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Consulting Engineers Limited

PEEL ENVIRONMENTAL MANAGEMENT UK LTD & BILSTHORPE WASTE LTD

BILSTHORPE ENERGY CENTRE

HEAT PLAN REPORT

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MANAGEMENT SUMMARY

Peel Environmental Management UK Ltd is seeking planning permission to build a plasma gasification plant at the Bilsthorpe Business Park site near Newark. It is possible that surplus heat generated from the plant could be captured and supplied to heat consumers in the vicinity of the facility.

This heat study has considered the high-level practicality to implement a district heating network using heat from the Bilsthorpe facility. Technical difficulties can be overcome by current technology commercially available.

Three options to evaluate the technical viability of supplying heat to potential consumers have been explored.

a) Option 1 - 45 potential consumers within the 10 km radius limit;

b) Option 2 - Centre Parcs facility approximately 3.5 km from the Bilsthorpe facility; and

c) Option 3 - 14 consumers in Bilsthorpe and to the southwest of Bilsthorpe.

All three options could be supplied heat from the Bilsthorpe facility. For Option 1 and Option 2 it is possible that, during periods of cold weather, the peak heat demand from all consumers may exceed the supply available from the Bilsthorpe facility. For Option 3 the Bilsthorpe facility would have the capacity to supply heat to all consumers throughout the year.

The R1 efficiency for the Bilsthorpe gasifier is predicted to be 0.66 with no heat export. When the calculation includes 1.4 MW of heat export the value of R1 increases to 0.68. Both options exceed the threshold for classification as recovery (as defined by the revised Waste Framework Directive), which is 0.65. Therefore, the Bilsthorpe plasma gasification facility will meet the definition of recovery with or without any heat export.

Yours sincerely
FICHTNER Consulting Engineers Limited

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1 BACKGROUND

1.1 Background

Peel Environmental Management UK Ltd ("Peel") and Bilsthorpe Waste Ltd is seeking planning permission to build a plasma gasification plant at the Bilsthorpe Business Park site near Newark. It is possible that surplus heat generated from the plant could be captured and supplied to heat consumers in the vicinity of the facility.

Fichtner Consulting Engineers (Fichtner) and Peel have provided information which indicates there are 45 commercial heat consumers within a 10 km radius of the proposed site to whom heat could be supplied.

1.2 Objective

Fichtner has been asked to assess the possibility of supplying low grade process heat to local consumers. To support the heat plan Fichtner will produce provisional pipe routing drawings from the proposed plasma gasification plant to potential heat consumers, using the most efficient and logical arrangement.

Peel has provided information on:

(1) existing heat load data and energy usage for the site;

(2) initial details of useful/obstructive infrastructure;

(3) name and location of identified potential external heat consumers; and

(4) estimated heat demand of potential external heat consumers.

Where information is not currently available Fichtner will make assumptions based on similar heat plans undertaken in the past.

This report also includes an R1 calculation to demonstrate whether or not the plant can be regarded as 'Recovery', as defined in the revised Waste Framework Directive.

2 CONCLUSIONS

(1) The Bilsthorpe plasma gasification facility is designed to process waste to create a syngas which can be combusted in 8 gas engines. Cooling the engines produces low grade heat which is typically exhausted to atmosphere. It is feasible to capture around 5.5 MW of heat energy and, in the form of pressurised hot water, deliver to consumers in the local area.

(2) A map of potential consumers within a 10 km radius limit is included in Appendix B, Option 1. A number of consumers are located at the radius limit, which implies that the development of a workable district heating network will involve significant cost.

(3) There are no insurmountable technical issues associated with installing the district heating system within a 10 km radius of Bilsthorpe. Significant piping runs will need to be installed to connect consumers at the limits of the radius limit.

(4) Consumers will expect heat to be available throughout the year, and especially in winter. If all consumers described in Option 1 signed up to the scheme then the supply of 5.5 MW of heat would not be capable of meeting peak demands during periods of cold weather.

