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Consulting Engineers Limited



Ringaskiddy Resource Recovery Centre

Indaver

Heat Network Feasibility Study and Cost Benefit Analysis

ENGINEERING CONSULTING

Document approval

	Name	Signature	Position	Date
Prepared by:	Ryan Barker		Associate Senior Consultant	08-11-2019
Checked by:	Nigel Garrod		Principal Consultant	08-11-2019

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Foreword

In November 2019 Fichtner prepared this report to assess the potential for a heat network supplied by the proposed RRRC. This was a follow-up report to the initial site selection report issued in April 2019 as part of the EIAR for the RRRC. An error was identified in the calculation of the heat demand for all the potential heat users identified in both reports. This error was in the conversion of the annual gas usage figures in the AERs to the heat demand; this calculation overestimated the heat demand. The site selection report has been corrected and updated. This updated Heat Network Feasibility Study and Cost Benefit Analysis completes the error correction.

The changes to this report are:

- Update to table 2 summarising the findings of the previous study, this reflects the corrected report issued in June 2020;
- Change in heat demand across the identified heat users from 177 GWh/year to 157 GWh/year (table 3);
- Clarification on the assumption behind the primary energy saving calculation in section 4.4 point 1.b.;
- Update to the required financial supports to make the project viable in section 4.6; and
- Update to four typographical errors unrelated to the calculation error.

The update to table 2 is based on 2017 AER data used in the previous report, which it summarises. Table 3 is based on 2018 AER data as this was the most recent at the time of writing this report in November 2019. The exception to this is Thermo Fisher Scientific which uses 2017 AER data in this report as there was an error in the 2018 AER data for gas consumption.

Management Summary

Indaver Ireland Limited (Indaver) is developing a waste to energy facility in Co Cork that could process 240,000 tonnes per annum of waste. The Ringaskiddy Resource Recovery Centre (RRRC) would generate up to 21 MW_e of electricity (in fully condensing mode) and be capable of exporting up to 12 MW_{th} of heat, subject to technical and economic feasibility. Following a Phase 1 feasibility study which reviewed six areas of County Cork identified in the Cork County Development Plan, the area of Ringaskiddy was found to offer the most favourable connection prospects for a heat network serving industrial consumers.

Indaver has engaged Fichtner Consulting Engineers Limited (Fichtner) to undertake this Phase 2 study to further the development of a heat network in Ringaskiddy and satisfy pre-commencement planning condition requirements relating to sustainable energy management. Based on a review of Environmental Protection Agency (EPA) licensed facilities for 2018, an estimated heat load of 15~~77~~ GWh per annum was identified within 10km of the proposed project site. Of this demand, a heat (steam) network serving pharmaceutical plants located within a 3km radius of the facility represents the optimal solution. Development proposals are also in place for the Port of Cork, which is located directly adjacent to the pipe corridor and could therefore present additional heat demand in the future. In combination, these consumers are likely to exceed the heat export capacity of RRRC, thereby maximising the potential for provision of low carbon heat and offsetting fossil fuel consumption.

Indicative design of the heat export system has been undertaken and comprises supply of 16.8 tonnes of steam per hour at a pressure of circa 10 bar(a) via extraction from the turbine. This approach represents a flexible solution by allowing export capacity to be modulated, while maximising facility efficiency and satisfying (likely) heat consumer requirements. It is proposed that steam would be recovered from a dedicated turbine extraction and supplied to consumer sites via an insulated pipe on structural supports. Following transfer of heat to consumer processes, condensate would be returned to the facility for reuse (where possible) or make-up water would replace the exported volume. The preferred solution would be to retain existing boiler plant on consumer premises to supply steam during times of unavailability of the heat export system (estimated as 760 hours per annum).

RRRC will have a total rated thermal input exceeding 20 MW_{th} therefore a cost benefit analysis (CBA) considering the potential for cogeneration opportunities must be carried out in accordance with SI 426 of 2014. The proposed heat network would result in Primary Energy Savings (PES) of 11.6%, which is in excess of the technical feasibility threshold established within the Energy Efficiency Directive (2012/27/EU). An assessment of the costs and revenues associated with the construction and operation of the proposed heat network has been undertaken, following the draft Article 14 guidance document issued by the Environmental Agency (EA) (for England and Wales) and adopting the associated toolset. The results of the CBA indicate that the nominal project internal rate of return and net present value (before financing and tax) are negative and therefore currently the proposed heat network does not yield an economically viable scheme. However, the CBA calculation does not include any potential capital grants or subsidies which may offset some of the capital/operational costs of the scheme. Support, from a scheme such as the Climate Action Fund, could make the project economically viable. The economic feasibility of the scheme will be reassessed in the future when there is more certainty regarding heat loads and considering any subsidies that may be available to support heat network delivery.

The R1 efficiency ratio of the RRRC has been calculated to confirm its status under the EU Waste Framework Directive (WFD). The R1 efficiency ratio is calculated as 0.70 in fully condensing mode (i.e. power export only), rising to 0.80 in the maximum heat export case. Both scenarios exceed the

threshold for new incineration facilities therefore the RRRC will meet the definition of a recovery operation with or without heat export.

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1 Introduction

1.1 Background

Indaver is developing a waste to energy facility in Co Cork for the treatment of up to 240,000 tonnes per annum of residual household, commercial, industrial, non-hazardous and suitable hazardous waste. The facility will be capable of generating 21 MW_e of electricity (in fully condensing mode) and could export heat if a viable heat network opportunity exists. Indaver is considering the feasibility of exporting a proportion of heat to offsite consumers via a heat network, which would require the facility to be capable of combined heat and power (CHP) operation.

Indaver is obliged to satisfy the following pre-commencement planning requirement contained in Condition 20 of Planning Permission reference 04.PA0045 granted by An Bord Pleanala.

"The developer shall commission an independent Feasibility Study in relation to the possibilities for the recovery of excess heat energy from the proposed facility. The terms of reference of the study shall be agreed with the planning authority, and the report shall be completed and submitted to the planning authority within 18 months of the date of this order and made publicly available.

Reason: In the interest of sustainable energy management, and to inform future land-use and development planning in the area."

Separate to this planning requirement, Statutory Instrument (SI) 426 of 2014 states that a CBA considering the potential for CHP must be carried out for any new thermal electricity generator with a total rated thermal input exceeding 20 MW_{th}. The SI explains that the CBA shall be submitted to the Sustainable Energy Authority of Ireland (SEAI).

1.2 Objective

A Phase 1 feasibility study was carried out by Fichtner on behalf of Indaver to review the potential for establishing a heat network in six areas of County Cork, which were identified in the Cork County Development Plan as potential locations for a waste to energy facility. The principal objectives of this Phase 2 study, which builds on the Phase 1 study, are as follows.

1. Build on the outputs of the Phase 1 study to develop a viable heat export concept.
2. Detail technical considerations for heat export and distribution from RRRC.
3. Consider locations and requirements for a heat station and back-up plant.
4. Undertake a CBA of the cogeneration opportunity in accordance with Statutory Instrument 426.
5. Conduct an R1 (recovery) assessment to verify RRRC status in the context of the waste hierarchy.

2 Description of the Technology and Heat Network

2.1 The facility

Indaver is considering a facility with a design capacity of 240,000 tonnes per annum, through a single combustion line, of residual household, commercial, industrial, non-hazardous and suitable hazardous waste. The fuel will have an estimated net calorific value (NCV) of 9.65 MJ/kg. The design point of the facility is approximately 29 tonnes per hour, based on an annual operational availability of 8,000 hours per annum. The process is illustrated in Figure 1.

