

Table 17: BAT 20- Gross electrical efficiency

Load Case	Annual Heat Export at Turbine (MW)	Gross electrical efficiency (%), NCV	BAT-AEEL (%) Gross electrical efficiency (NCV) New plant
Nominal Design case			
1. No heat export	0.0	31.50%	20-35
3. Average network heat load	2.21	31.18%	20-35
5. Maximum heat export capacity	17.0	29.09%	20-35
2021 operational data			
1. No heat export	0.0	29.71%	20-35
3. Average network heat load	2.21	29.41%	20-35
5. Maximum heat export capacity	17.0	27.42%	20-35

As shown in Table 17, the gross electrical efficiency of the Facility for each load case is in accordance with the BAT-AEELs.

8.4 CHP Boundary Calculations

The figures presented below show the system boundary diagrams used for calculating energy efficiencies in this Heat and Power Plan. The diagrams are based on the method described in Annex 3 of the TTWG. The contents of the figures are as follows:

1. Figure 5 is for Load case 1 with no heat export; and
2. Figure 6 is for Load case 2 with average heat network load.

[9] https://eippcb.jrc.ec.europa.eu/sites/default/files/2020-01/JRC118637_WI_Bref_2019_published_0.pdf

The heat and power efficiencies were calculated by following the methods as listed in TTWG. The calculations behind Figure 5 and Figure 6 are described as follows:

1. Figure 5 is for Load case 1 with no heat export:
   a. Energy input (annual basis):
      i. Waste
         Annual input = 834,542 tonnes/year
         Gross calorific value = 11.58 MJ/kg
         Energy input = (834,542 x 107 x 11.58 x 10^{-3}) /3.6 = 966,400 MWh/year
      ii. Support fuel
         Energy input = 6,230 MWh/year
      iii. Total electric power = 2.8 x 7,800 + 0.55 x 960= 22,138 MWh/year
         Parasitic Load - on line = 2.8 MW
         Parasitic Load – downtime = 0.55 MW
      iv. Return heat from users = 0 MWh/year
      v. Total energy input based on GCV
         = 966,400 + 6,230 + 22,138
         = 994,767 MWh/year
   b. Energy outputs and efficiency:
      i. Power efficiency = Electrical Power provided to external users / total energy input
         = 262,860 MWh / 994,767 MWh
         = 26.4 %
      ii. Heat efficiency = heat energy provided to external users / total energy input
         = 0 MWh / 994,767 MWh
         = 0 %
      iii. Overall indicative efficiency = total energy exported / total energy input
         = (262,860 MWh + 0) / 994,767 MWh
         = 26.4 %
2. Figure 6 is for Load case 2 with average heat network load:
   a. Energy input (annual basis):
      i. Waste
         Annual input = 834,542 tonnes/year
         Gross calorific value = 11.58 MJ/kg
         Energy input = (834,542 x 107 x 11.58 x 10^{-3}) /3.6 = 966,400 MWh/year
      ii. Support fuel
         Energy input = 6,230 MWh/year
      iii. Total electric power = 2.8 x 7,800 + 0.55 x 960= 22,138 MWh/year
         Parasitic Load - on line = 2.8 MW
         Parasitic Load – downtime = 0.55 MW
      iv. Return heat from users = 40,062 MWh/year
      v. Total energy input based on GCV
         = 966,400 + 6,230 + 22,138 + 40,062
         = 1,034,829 MWh/year

b. Energy outputs and efficiency:
    i. Power efficiency = Electrical Power generated / total energy input
    = 260,248 MWh / 1,034,829 MWh
    = 25.1 %
    ii. Heat efficiency = heat energy provided to external users / total energy input
    = 57,300 MWh / 994,767 MWh
    = 5.5 %
    iii. Overall indicative efficiency = total energy generated/ total energy input
    = (260,248 MWh + 57,300) / 1,034,829 MWh
    = 30.7 %