Network option	Peak Heat demand (MW)
Option 1: Entire network (45 consumers)	36.0
Option 2: Centre Parcs leisure and accommodation facilities	8.1
Option 3: Bilsthorpe and southwest (14 consumers)	5.4

If Centre Parcs was keen to receive a heat supply from the Bilsthorpe facility, Option 2 describes a technically neat solution as the distance to transport heat is around 3.5 km. Bilsthorpe is likely to be able to meet the heat demand for Option 2 for the majority of the year, and would make a large contribution to the peak heat demand which may occur at times during cold weather. It may be possible to use existing heating distribution systems at the Centre Parcs facility which would significantly reduce the capital cost.

As described in Option 3, fourteen heat consumers within Bilsthorpe and to the southwest of the village could potentially use heat supplied by the gasifier. The potential magnitude of heat demand could be met by the gasifier throughout the year.

(5) The plant achieves a R1 value of 0.66 (with no heat export) which meets the criteria for recovery under the Waste Framework Directive. When the calculation includes for 1.4 MW of heat export the value of R1 increases to 0.68. In this case the plant still achieves a R1 value of 0.66 (with no heat export) and again meets the criteria for recovery under the Waste Framework Directive.

3 RECOMMENDATIONS

(1) It is recommended that an action plan is produced to explore the potential benefits of the district heating project. This may include:

a) developing a master plan with a clear strategy and objectives clearly defined to progress a viable district heating scheme - this will then be developed into a commercial business plan;

b) making contact and maintain dialogue with other potential heat users in and around Bilsthorpe to build up a data base of potential customer - a programme of canvassing and surveys could be carried out annually to build up a picture of the potential for more heat consumers;

c) setting up a working group involving local stakeholders to demonstrate to local businesses that there is widespread support for the project which may encourage more interest to be involved; and

d) open negotiations with potential energy supply companies (ESCOs) to identify the right ESCO for the project and enable Heads of Terms will be put in place while the final definition of the scheme is developed.

4 DESCRIPTION OF THE TECHNOLOGY AND HEAT NETWORK

4.1 Bilsthorpe plasma gasification facility

Peel Environmental Management UK Ltd and Bilsthorpe Waste Ltd are seeking planning permission to develop the Bilsthorpe plasma gasification facility located on the Bilsthorpe Business Park site. Working with Waste2Tricity the current approach is to use plasma gasification technology provided by Alter NRG that will form the basis of this assessment.

The facility will thermally treat up to 95,000 tonnes of solid recovered fuel (SRF) with a net calorific value of 14.46 MJ/kg. The syngas produced would be combusted in gas engines to generate up to 13.6 MW of electricity (net).

It is technically feasible that low grade heat from the process could be exported through a district heating network to the local community.

4.2 Process summary

As a summary of the process, pre-processed waste is mixed with coke and limestone and gasified in a gasification chamber. The resultant synthesis gas (syngas) is cleaned and combusted in gas engines to produce electricity.