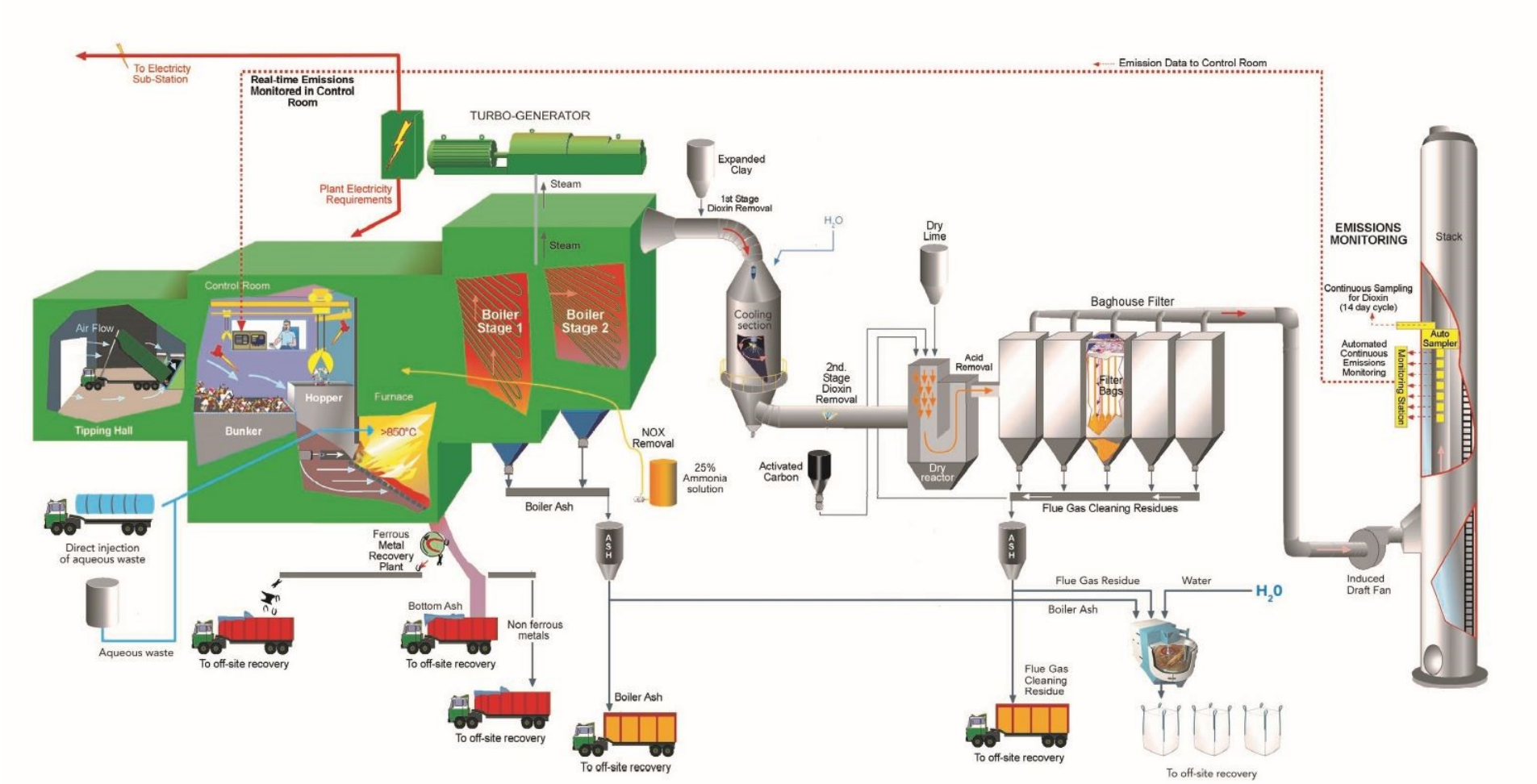
Waste will be combusted on a moving furnace and the heat released by combustion will be recovered in a water tube boiler, which is integral to the furnace and will produce (in combination with superheaters) high pressure superheated steam. The steam from the boiler will feed a steam turbine-generator used to generate electricity. Exhaust steam will then be cooled using an air-cooled condenser, with condensate being retained for reheating, to minimise make-up water volumes.

In fully condensing mode, the steam turbine will generate up to 21 MW_e. The house load is projected to consume approximately 2.5 MW_e, leaving the balance of 18.5 MW_e available for export to the grid.

Based on Fichtner's experience of similar facilities, it should be possible to export approximately 12 MW_{th} of heat. This figure will be subject to the method of heat recovery selected and the design of the turbine and primary water/steam cycle. This figure could therefore vary considerably from 12 MW_{th} when the detailed design is completed.

Subject to technical and economic feasibility, a heat supply system may be installed to export heat to offsite consumers, and is discussed in the following sections.

Figure 1: Indicative process schematic



Source: Indaver

2.2 Heat available

Assuming detailed design of the RRRC is progressed based on exporting up to 12 MW_{th} of heat, a maximum of 96 GWh/annum would be available for export. Due to seasonal and diurnal variations in heat demand which are universally present in heat networks, it may not be possible to utilise the maximum heat export capacity consistently. The heat supply system must be capable of supplying peak heat loads, or alternatively peak lopping plant or accumulators (thermal stores) could be incorporated within the network, as discussed in the following section.

2.3 Heat recovery

Heat is typically supplied from waste to energy facilities in the form of steam and/or hot water, depending on the grade of heat required by end consumers. The most commonly considered options for recovering heat from waste to energy facilities are discussed below.

2.3.1 Heat recovery from the air-cooled condenser

Wet steam emerges from the steam turbine typically at around 40°C. Steam is condensed in a large air-cooled system which rejects the heat in the steam into an air flow, which is rejected to atmosphere. An air-cooled condenser generates a similar temperature condensate to mechanical draught or hybrid cooling towers but 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 facility. In addition, this heat is of low grade (temperature) and so is not suited to the high grade, industrial heat demands in the area.

2.3.2 Heat extraction from the steam turbine

Steam extracted from the steam turbine can be used to generate hot water or steam for a heat network. Conventional hot water networks typically operate with a flow temperature of 90 to 120°C and return water temperature of 50 to 80°C. If heat is exported as steam, temperatures and pressures will be subject to end consumer requirements and the turbine extractions will be designed accordingly.

If heat is extracted via a hot water system, 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 exchangers, with condensate recovered back into the feedwater system. Hot water is pumped to heat consumers for consumption before being returned to the condensing heat exchangers where it is reheated.

In this case, the steam is normally extracted from the two 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.

2.3.3 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 in the range 90 to 120°C and this method of heat extraction does not significantly impact the power generation from the facility.

Condensing the flue gas can also be achieved in a wet scrubber, but this has several disadvantages over the option described above. The scrubber temperature is typically no more than 80°C, which restricts the hot water temperature available for consumers. 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 could require a higher stack height to effect adequate dispersion. The additional cooling of the flue gas results in the 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 as an effluent. The low-grade heat available is below the temperature that is likely to be needed by the local industrial heat demands and so does not provide a viable system.

2.3.4 Summary

Due to the disadvantages outlined above for the heat recovery from the air-cooled condenser condensate and the heat recovery from the flue gases, the solution most commonly selected to extract heat to a heat network is extraction of low or medium pressure steam from the turbine. This is typically chosen for the following reasons.