Figure 5: CHP Boundary Diagram Load Case 1: No Heat Export

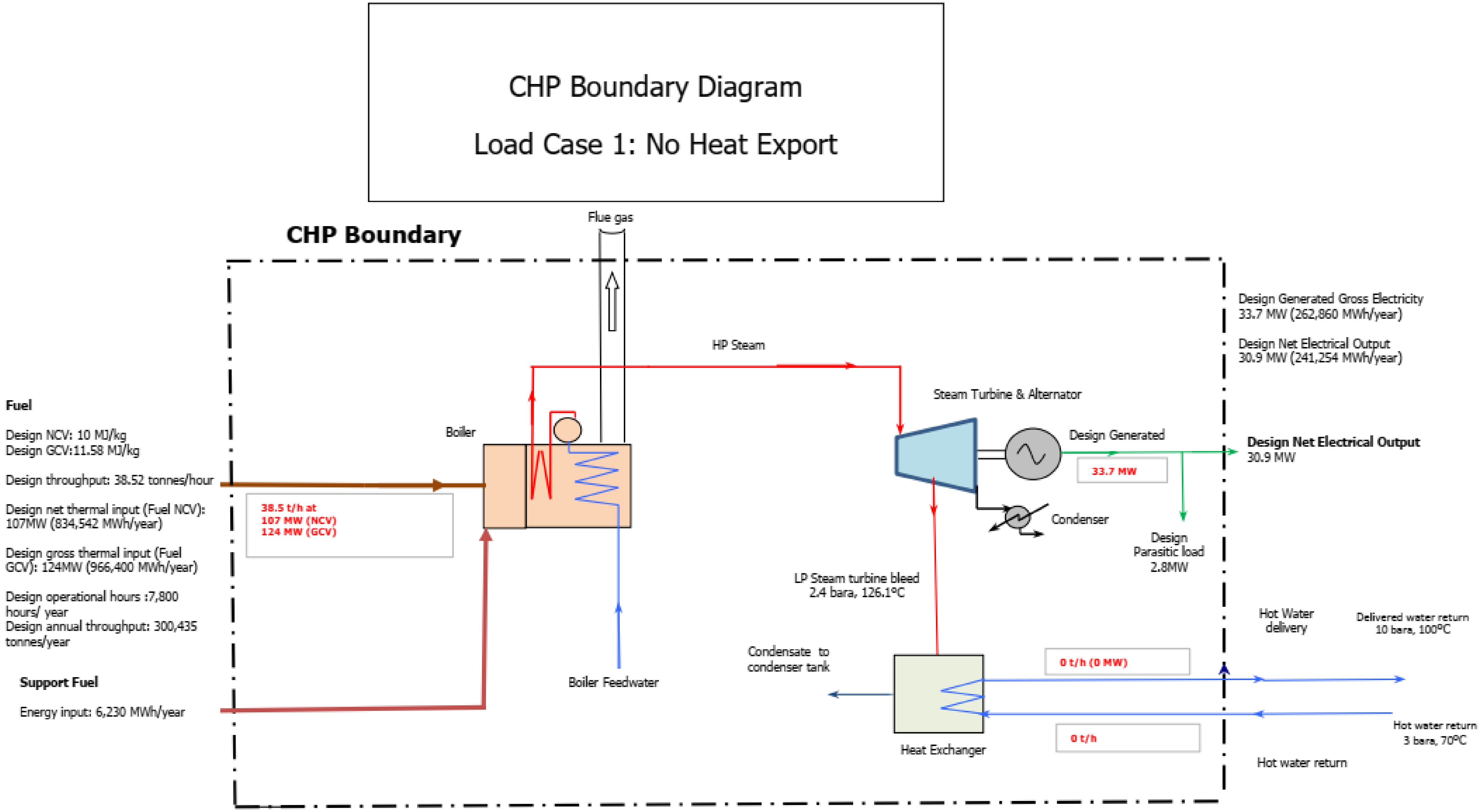
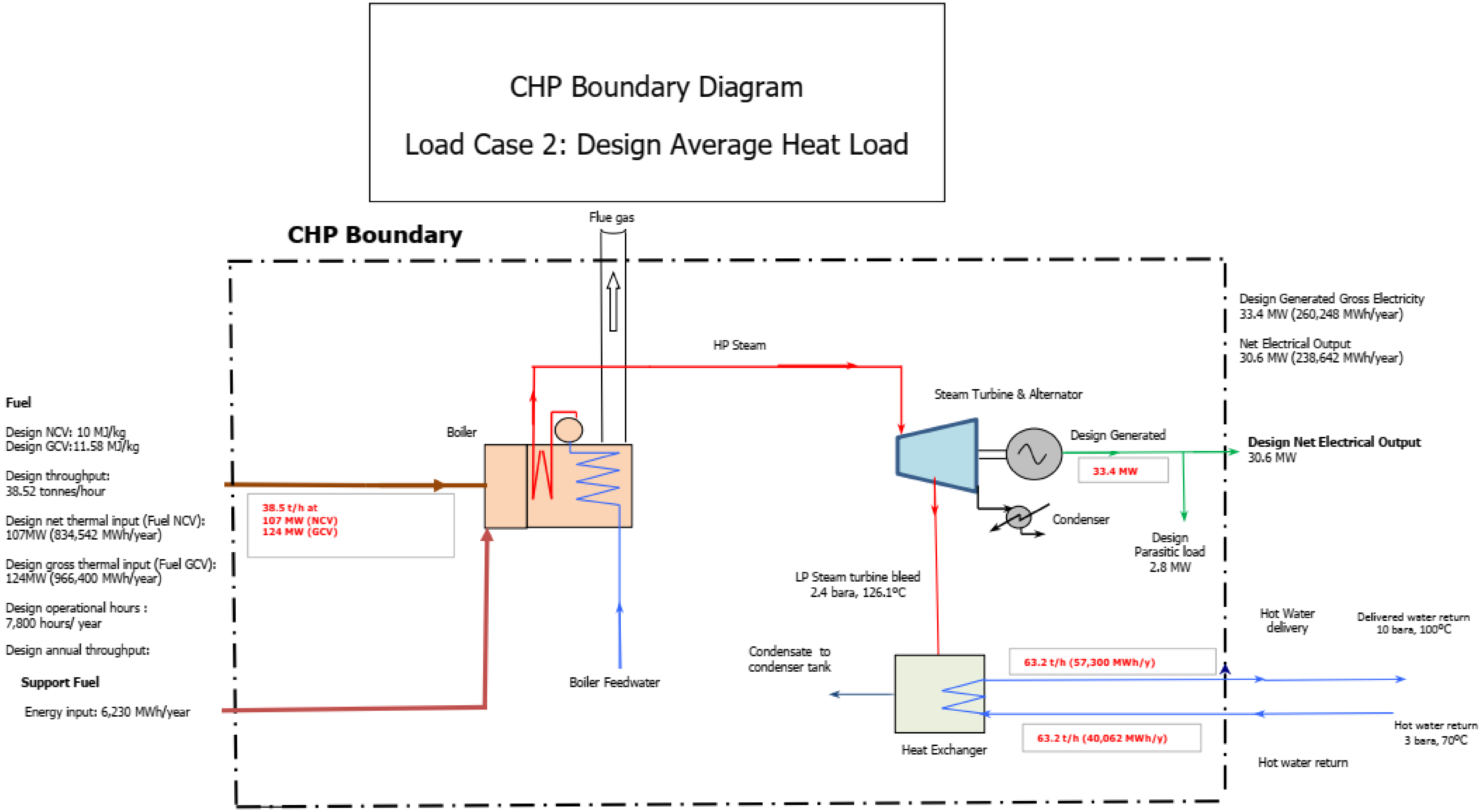