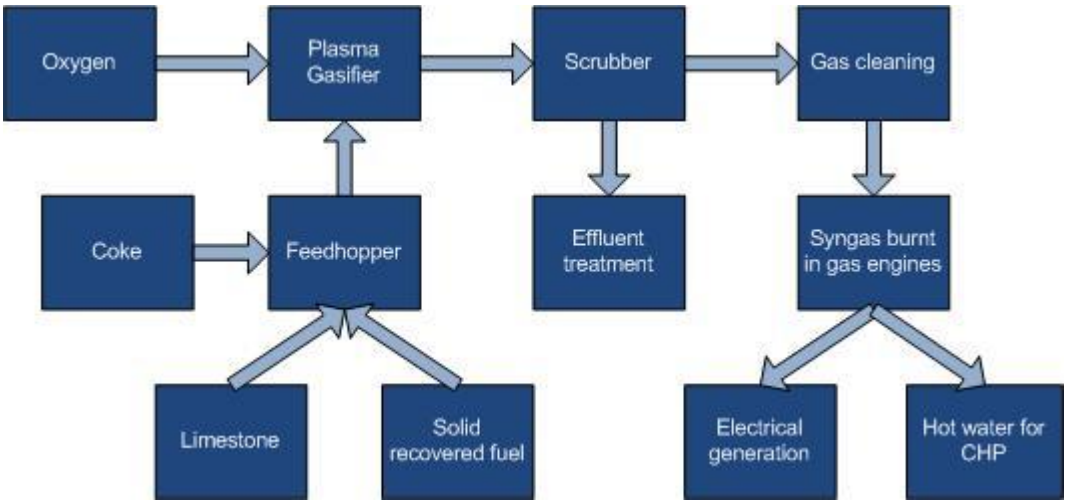


Figure 1 – Simplified process flow diagram

4.3 Systems for heat recovery

Waste heat from process systems is normally supplied in two forms, steam and hot water. Plants which use steam turbines to generate electricity will often bleed steam from a low pressure turbine extraction point for use in heat applications.

At the Bilsthorpe facility, production of steam does not form part of the system process. Instead, electricity is generated by combusting the syngas in a gas engine. The resultant heat from the combustion process will be captured through cooling systems which transfer the heat into pressurised hot water for use elsewhere.

A number of heat sources exist in the vicinity of the gas engines. Selection is based on the magnitude of the available heat and robustness of the technology available.

High level evaluation of the available options shows that water jackets enclosing the engine body will capture the majority of waste heat available. A second approach using energy from the second stage intercooler is also a viable source of useable heat.

It is possible that heat could also be collected from the flue gas. However the technology is unlikely to be economically feasible as the amount of heat collected will be small compared to the water jackets and the cost of the technology is relatively high.

4.4 Details of heat supply system

Heat from the Bilsthorpe facility would be supplied to consumers in the form of hot water. The temperature of the water can be supplied at up to 110°C depending on the consumer's specific requirements.

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

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

Heat delivery arriving at a consumer's premises usually terminates using a secondary heat exchanger. The heat exchanger is typically arranged to supply heat to a tertiary heating circuit upstream of any boiler plant. The water in the tertiary circuit is boosted to the temperature required to satisfy the heating needs of the building. Domestic hot water can also be provided by a separate heat exchanger. Heat exchangers can be supplied as pre-fabricated substations making installation quick and easy.

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.

4.4.1 Back-up systems

It is possible to install back-up heat generation plant at the Bilsthorpe facility in the event of failure of the primary heat distribution system. However, it is currently considered more efficient to retain existing gas or oil-fired boilers at the consumer's premises to minimise heat losses and minimise fossil fuels use. This also gives the customer the option to control the heat supply so they can reasonably avoid the high cost of heat produced from fossil fuels and control their own heating plant when the Bilsthorpe facility is shut down for maintenance or there is unplanned downtime. If the heating network develops into a complex system with a large number of critical heat consumers then a central stand-by boiler plant could be considered.

4.4.2 Local cooling

During summer months, when heat demand is low, it may be possible to use the heat to provide a cooling system. The system would use local absorption chillers (which work like a reverse heat pump) to power air conditioning systems. This will be cheaper to run than electrically-powered air conditioning but is likely to involve significant installation costs.

Thermal chillers have a large footprint, but they have very low electrical power requirements since power is only required for the solution and refrigerant pump.

For the purposes of this report, this option has not been considered as suitable numbers of consumers were not identified in the investigation.

4.5 Engineering issues associated with supply of heat

The predominant engineering issue associated with the supply of heat by hot water is installation of the heat supply pipeline. Determining a feasible route for this pipeline is complex.

To export heat from the Bilsthorpe site a pipeline has to be routed along public highways, which will require suitable traffic management and avoidance of other buried utilities, along with suitable licenses as required by the New Roads and Street Works Act.

If heat is to be delivered to an existing building then modifications will be required to the heating system of the building. The cost of making a connection depends on the age and complexity of the system to be connected. Space to install new plant may also be an issue if existing boiler plant is to be retained. Timing can also be problematic as interruptions to a buildings heating system during winter months may not be acceptable to the building occupier.