1. Extraction of steam from the turbine offers the most flexibility for varying heat quality and capacity to supply variable demands or new future demands, which is particularly relevant where there is uncertainty over heat loads.
2. Extraction of steam from the turbine, heat transfer to a distribution circuit and delivery of heat to consumers can be facilitated by well proven and highly efficient technology.
3. The heat requirements of the identified consumers (as described in section 3.4) are suited to the temperatures attainable from the turbine with power loss minimised, thereby optimising the thermodynamic efficiency of the facility.
4. The use of a flue gas condenser often generates a visible plume which would be present for significant periods of the year. This is often not desirable as it significantly adds to the visual impact of the facility.

2.4 Heat export medium

The choice to export heat as hot water or steam is substantially driven by the requirements of consumers in the locality of the facility. On the basis that the proposed heat network will serve industrial consumers, the export medium will be medium pressure steam.

Steam is considerably less dense than water so the space requirements and capital cost of the pipework is typically higher than a comparative hot water system. In addition, expansion joints may be required, which increase the total pipe length. Heat losses from steam pipework, resulting from higher working fluid temperatures, can be offset though improved insulation.

Subject to the processes undertaken at the consumer sites, it may or may not be possible to recover and return condensate to the source. Any condensate lost, for example due to direct use within an

industrial process, would need to be made up to ensure that water supply to the RRRC boiler is not compromised. This configuration could necessitate an increased water usage and larger demineralised water preparation plant but can be managed with an appropriate heat pricing structure.

Where condensate is returned from consumers, monitoring of condensate conductivity is advisable to ensure that water quality remains within acceptable limits stipulated by the boiler and turbine suppliers. This risk could be mitigated by incorporating a hydraulic break in the system, in this case by means of steam generators, so that heat supply to consumers is provided via a secondary circuit.

To protect against condensate formation in the steam supply pipeline, pipe gradients, steam traps and associated valving need to be incorporated into the design. These additional components require ongoing maintenance and as a result steam pipelines are typically routed above ground. The pipeline and structural supports will therefore require planning permission. Health, safety and asset protection considerations of running steam mains above ground would need to be considered. However, this approach has already been adopted on industrial sites within Ringaskiddy. Indaver has also commissioned a large-scale industrial steam network, ECLUSE, at the Port of Antwerp which commenced operations in March 2019. The network provides steam from three waste to energy facilities to six chemical companies at the port, reducing CO_2 emissions by an estimated 100,000 tonnes per year. The majority of the steam and condensate piping is routed above ground.

2.5 Heat station

Within the RRRC site, space will be required for the heat export infrastructure. The space required for a steam export system is considerably less than that of an equivalent hot water system since much of the equipment required for a closed loop district heating system is not required. For the proposed heat network, the main infrastructure to be located within the heat station will comprise:

1. insulated steam export pipeline interfaced at a designated turbine extraction;
2. steam supply isolation and control valving, possibly in lag and lead configuration (subject to heat demand profile);
3. associated control and instrumentation devices including temperature and pressure monitoring;
4. a heat meter to record the quantity of heat exported;
5. insulated condensate return pipeline interfaced at an appropriate tie into the condensate system (most likely the main condensate tank);
6. as a minimum, a strainer and conductivity monitor to ensure that the quality of condensate is maintained at the required standard, with the possibility to discharge to drain if the risk of contamination is sufficiently large; and
7. condensate isolation valving and associated control and instrumentation devices including temperature and pressure monitoring.

A significant consideration is whether to export the primary circuit steam directly, or whether to use this energy to raise steam in a secondary circuit via steam raising heat exchanger(s). This approach may be preferable in circumstances where the fluid becomes contaminated during consumption within the heat consumer process, however it would be significantly more costly and has therefore not been accounted for in the baseline proposal. The risk of contamination will need to be assessed through liaison with the heat consumer site operators, when there is more certainty over heat use applications.

Since the steam export system in this case would not be a closed loop circuit in a single phase, expansion and pressurisation sub-systems would not be required. In addition, pumps required to deliver the motive force to return condensate from heat consumer sites would need to be located at a suitable location within the consumer sites.

Since it is preferential to route steam pipes above ground, pipe bridges are likely to be required for steam supply and condensate return pipelines routed across roads.

2.6 Back-up heat source

During periods of routine maintenance or unplanned outages of the RRRC, the heat consumers will still require heat. There is therefore a need, somewhere within the heat distribution system, to provide a back-up source of heat to ensure continuity of supply to heat consumers.

Since the proposed heat network will be based on retrofit connections to existing industrial consumers, it will be preferable to retain existing heating infrastructure as back-up. This approach would lessen the capital outlay required for the heat network, since new oil- or gas- fired or steam boilers would not be required. This approach would however expose heat consumers to additional operational and maintenance costs (relative to an entirely standalone heat supply system) since the existing plant would need to be maintained as hot standby, particularly if heat use processes are sensitive to even minor steam interruptions. To mitigate this risk, steam accumulators will need to be considered as part of the back-up strategy to manage unplanned interruptions and allow time for the back-up boilers to ramp up to full load.

Utilising existing boiler plant as back-up will also ensure security of supply to consumer site operators, who are likely to be risk averse, utilising assets within their control. This approach also has the benefit of reducing heat losses associated with fossil fuelled plant, since the back-up heat will be generated at the location where it is used.

A detailed back-up strategy will need to be developed through liaison with individual heat consumers.

3 Summary of Phase 1 Heat Demand Investigation

Between January and April 2019, Fichtner completed a review of the potential for a heat network in six areas of Co Cork (reference S2682-0030-0001RLB). A summary of this Phase 1 feasibility study is presented in the following sections.

3.1 SEAI heat map

In 2015, AECOM completed a study commissioned by SEAI to fulfil Ireland's obligation under Article 14 of the Energy Efficiency Directive (2012/27/EU) and SEAI's obligation under 23(1) of Statutory Instrument 426. As part of this study a spatial representation of Ireland's heat demand was developed and is available online at http://maps.seai.ie/heatdemand/.

The projected heat demands for 2025 are summarised in Table 1. It should be noted that these figures are unscreened, and it would be impractical to connect many of the heat loads included within these figures to a heat network in that area.

Table 1: Total estimated heat demand in 2025 (including all townlands within, or touching, a 5 km and 10 km of the areas centre point)

Area	5km	10km
Bottlehill	10 GWh	25 GWh
Carrigtwohill	27 GWh	104 GWh
Kilbarry	211 GWh	729 GWh
Little Island	49 GWh	289 GWh
Ringaskiddy	67 GWh	156 GWh
Whitegate	13 GWh	85 GWh

Source: SEAI heat map

The volume of heat which could realistically be connected from a heat source located at Carrigtwohill and Kilbarry is overestimated due to constraints posed by the local rail network and River Lee respectively. Accounting for the significant volume of existing domestic buildings which are unsuitable for inclusion in a heat network as a result of the prohibitive costs, the potential heat demand in Kilbarry is significantly reduced.

With reference to the benchmarks offered by the Dublin District Heating scheme and the local topology, Fichtner does not consider it feasible for Indaver as a private company to develop a hot water-based district heating scheme in any of the areas reviewed in Co Cork. Indaver has therefore elected to focus on developing a steam export system to serve local industrial consumers, as discussed subsequently.