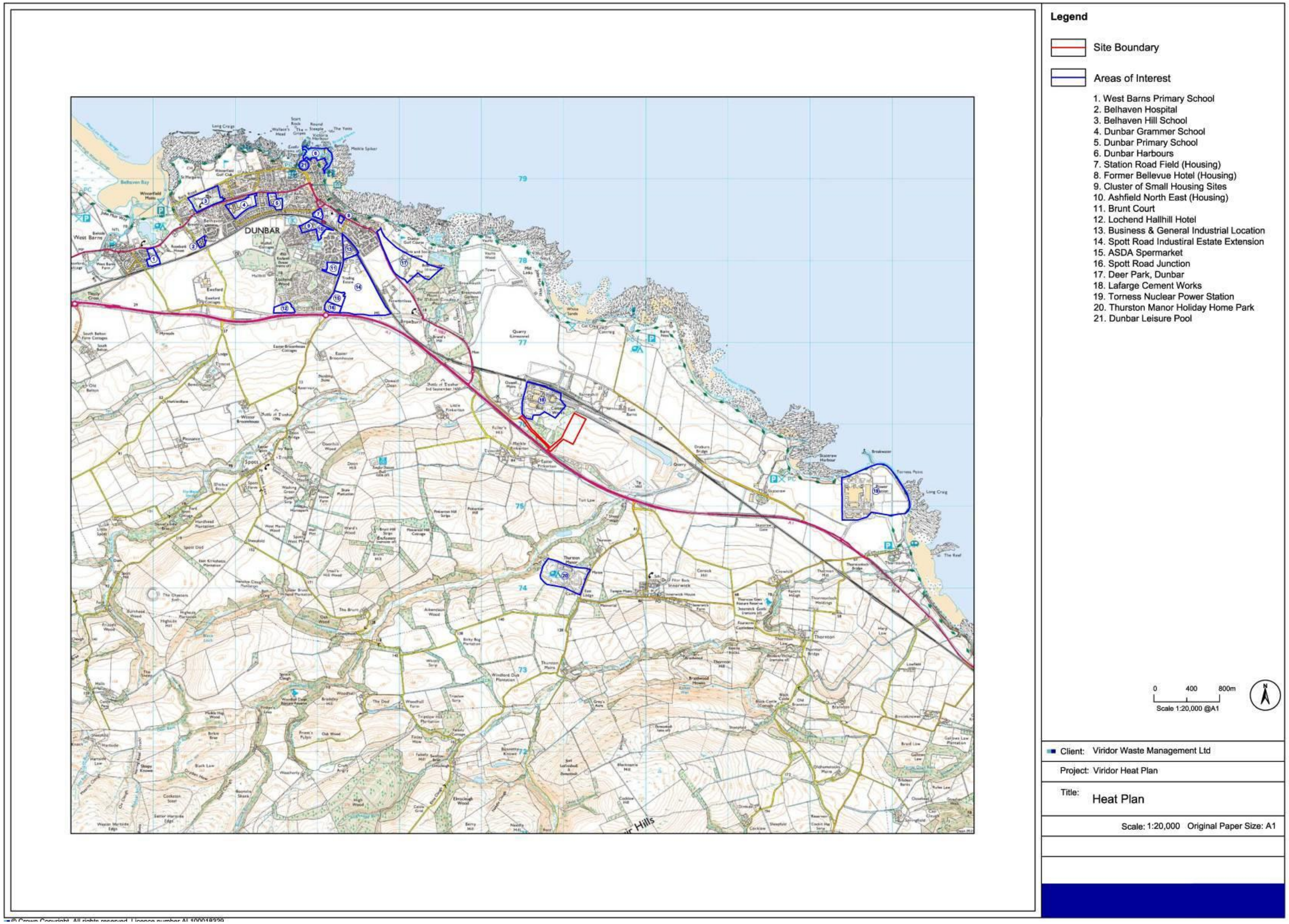
Figure 6: CHP Boundary Diagram Load Case 2: Design Average Heat Load