4.6 Legislative requirements

In February 2013, the EA produced a guidance note titled 'CHP Ready Guidance for Combustion and Energy from Waste Power Plants'. This guidance applies to the following facilities, which will be regulated under the Environmental Permitting (England and Wales) Regulations 2010:

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

The Bilsthorpe facility will be regulated as a waste incineration facility with a throughput of more than 3 tonnes per hour, thus the above guidance will apply.

Section 4.1 of the guidance describes the requirements relating to the plant, plant location and potential heat loads. It states that for plants of less than 300 MW capacity, CHP opportunities should be evaluated using an indicative search radius of 10 km from the proposed facility.

The CHP-R guidance states that it a requirement of demonstrating Best Available Techniques (BAT) to consider energy efficiency, principally through the use of Combined Heat and Power (CHP). For facilities which are located in close proximity to potential heat consumers the EA would expect them to be designed 'CHP Ready'. On this basis, we would envisage that the EA would expect to see that the facility is demonstrated as being 'CHP Ready' when applying for an environmental permit.

4.7 Heat users

A number of potential types of heat consumer exist for the export of hot water, including office and light industrial facilities, public service facilities and industrial process facilities. The applicant is committed to pursuing any viable heat use opportunities that exist in the area.

It is noted that no agreements have yet been reached, as without the necessary planning consent and environmental permit heat consumers remain unable to take commercial decisions about the availability of heat. It needs to be appreciated that, in the commercial arena, the certainty that potential heat consumers need to progress detailed commercial agreements is only likely to occur some way off in the future.

Therefore, the applicant is in a position that, until such time that planning and permitting have been obtained and the heat is likely to come to fruition, potential consumers will be hesitant to enter into a commercial agreement. This will extend to their propensity to develop detailed designs and obtain relevant authorisations for their operations. Notwithstanding this, the applicant is still committed to pursuing potential opportunities.

The sections below detail the identified existing heat demands and any future potential heat consumers. The approach has centred on industrial and business users, as the benefits of providing heat to a large business is generally more financially viable than supply to smaller consumers. It is noted that standard housing stock has not been considered as a potential heat consumer at this stage of the assessment. This is because capital costs are typically excessive and may unfairly skew the financial payback period. If inadequate numbers of consumers are identified, then the next stage of the evaluation will be to include domestic dwellings.

4.8 Method of heat production

The Bilsthorpe facility will be designed with 8 gas engines to combust the syngas. Each engine is capable of producing 2 MW of electricity. Heat generated from this process is normally directed to heat exchangers that exhaust the heat to atmosphere. To achieve 'CHP Ready', the heat will need to be diverted for use in further applications.

The term 'CHP Ready' will require a design approach which can demonstrate that the facility is set up to collect heat from the process. For Bilsthorpe this is likely to apply to the inclusion of water jackets around the engines and a second stage intercooler system for diverting heat for further usage. Other sources of heat are also possible (such as the exhaust) but the technology to collect this heat is expensive and the heat collected is significantly smaller than that from the water jacket and intercoolers.

4.8.1 Magnitude of heat production

The primary engine water jacket will produce in the order of 550 kW ±12% of heat (engine running at 75% load) at a temperature of 110°C.

The second stage after-cooler will reject around 145 kW ±10% of heat.

Summating the above energy, the total facility heat source available is likely to be around 5.5 MW. Assuming an annual facility availability of 8000 hours, the total annual heat supply provided by the Bilsthorpe facility potentially available for CHP applications will be 44,000 MWh.

4.9 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 consumers since no specific agreements have been made. However, indicative pipe routes are shown in Appendix B.

Planning permission, easements and Highways Licenses will need to be obtained for access, construction, and maintenance of the pipes. There will be a significant financial implication for obtaining easements, and these would only be progressed once planning permission has been received for the Bilsthorpe facility and heat supply agreements put in place.

Traffic management requirements will 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 4.10.

As the project proceeds, discussions with the various potential heat consumers will be required to agree heat supply agreement. A full economic analysis will need to be undertaken, considering the costs associated with pipe installation and system operation and maintenance, in order to determine a suitable heat price per unit.

Peel would propose to contact potential heat consumers following the granting of planning consent for the Bilsthorpe facility.