3.2 Heat load assessment

The SEAI heat map lists the locations of Emissions Trading Scheme (ETS) sites licensed by the EPA and members of SEAI's Large Industry Energy Network[1] (LIEN). Fichtner has reviewed the corresponding information on the heat map but some of the information appears to be out of date

[1] Details at: https://www.seai.ie/energy-in-business/lien/

(the map was produced in 2015). As a result, a more detailed assessment of industrial heat demand in the six areas was conducted by assessing publicly available information on all EPA licensed sites in Co Cork.

Fichtner undertook a shortlisting exercise and identified 21 EPA licensed facilities within 10 km of Carrigtwohill, Little Island, Ringaskiddy and Whitegate. Fichtner reviewed the Annual Environmental Returns (AERs) for each licensed facility where available. The areas of Carrigtwohill, Little Island, Ringaskiddy and Whitegate were found to contain sizeable industrial heat loads. Table 2 summarises the heat loads based on the distance to the centre of each area.

Table 2: Industrial heat loads in GWh/annum

Area	Less than 2.5km	2.6 to 5km	5.1 to 7.5km	7.6 to 10km	Total
Carrigtwohill	-	41~~57~~	-	191~~265~~	232~~321~~
Little Island	72~~100~~	-	-	-	72~~100~~
Ringaskiddy	2~~6~~8	91~~139~~	~~44~~32	-	151~~209~~
Whitegate	1475	-	-	-	1475

Source: EPA website and Google maps

From the information assessed, Fichtner considered Ringaskiddy the most suitable area for a heat network that focuses on industrial consumers.

3.3 Site visits

In order to investigate the potential heat consumers and connection viability, Fichtner visited each of the six areas of Co Cork on 25 and 26 February 2019. The visits comprised a visual inspection of each of the key heat consumers across all sectors, but did not include communication with any site owners or access onto the premises. Local infrastructure and topology were reviewed as part of the visits to better understand potential pipe routing options and constraints.

Based on the concentration of large heat loads within a relatively short distance of the proposed facility, pipe routing feasibility and potential for development expansion in the locality, we consider Ringaskiddy as the most favourable area for establishing a heat network. Little Island also accommodates several pharmaceutical plants (and to a lesser degree office and retail space) which may offer connection prospects, although these are smaller in scale. Smaller still are the pharmaceutical and manufacturing plants located in Carrigtwohill.

Kilbarry comprises a wider mix of development types, many of which are unlikely to require heating or utilise heating systems which are not suitable for connection to a heat network. At Carrigtwohill and Kilbarry, local infrastructure presents a major barrier to connecting potential consumers, therefore reducing the amount of accessible heat demand.

There were poor synergies in terms of the development of a heat network in the areas of Bottlehill and Whitegate.

3.4 Anchor heat loads

Table 3: Heat Loads within 10 km of Ringaskiddy

Site name	Potential heat load (GWh/annum)	Distance from RRRC (km)	Potential to connect
BioMarin International	8.912~~12.3~~	3.1	Possible
Hovione	20.2~~8.0~~	1.9	Possible
Novartis[1]	~~49.7~~35.9[2]	2.9	Possible
Recordati	2.4~~3.4~~	2.8	Possible
Thermo Fisher Scientific (formally Smithkline Beecham, transferred 30/09/2019)	31.9[2]~~3.9~~	5.2	Possible
Pfizer Ireland Pharmaceuticals	57.6~~79.7~~	2.7	Possible
Janssen Sciences	0.2~~3~~	2.5	Possible

[1]A phased reduction in operation is expected to 2022, which will likely reduce heat load. This site does not form part of the proposed core heat network therefore immaterial to the CBA.

[2]Based on 2017 data since 2018 AER not available.

Source: EPA website, Phase 1 study figures updated to reflect 2018 consumption

Ringaskiddy has seven potential sites that use an estimated 15~~7~~7 GWh of heat per year (based substantially on 2018 AERs, updated from the Phase 1 study). This volume of heat translates to an average instantaneous heat requirement of approximately ~~22.2~~19.6 MW_{th}, assuming the facilities operate for 8,000 hours per annum. This is greater than the suggested design capacity of the RRRC (circa 12MW_{th}) but it is likely that not all of the heat consumers identified would take up this option in the future for a variety of reasons ranging from business activities to corporate policy and financial business case.

Based on the nature of activities undertaken at these sites and information contained within the AERs, it is reasonable to assume that most of the heat demand will be for high grade heat (steam). Discussion with potential heat consumers will be required to verify heat loads (in terms of volume of heat and grade of heat required) and to determine whether site owner/operators are willing to enter into a commercial agreement for the provision of heat.

Based on a review of local infrastructure and topology, there are sites within a 3km radius of the site that appear to provide appropriate connection opportunities and would have sufficient heat demand to utilise the potential heat off take from the RRRC.

As detailed in '*Planning Report: Industrial Lands within Metropolitan Cork*'[2], June 2019, prepared by Coakley O'Neill Town Planning Ltd, development proposals are in place for the Port of Cork, which is located directly adjacent to the potential arterial pipe corridor, and could therefore present additional heat demand in the future. We have therefore progressed the CBA on the basis of serving facilities within 3km with steam from the RRRC, as the optimal case in terms of maximising low carbon heat utility and proximity of a relatively small number of anchor heat loads. The estimated heat demand for the proposed heat network is ~~92~~66.5 GWh per annu~~u~~m, which equates to ~~11.5~~8.3 MW as an instantaneous average assuming operational availability of 8,000 hours per annum. Heat demand may increase further as the Port of Cork is developed.

[2] test.ringaskiddyrrc.ie/wp-content/uploads/EIAR-2019-Appendix-3.1-Planning-Report-In-Relation-to-Industrial-Lands-Within-Metropolitan-Cork.pdf