Appendices

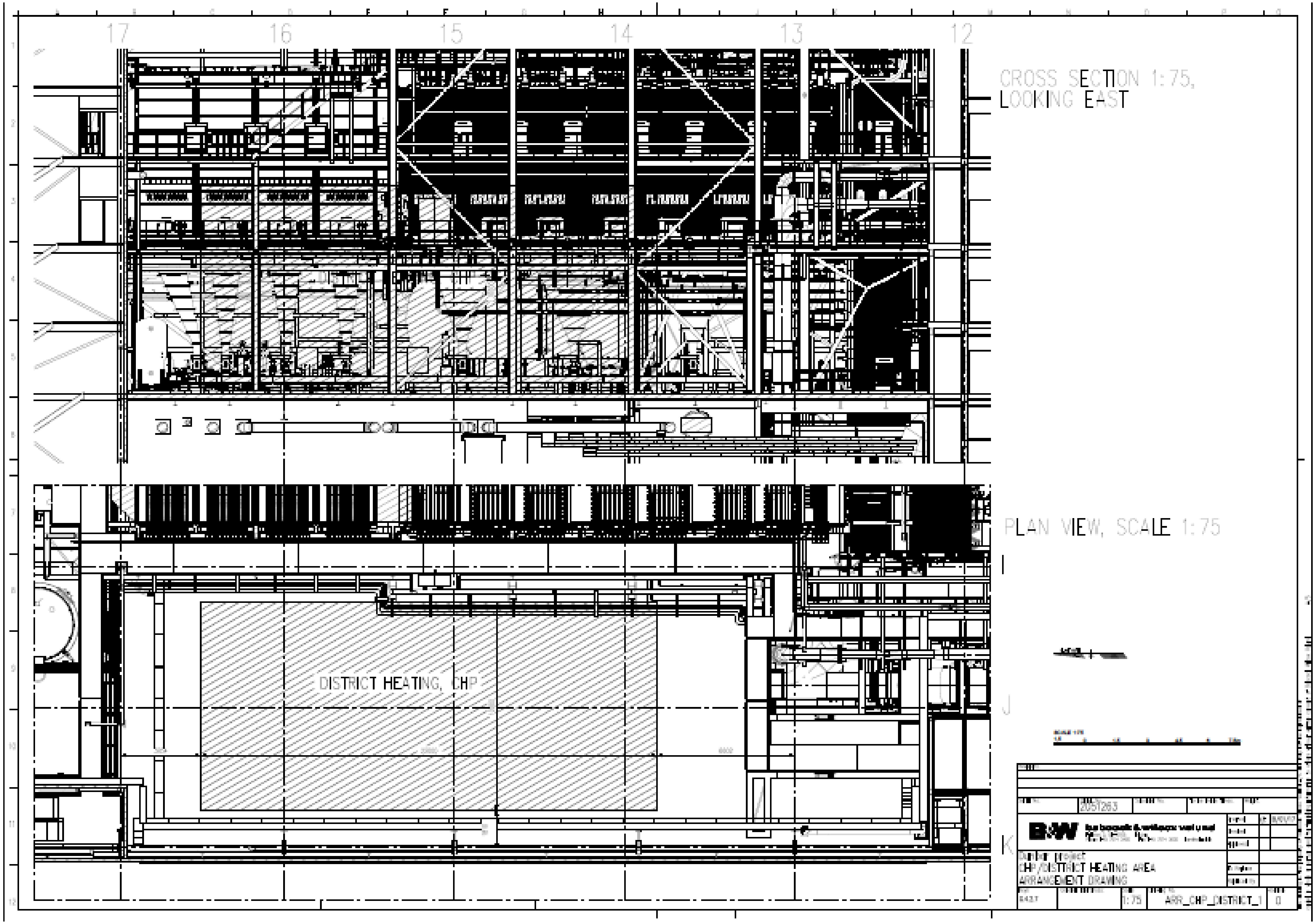
A Proposed District Heating Pipe route

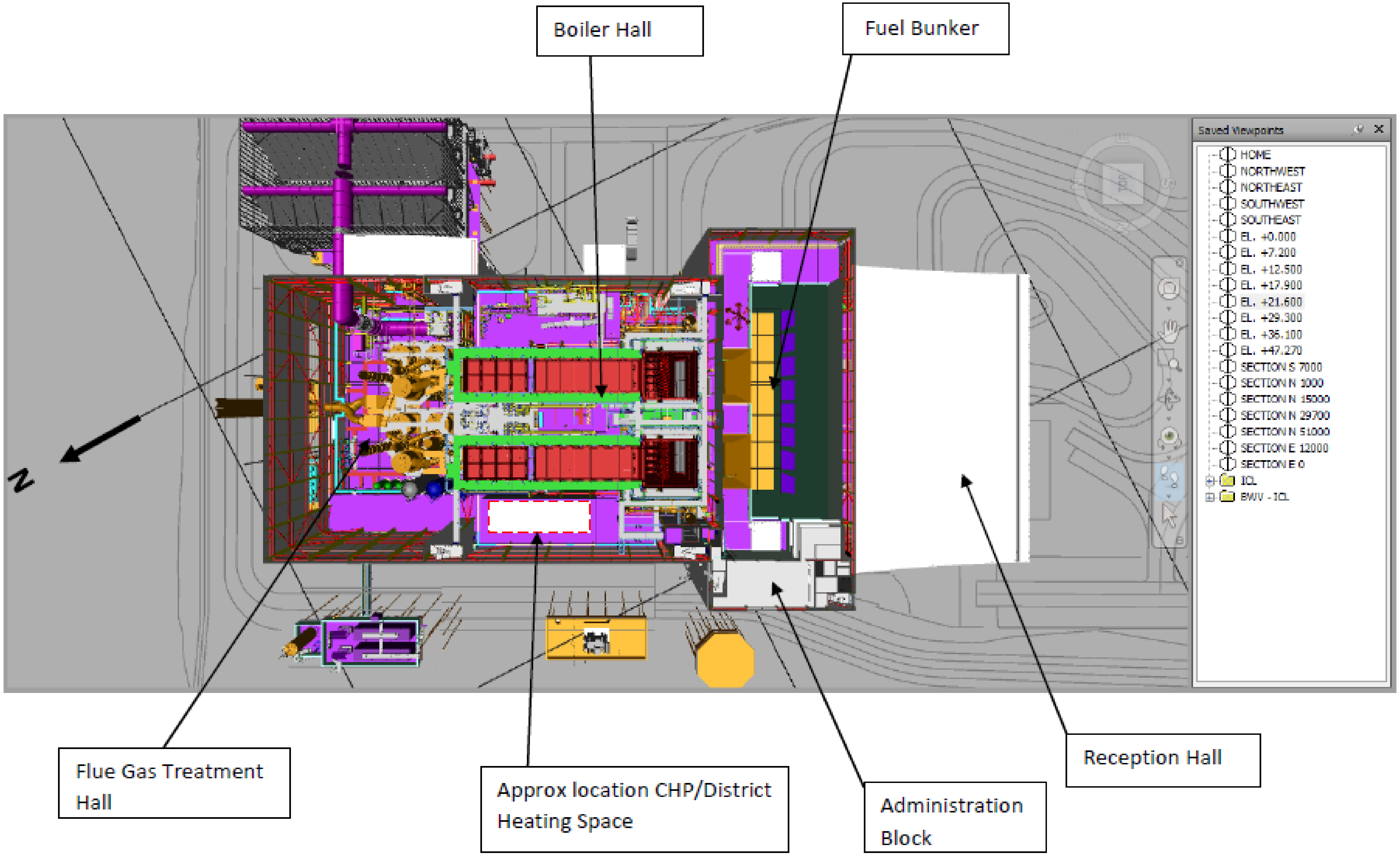
B Potential heat consumers


Legend
Site Boundary
Areas of Interest
1. West Barns Primary School
2. Belhaven Hospital
3. Belhaven Hill School
4. Dunbar Grammer School
5. Dunbar Primary School
6. Dunbar Harbours
7. Station Road Field (Housing)
8. Former Bellevue Hotel (Housing)
9. Cluster of Small Housing Sites
10. Ashfield North East (Housing)
11. Brunt Court
12. Lochend Hallhill Hotel
13. Business & General Industrial Location
14. Spott Road Industrial Estate Extension
15. ASDA Spermarket
16. Spott Road Junction
17. Deer Park, Dunbar
18. Lafarge Cement Works
19. Torness Nuclear Power Station
20. Thurston Manor Holiday Home Park
21. Dunbar Leisure Pool
0 400 800m
Scale 1:20,000 @A1
Client: Viridor Waste Management Ltd
Project: Viridor Heat Plan
Title: Heat Plan
Scale: 1:20,000 Original Paper Size: A1
DUNBAR

C Engagement with stakeholders

D Room safeguarded for heat export equipment


17
16
15
14
13
12
CROSS SECTION 1:75,
LOOKING EAST
PLAN VIEW, SCALE 1:75
DISTRICT HEATING, CHP
J
K
2051263
B&W
Dunbar project
CHP/DISTTRICT HEATING AREA
ARRANGEMENT DRAWING
1:75
ARR_CHP_DISTRICT_1
0


Boiler Hall
Fuel Bunker
Flue Gas Treatment Hall
Approx location CHP/District Heating Space
Administration Block
Reception Hall
N
Saved Viewpoints
HOME
NORTHWEST
NORTHEAST
SOUTHWEST
SOUTHEAST
EL. +0.000
EL. +7.200
EL. +12.500
EL. +17.900
EL. +21.600
EL. +29.300
EL. +36.100
EL. +47.270
SECTION S 7000
SECTION N 1000
SECTION N 15000
SECTION N 29700
SECTION N 51000
SECTION E 12000
SECTION E 0
ICL
BWV - ICL

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