4.10 Implementation Timescale

The table below gives an indicative timetable for the programme for the construction of the Bilsthorpe facility and heat network. The start of the construction of the heat system is dependent on the viability of the system and the location of the heat consumers. 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 consumers have been identified and contracted to take heat, pipeline installation will not commence.

Table 1 – Implementation Programme

Description	Schedule
Obtain planning consent and permitting	Day 1
Completion of negotiation for heat supply contracts	6 months
Start of construction of facility	9 months
Obtain consents for heat mains	18 months
Start of commissioning of the facility	33 months
Take-over of the facility	39 months
Completion of construction on heat system	46 months
Testing of heat network	47 months
Start up of the heat supply	48 months

4.11 Design criteria

A number of considerations have an input on the design of the district heating system. The following assumptions have been made in relation to sizing the appropriate pipe diameter.

Table 2 – District heating network design criteria

Description	Measure
Heat flow to consumer	110°C
Heat return temperature from consumer	70°C
Distance between flow and return pipes	150 mm
Maximum pressure drop along main trunk pipes	1 bar/km
Maximum velocity flow along pipe	< 2m/s
Soil temperature	10°C
Depth of soil covering	600 mm

Figures for the amount of space heating required by different buildings has been taken from CIBSE Guide F and supplemented with Fichtner in-house experience, where necessary. The majority of consumers fall into the following categories.

	Table 3 – Consumer heat load	
	Description of consumer	**Heat consumption ($kWh/m^2/yr$)**
n/a	Library (non air-conditioned)	115
A1	Food superstore	200
A1	Non food (clothing shops)	65
A3	Cafes/restaurant	1100
A4	Pubs	2700
B1	Small/large offices/light industry	65
B2	Industry processes	320
B8	Storage/distribution	114
C1, C2	Primary school	113
Residential	Terraced housing ($60m^2$)	105
Residential	Semi-detached housing ($77m^2$)	77
Residential	Detached housing ($130m^2$)	59

Consumer facility areas have been estimated using Google Earth.

4.12 Seasonal variation in heat load

It is likely that there will be a strong seasonal variation in heat demand by consumers. Where a district heating system supplies a large number of buildings with seasonal demand, the peak winter load can be as much as ten times higher than the summer load and up to four times the annual average load.