4 Cost Benefit Analysis

4.1 Methodology

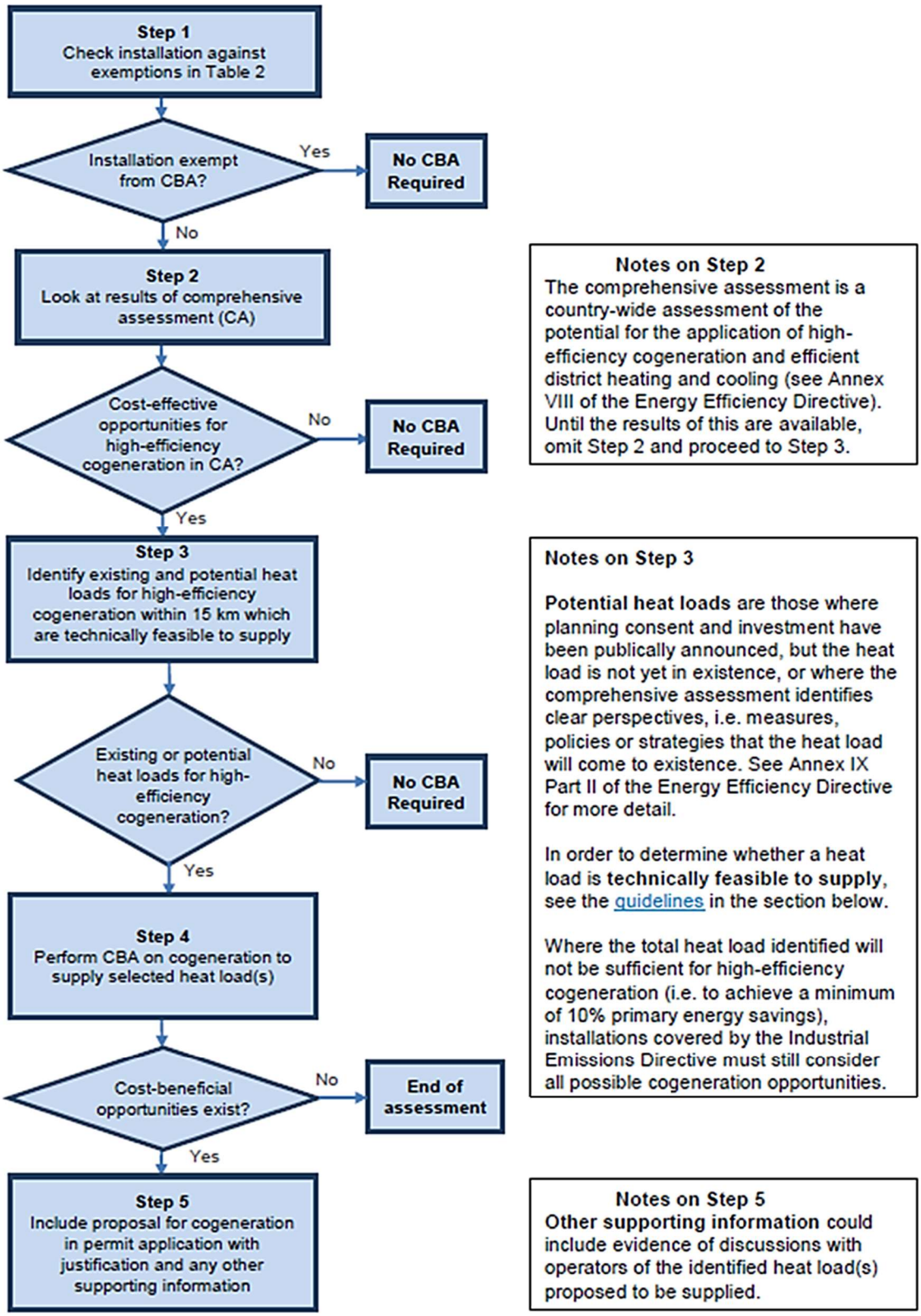
In addition to Planning Condition 20, RRRC will have a total rated thermal input exceeding 20 MW_{th} therefore a Cost Benefit Analysis (CBA) considering the potential for CHP must be carried out under Regulation 23(11) of Statutory Instrument 426 of 2014, as adopted under Article 14 of the Energy Efficiency Directive (2012/27/EU).

In lieu of guiding principles for the preparation of installation level CBA from SEAI, this CBA has been prepared in accordance with equivalent guidance and toolsets published by the Environment Agency (EA) for installations located in England and Wales.

In April 2015, the EA (for England and Wales) 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*'[3]. As new electricity generation installation with a total aggregated net thermal input of more than 20 MW_{th}, RRRC would be classified as an installation type 14.5(a) under the guidance. The following methodology describes the process that must be followed for type 14.5(a) and 14.5(b) installations.

[3] Draft guidance on completing cost-benefit assessments for installations under Article 14 of the Energy Efficiency Directive, V9.0 April 2015, Environment Agency

Figure 2: CBA methodology for type 14.5(a) and 14.5(b) installations



Source: EA guidance

4.2 Comprehensive Assessment

The SEAI published a comprehensive assessment '*Cost Benefit Analysis of the potential for High-Efficiency Cogeneration and Efficient District Heating & Cooling in Ireland*'[4] in December 2015. The headline conclusion of the assessment notes that heat demand in Ireland is generally low density in nature and analysis of linear heat density demonstrates that around 90% of the heat demand is at densities too low to make district heating a viable proposition.

The analysis shows that the most likely potential appears to be based around two types of district heating scheme.

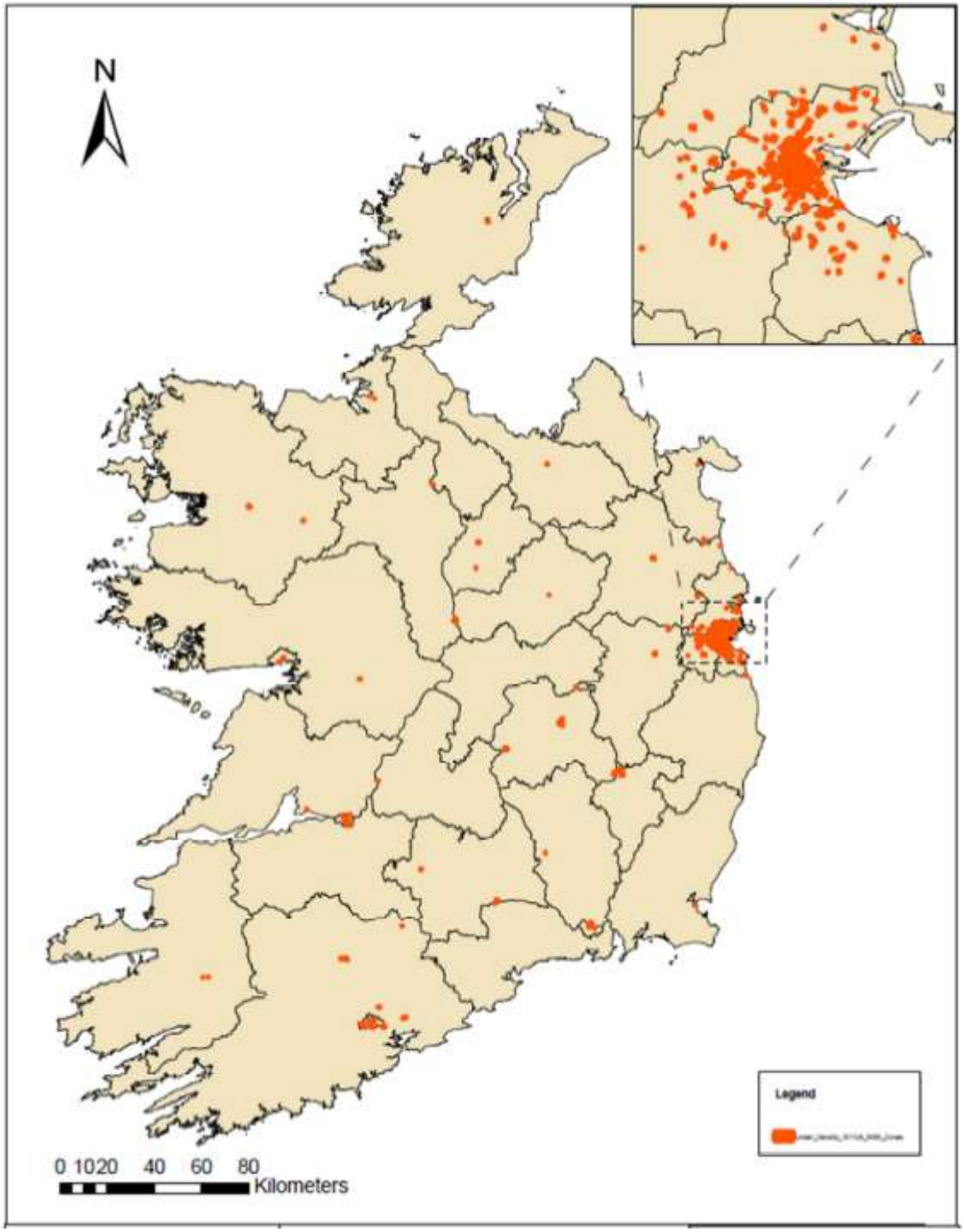
1. Large scale schemes located in Dublin which have a small cost benefit over the counterfactual technology options, and which are reliant on a source of waste heat from power stations.
2. Small scale schemes (potentially outside of Dublin), where there is a much larger cost benefit in terms of levelised cost, but the overall heat provision potential is very limited. These types of scheme are likely to be located where more expensive existing heating sources prevail (potentially off the gas network). The predominant network heat source is boilers due to the small scale of the schemes.

As a scheme comprising the supply of steam from a waste to energy facility to industrial consumers outside of Dublin, the proposed scheme for RRRC does not align closely with either of these archetypes. Given the introduction of fiscal support mechanisms (discussed in the following sections) since the comprehensive assessment was published, there is potential to consider the type of scheme proposed. The location of this particular project is also in relative proximity to a number of higher heat density, industrial areas.

The comprehensive assessment identifies system boundaries which are defined to limit the assessment of areas which may offer cost effective potential heat demands. The resulting zones represent geographic areas which have a linear heat density above the set threshold. The analysis demonstrates that industrial and commercial heat loads increase along the transition to moderate and high heat densities. As such, we have considered the moderate and high heat density system boundaries (5,000 MWh/km and 10,000 MWh/km respectively). The heat maps presented in Figure 3 and Figure 4 show the resulting potentially viable heat network zones.

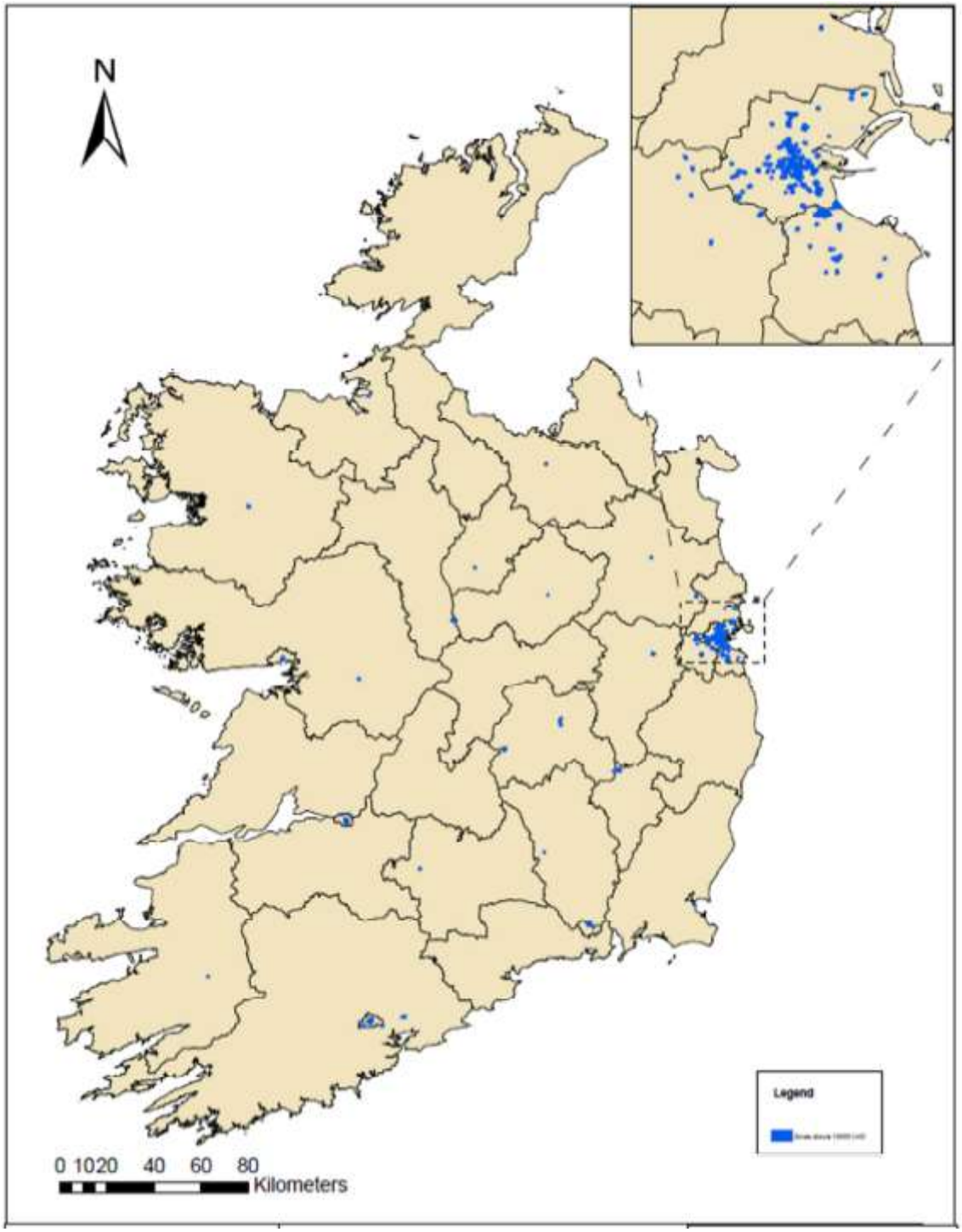
[4] Cost Benefit Analysis of the potential for High-Efficiency Cogeneration and Efficient District Heating & Cooling in Ireland, December 2015, Sustainability Energy Authority Ireland

Figure 3: Heat map showing 5,000 MWh / km system boundary



Source: SEAI Cost Benefit Analysis of the potential for High-Efficiency Cogeneration and Efficient District Heating & Cooling in Ireland

Figure 4: Heat map showing 10,000 MWh / km system boundary



Source: SEAI Cost Benefit Analysis of the potential for High-Efficiency Cogeneration and Efficient District Heating & Cooling in Ireland

As can be seen from the preceding figures, the majority of zones are located in Dublin, with other main areas around Waterford, Cork, Limerick, and Galway (in which a reduction in the number of viable zones decreases with increasing heat density threshold). The region of Cork retains a reasonable number of viable zones even in the highest heat density threshold scenario.

Due to the relatively low resolution of the data, the results of the comprehensive assessment are considered foundational. Higher resolution heat demand data has been ascertained as part of the heat demand investigation outlined in section 3 of this study. This investigation demonstrates that there is potential for high-efficiency cogeneration in the locality of RRRC, hence a CBA is required.

4.3 Fiscal support

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

4.3.1 Support Scheme for Renewable Heat

The Support Scheme for Renewable Heat (SSRH) is a government funded initiative designed to increase the energy generated from renewable sources in the heat sector. The scheme is open to public and private sector non-domestic heat users. SEAI has been appointed by the Department of Communications, Climate Action and Environment as the administrator for the SSRH.

Two support mechanisms are available under the scheme.

1. Installation grants are intended to bridge the gap between the cost of installation of renewable heating systems and conventional fossil fuel alternatives. The installation grant provides funding of up to 30% of eligible costs to commercial, industrial, agricultural, district heating or other non-domestic heat users not covered by the Emission Trading System. At present only air, ground and water source heat pump technologies are supported.
2. On-going operational support is available, via a tariff for a period of up to 15 years and based on useable heat output in renewable heating systems in new installations, or installations that currently use a fossil fuel heating system and convert to an eligible technology. Eligible technologies include biomass boilers or biomass CHP heating systems, or biogas (anaerobic digestion) boilers or biogas CHP heating systems. However, the guidance states that combustion of the biodegradable fraction of municipal waste is not eligible for support.

As it is not currently an eligible technology under the terms and conditions of the SSRH, a heat network served by RRRC is not eligible for support under the SSRH at this time.