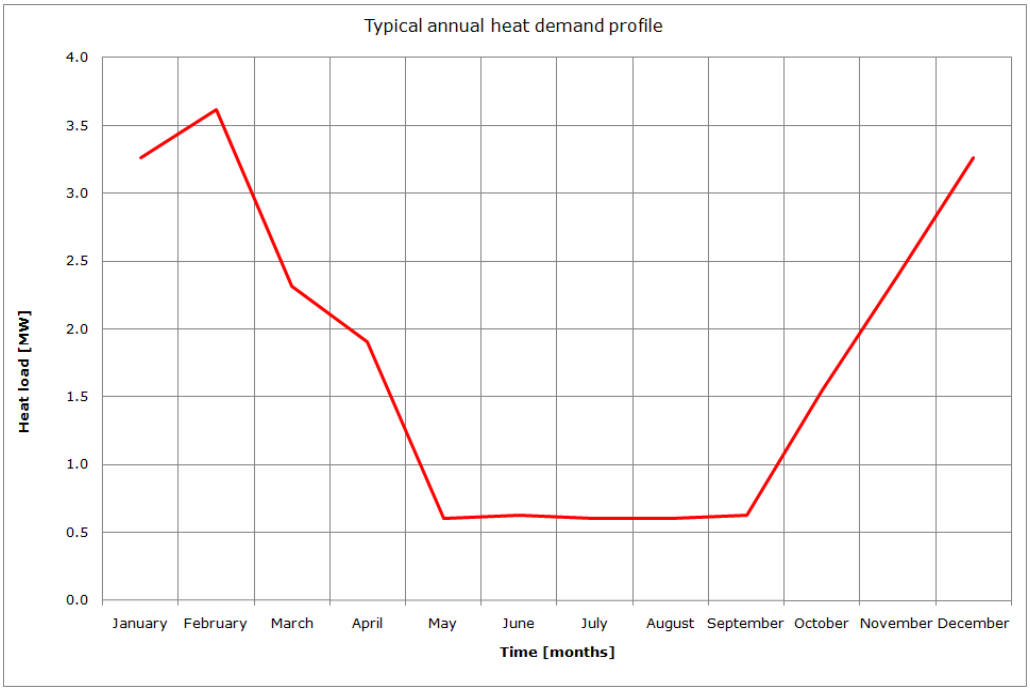


Figure 2 – Example heat load duration curve throughout the year

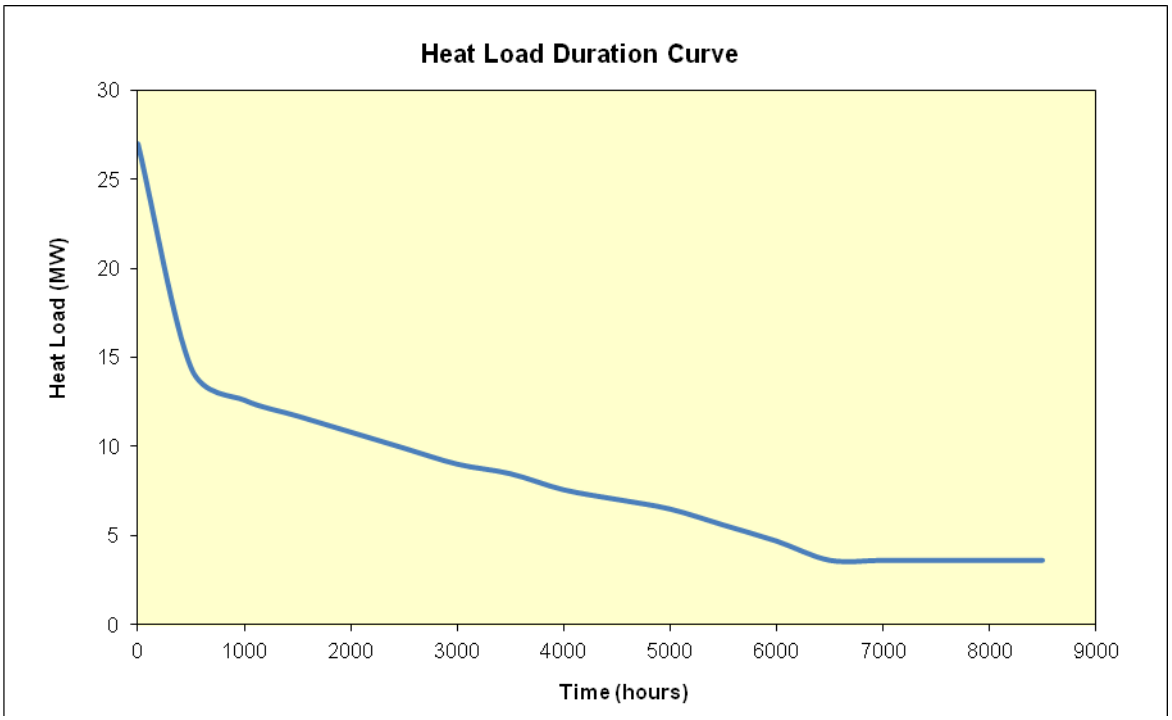


Figure 3 – Example heat load duration curve

Although the Bilsthorpe facility will produce around 5.5 MW of heat, seasonal variations are likely to impact on the number of consumers that can be provided heat throughout the year. During winter heat demand is likely to use all the 5.5 MW available, constricting the number of consumers that can be signed up. During summer months this demand will dwindle to maybe 0.5 – 1MW, with surplus heat being exhausted to atmosphere.

To enable a reasonable measure of heat revenue, the average annual load is taken as 25% of the maximum (winter) load. For the Bilsthorpe facility this equates to 1.4 MW of heat available to consumers.

The details of the design for the Bilsthorpe facility will be finalised during detailed design in order to maximise efficiency and provide heat consumers with a stable heat supply throughout the year.

5 TECHNICAL EVALUATION OF PROPOSED HEAT NETWORK

5.1 Network map arrangement

Searching within a 10 km radius of the Bilsthorpe site has identified 45 potential consumers for heat.

A map of potential consumers and proposed pipe routes can be found in Appendix B.

A list of consumer details can be found in Appendix C.

Evaluating heat usage on the basis of floor area, the analysis shows that potential peak heat demand of up to 36 MW from the 45 consumers will have capacity to consume the 5.5 MW heat output from the gasifier.

5.2 Demand considering restrictions due to seasonal demand

Taking into account the limitations described in section 4.12, to be able to supply heat to consumers all year round limits the likely average heat output from the gasifier to around 1.4 MW.

This quantity of available heat would exclude providing heat to all users throughout the year. During winter months the heat demand would exceed the 5.5 MW capacity of the gasifier. However, considering the heat load estimated in Option 3, it would be possible to supply heat demand to all potential consumers in Bilsthorpe and to the southwest of Bilsthorpe throughout the year.

Centre Parcs Sherwood lies approximately 3.5km to the north of Bilsthorpe. With large leisure facilities and 983 accommodation units the facility represents a potentially large consumer of heat. Calculations imply that if Centre Parcs considered using heat from Bilsthorpe the average demand could be in the order of 430 kW for the main leisure facilities and 1597 kW for the accommodation units. This summates to 2027 kW of average heat load.

Considering the factors discussed in section 4.12, a maximum heat load of 8.1 MW may occur in cold conditions. On this basis Bilsthorpe would be capable of meeting the heat demand from Centre Parcs for the majority of the year. However, during cold periods of weather, demand may increase beyond the maximum 5.5 MW which can be supplied from the gasifier.

6 R1 CALCULATION

The European Commission has produced a revised Directive on waste, which replaced the old Waste Framework Directive (WFD) on 20th October 2008. In this revised Directive, incineration facilities for municipal waste can be regarded as "Recovery" operations if the energy efficiency of the plant is greater than 0.65 (for plants permitted after Jan 2009). Plants which do not meet this criterion are classed as "Disposal" operations and therefore lie on the same hierarchical level as landfill.

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

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

where:

E_p means annual energy produced as heat or electricity. It is calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1 (units of GJ/yr)

E_f means annual energy input to the system from fuels contributing to the production of steam (units of GJ/yr)

E_w means annual energy contained in the treated waste calculated using the lower calorific value of the waste (units of GJ/yr)

E_i means annual energy imported excluding Ew and Ef (units of GJ/yr)

0.97 is a factor accounting for energy losses due to bottom ash and radiation.

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

We have therefore used the formula, interpreted in accordance with the guidance, to assess the energy efficiency of the plant. The calculation is based on predicted design figures and predicted levels of fuel consumption and electricity usage.

The R1 efficiency is predicted to be 0.680 with 1.4 MW of heat export. Without heat export the R1 efficiency is predicted to be 0.66. Both modes of operation are above the threshold for new gasification plants, which is 0.65. Therefore, the Bilsthorpe plasma gasification facility will meet the definition of recovery with or without any heat export. The calculation is shown in Appendix A.