4.3.2 Renewable Electricity Support Scheme

The proposed Renewable Electricity Support Scheme (RESS) is designed to deliver Ireland's contribution to the EU-wide binding renewable energy target of 32% by 2030 and Irelands nationally determined 70% renewable electricity target by 2030. Scheme proposals allow support to be provided through a two-way arrangement through a floating feed in premium i.e. the difference between a strike price and a market reference price, for up to 15 years. When the strike price is above the market reference price, the project owner receives a premium from the state. When the strike price is below the market reference price, the project owner pays a premium. This approach provides a level of certainty to investors.

Strike prices will be offered through a series of scheduled, competitive auctions, which are intended to drive value for money. The scheme is also intended to deliver wider policy objectives. Projects seeking support under the RESS are required to meet pre-qualification criteria including offering the community an opportunity to invest in and take ownership of a portion of renewable projects.

An industry briefing[5] was held on the 13th September 2019 indicating that the scheme is projected to obtain State Aid approval by February 2020, with the first auction planned for June 2020. The draft eligibility criteria have not yet been published, therefore it is not appropriate to account for revenue from RESS in the CBA at this stage. In any event, it appears as though support will be reserved for metered electricity generation only (not export of heat).

4.3.3 Climate Action Fund

The Climate Action Fund is one of four funds established under the National Development Plan 2018-2027 as part of Project Ireland 2040. The fund aims to support initiatives that contribute to the achievement of Ireland's climate and energy targets in a cost-effective manner. The Department of Communications, Climate Action and Environment has responsibility for implementing the fund, which will have an allocation of at least €500 million over the period to 2027.

The fund is aimed at a broad range of projects including renewable energy, energy efficiency and district heating, amongst others. Up to 50% of the total investment costs may be supported with specific ceiling thresholds applicable to different types of projects. In the case of energy efficiency measures, offers for up to 30% of 'extra investment costs' (being the difference between the level of investment that would otherwise be made and the project cost including energy efficiency measures) are available.

The results of the first call for applications under the fund were announced in November 2018 (for projects scheduled to commence development in 2019 or 2020). Seven projects were approved as eligible, with support levels ranging from €1.4 million to €20 million, with an average size of €11 million. This support mechanism could potentially be used to support the RRRC heat network.

4.3.4 High-Efficiency CHP

The high-efficiency combined heat and power (HE CHP) certification scheme is administered by the Commission for Regulation of Utilities (CRU). CHP plants may submit an annual report to the CRU to demonstrate the portion of power that qualifies as HE CHP electricity and the portion of fuel to create this electricity. The power that qualifies as HE CHP power is not charged electricity tax and for plants that are in the REFIT 3 scheme, is paid an additional subsidy (although the REFIT scheme is now closed for new applications). For smaller fossil fuel plants, in sites that are not part of the Emissions Trading Scheme, the portion of fuel (that produced CHP power) pays a significantly reduced carbon tax. Plants with a HE CHP certificate may also be instructed to run more often than non-HE CHP plants by the grid. The HE CHP scheme is assessed on two primary metrics; primary energy savings and total efficiency (heat and power production).

The RRRC is not expected to achieve HE CHP certification due to the nature of the facility and the type of fuel source and so would not be able to avail of the associated opportunities.

4.4 Technical feasibility

Step 3 of the CBA methodology requires identification of existing and proposed heat loads which are technically feasible to supply, as detailed in section 3 of this study. The draft Article 14 guidance

[5] https://www.dccae.gov.ie/documents/RESS-1%20Auction%20Industry%20briefing.pdf

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 preferred heat network solution is to supply heat, in the form of steam, to local industrial heat consumers in Ringaskiddy. While liaison with potential consumers is required to verify technical requirements and develop heat supply negotiations, the design of RRRC is likely to offer compatible steam conditions to the types of industry identified.

Heat export will be facilitated through steam extraction from the turbine as follows.

a. Live steam would be supplied to the turbine at 53 bar(a). This represents the maximum theoretical export pressure, however it would be preferential to reduce export pressure as far as reasonably practical while ensuring compatibility with heat consumers, to optimise efficiency of the RRRC.
b. Steam could be supplied through medium to low pressure turbine bleeds at a pressure which most favourably aligns with heat consumer requirements, accounting for pressure drop along the export pipeline. Based on review of heat consumer industry types, an export pressure of circa 10 bar(a) is likely to be sufficient. This would equate to export of circa 16.8 tonnes of steam per hour, to export the assumed practical maximum of 12 MW_{th} of heat.
c. Following transfer of heat to the consumer process, condensate would be returned to the RRRC (where possible) to minimise make-up water requirements. This approach assumes that heat is utilised in a non-contact process such that condensate does not become contaminated. Based on industry experience, condensate is assumed to be returned at a temperature of 50°C. In the event that condensate becomes contaminated, it would be necessary to make up the volume of exported fluid via the RRRC's demineralised water preparation plant.

By recovering heat from the turbine, it will be relatively straightforward to modulate export capacity via a control valve and integrated control system. Varying heat demand profiles could therefore be supplied by RRRC. The export range will be selected at the detailed design stage, when there is more certainty over heat consumer requirements.

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

Back-up boilers (as detailed in section 2.6) are likely to be included in the heat network to ensure continuity of supply. To support the economic case, and on the basis that the majority of the identified heat demand is pre-existing with dedicated heat generation plant, the preferred solution would be to retain the existing heating infrastructure as back-up. Locating back-up plant at the point of use would also have the benefit of reducing heat losses resulting from heat provided via conventional fossil fuels.

Thermal storage can be utilised to ensure that low carbon energy provision is prioritised by demand shifting. However, this principle is typically reserved for heat exported as hot water, where it is possible to store large amounts of heat with relatively low heat losses (as a result of the lower temperature of the network). In the case of steam export, heat losses are likely to present a prohibitive barrier to thermal storage opportunities. A steam accumulator will be considered at the detailed design stage to allow any short-term peaks in heat demand fluctuations to be met.

3. Whether there is enough demand for heat to allow high-efficiency cogeneration

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

4.5 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 in accordance with Directive 2012/27/EU Annex II part (b), using the following assumptions.

1. Waste throughput of 29.8 tonnes per hour based on an NCV of 9.65 MJ/kg.
2. Gross electrical output (fully condensing mode) of 21.0 MW_e.
3. Parasitic load of 2.5 MW_e.
4. Z ratio of 5.06 based on UK CHP Quality Assurance programme (CHPQA) Guidance Note 28[6] (used in the absence of detailed design) at an extraction pressure of 10 bar(a).
5. Efficiency reference values for the separate production of heat and electricity have been taken as 75% and 25% respectively, as defined in Annexes 1 and 2 of Commission Delegated Regulation (EU) 2015/2402[7].

When operating in cogeneration mode (i.e. heat export of 12 MW_{th}) the RRRC will achieve PES of 11.6%.

4.6 Results of cost-benefit analysis

We have adopted the (England and Wales) EA's methodology, as outlined in the draft Article 14 guidance, in order to appraise the economic feasibility of implementing the proposed heat 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 study. We have entered all expenditures and revenues into the model in Euros (using a GBP to Euro exchange rate of 1.16) to generate a comparative assessment.

The CBA model takes into account:

1. revenue streams (heat sales and fiscal benefits);
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 A. The following assumptions have been made.

1. The construction contract will be executed in 2024 to form the cost base date.
2. The heat export infrastructure is estimated to have a capital cost of approximately €6.6 million, split over a two year construction programme. This assumes a basic pipe support system and reasonable ground conditions along the pipe route. The market has not been approached to verify costs at this stage.
3. Existing boiler plant at heat consumer sites will be utilised as back-up to cover periods of unavailability, therefore no associated cost is included.

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

[7] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R2402&from=EN

4. Operational costs have been estimated based on comparable projects and accounting for the technical proposals within the proposed heat network.
5. Heat sales revenue will be €18/MWh, index linked for inflation, to align with typical market prices.
6. Electricity sales revenue will be €65/MWh, index linked for inflation, to align with typical market prices.

The results of the CBA indicate that the nominal project internal rate of return and the net present value (before financing and tax) over 32 years are negative. Therefore, the returns based on heat sales revenue alone are unattractive. We consider that the proposed heat network does not yield an economically viable scheme in its current configuration if unsubsidised.

It may be possible to secure funding under the Climate Action Fund (as discussed in section 4.3.3) to improve the economic case. A grant of circa €2.4~~1.2~~ million, equal to 36~~18~~% of the estimated capital cost and a heat sale price of €30/MWh, would be sufficient to raise the net present value to a marginally positive figure, and would achieve an internal rate of return of 17%. Alternatively, the heat sale price could be escalated to around €3~~0~~7/MWh to warrant a similar economic case, however this price is likely to be considered excessive for the service offered. The economic feasibility of the scheme should be reassessed in the future when there is more certainty over heat loads, following discussion with potential heat consumers, and in light of any developments to the subsidy landscape.

5 R1 Efficiency Calculation

Energy efficiency thresholds for municipal waste incinerators are set out in EU Annex II of Directive 2008/98/EC on waste, the Waste Framework Directive (WFD). The WFD allows municipal waste incinerators to be classified as recovery operations provided that they contribute to the generation of energy with high efficiency.

In accordance with the WFD, incineration facilities for municipal solid waste can be regarded as "Recovery" operations if the energy efficiency of the facility is greater than 0.65 (for facilities permitted from 1st January 2009). This is referred to as achieving "R1 status". R1 status is formally granted by the Competent Authority of the Member State. Facilities which do not meet the energy efficiency criterion are classed as "Disposal" operations and are therefore considered as being equivalent to landfill (disposal) in terms of the waste hierarchy.

Fichtner has undertaken an assessment to determine whether the proposed ~~the~~ RRRC would be classified as a recovery operation under the requirements of the WFD.

The European Commission has published guidance titled '*Guidelines on the Interpretation of the R1 Energy Efficiency Formulae for Incineration Facilities Dedicated to the Processing of Municipal Solid Waste According to Annex II of Directive 2008/98/EC on Waste*'. Within the guidance the formula to calculate the efficiency of a facility processing municipal waste is defined as follows.

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

where:

- E_p means annual energy produced as heat or electricity. It is calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1 (units of GJ/yr).
- E_f means annual energy input to the system from fuels contributing to the production of steam (units of GJ/yr).
- E_w means annual energy contained in the treated waste calculated using the lower calorific value of the waste (units of GJ/yr).
- E_i means annual energy imported excluding Ew and Ef (units of GJ/yr).
- 0.97 is a factor accounting for energy losses due to bottom ash and radiation.
- Climate Change Factor (CCF), was not included in the original (2011) guidance but was introduced following the findings presented in the Joint Research Centre of the European Commission report[8], published in 2014. The report identified inconsistencies in the amounts of energy that can technically be used or produced in the form of electricity, heating, cooling or process steam across Europe. The CCF accounts for the impact of climate conditions on the R1 formula, which vary subject to the location of the facility.

To calculate the efficiency ratio the following assumptions have been made:

- the RRRC consists of one stream with an availability of 91.32 %, equating to 8,000 hours per annum;
- the waste throughput per stream would be 29.8 tonnes per hour;
- the waste would have an NCV of 9.65 MJ/kg;

[8] https://publications.europa.eu/en/publication-detail/-/publication/b770609d-7125-4163-ab62-edc530963d99/language-en

- the gross electricity produced would be 21 MW_e (in fully condensing mode), with a parasitic load of 2.5 MW_e;
- start-up electricity used would be 70% of parasitic load;
- the auxiliary burner would have a capacity of 60% of the boiler thermal input;
- the axillary burner consumption during start-up would be 50% of the burner duty;
- the number of start-ups per year would be 5 and each start up would take a period of 16 hours;
- 50% of the fuel used in the start-up would be used to generate electricity; and
- up to 12 MW_{th} of heat would be exported from the RRRC.

Taking the above into consideration, the efficiency ratio of the RRRC has been calculated as 0.70 in fully condensing mode, rising to 0.80 in the maximum heat export case. Therefore, provided that the design of the fFacility is implemented in accordance with the assumptions presented in the planning application, once operational the RRRC would be able to achieve the R1 status (0.65 or greater) and would be classified as a recovery operation under the terms of the WFD in all operational configurations.

Appendices

A Cost Benefit Analysis 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

	Scenario used
Heat carrying medium (hot water, steam or other) (dropdown box)	Steam
Total length of supply pipework (kms)	3.14
Peak heat demand from Heat User(s) (MWth)	8.3
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)	2				
Number of years to build		2	2	2	0
	% (ONLY IF APPLICABLE)	£m	£m	£m	£m
Year 1 costs (£m) and build up of operating costs and revenues (%)	0%	3.178756999	0.108035687	0	
Year 2 costs (£m) and build up of operating costs and revenues (%)	0%	3.178756999	0.108035687	0	
Year 3 costs (£m) and build up of operating costs and revenues (%)					
Year 4 costs (£m) and build up of operating costs and revenues (%)					
Year 5 costs (£m) and build up of operating costs and revenues (%)					

Non-power related operations

OPEX for full steady state Heat Supply Infrastructure on price basis of first year of operations (partial or steady state) (£m)	0.1
OPEX for full steady state Heat Station on price basis of first year of operations (partial or steady state) (£m)	0.0
OPEX for full steady state Standby Boilers on price basis of first year of operations (partial or steady state) (£m)	0.0
OPEX for full steady state Industrial CHP on price basis of first year of operations (partial or steady state) (£m) *	
Additional equivalent OPEX to pay for a major Industrial CHP overall spread over the life of the asset (£m) on price basis of first year of operations (partial or steady state) (£m) *	
Other 1 - Participant to define (£m)	
Other 2 - Participant to define (£m)	
Total non-power related operations	**0.1**
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)	18.00	18.00				
Annual quantity of heat supplied from the Heat Source(s) to Heat User(s) at steady state (MWh)	60,737	60,737				
Equivalent heat sales if first year of operations is steady state (£ m)	1.1					
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)	9%	9%				
'Lost' electricity sale price (£/ MWh) at first year of operations	65.56	65.56				
Z-ratio (commonly in the range 3.5 - 8.5)	5.06	5.06				
Power generation lost at steady state (MWh)	10,962	10,962				
Equivalent 'lost' revenue from power generation if first year of operations is steady state (£ m)	0.72					
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)	46.40	46.40				
Boiler efficiency of Standby Boiler (%)	80%	80%	80%	80%		
Additional fuel required per year for Standby Boiler in steady state (MWh)	6,587	6,587	-	-		
Equivalent additional fuel costs if first year of operations is steady state (£m)	0.31					
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					
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 32 years	#NUM!
Nominal NPV (before financing and tax) (£m) over 32 years	-5.32

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