Appendix A R1 Calculation

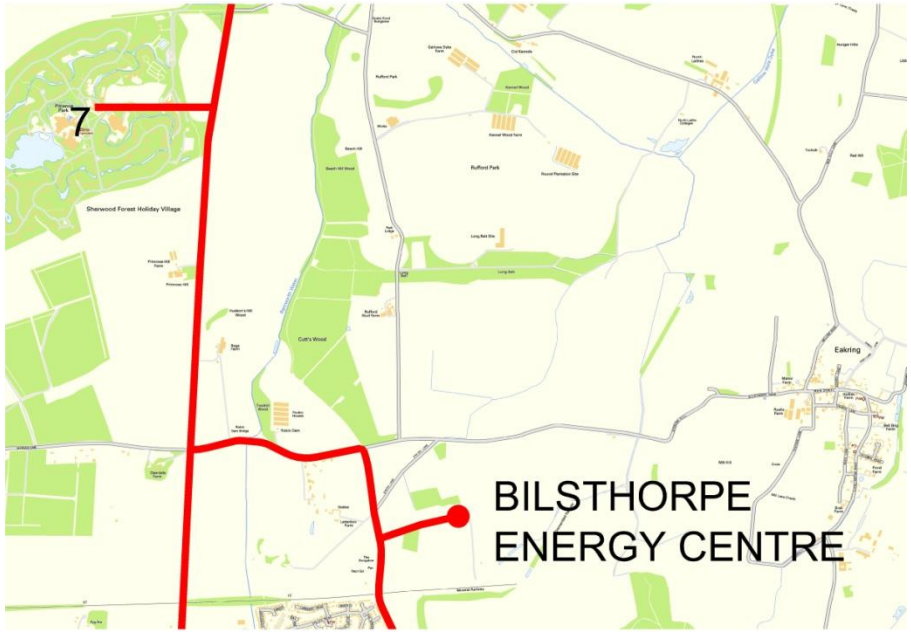
R1 formula	No heat export	1.4 MW heat export	Units
Number of streams	1	1	
Average through-life availability	92	92	%
Equivalent full load operating hours per year	8,055	8,055	h/y
Feed stock			
Waste throughput at design point per boiler	11.79	11.79	tph
Waste NCV at design point	14.46	14.46	MJ/kg
Guaranteed fuel input per boiler	47.38	47.38	MW
Waste throughput	95,000	95,000	t/y
Waste Energy input	381,622	381,622	MWh/y
Waste Energy input	1,373,838	1,373,838	GJ/y
Coke input	1.08	1.08	MJ/kg waste
Coke input per stream	3.525	3.525	MW
Coke Energy input	28,394	28,394	MWh/y
Coke Energy input	102,220	102,220	GJ/y
Limestone input	0.07	0.07	MJ/kg waste
Limestone input per stream	0.223	0.223	MW
Limestone Energy input	1,794	1,794	MWh/y
Limestone Energy input	6,460	6,460	GJ/y
Feedstock input per stream	51	51	MW
Feedstock energy input	411,810	411,810	MWh/y
Electricity exported			
Gross electricity production at design point	13.6	13.6	MWh/h
Gross electricity production after heat export	13.6	13.2	MWh/h
Gross generation efficiency (Net CV)	26.53	25.85	%
Net average electrical output	9.6	9.3	MWh/h
Net generation efficiency	18.78	18.10	%

R1 formula	No heat export	1.4 MW heat export	Units
Total electricity produced	109,264	106,445	MWh/y
Total electricity produced	393,350	383,201	GJ/y
Heat exported			
Heat exported	0	1.4	MWh/h
Heat produced	0	11,277	MWh/y
Heat produced	0	40,597	GJ/y
Heat used internally (a)			
For steam driven turbo pumps for boiler water, backflow as steam	0	0	MWh/y
For heating of flue gas with steam, backflow as condensate	0	0	MWh/y
For concentration of liquid APC residues with steam, backflow as condensate	0	0	MWh/y
For sootblowing without backflow as steam or condensate	0	0	MWh/y
For heating purposes of buildings/instruments/silos, backflow as condensate	0	0	MWh/y
For deaeration - demineralization with condensate as boiler water input	0	0	MWh/y
For ammonia injection without backflow as steam or condensate	0	0	MWh/y
Heat used internally	0	0	MWh/y
Heat used internally	0	0	GJ/y
Total heat produced			
Total heat produced	0	11,277	MWh/y
Total heat produced	0	40,597	GJ/y
Fuel used			
Auxiliary Burner capacity	60	60	%
Auxiliary Burner capacity (total)	31	31	MW
Average auxiliary burner duty during start up	50	50	%
Number of start ups per year per stream	5	5	
Start up time	16	16	hour
Annual time for start ups	80	80	hr/y
Energy in fuel consumed by start-up burners	1,227	1,227	MWh/y
Energy in fuel consumed by start-up burners	4,417	4,417	GJ/y

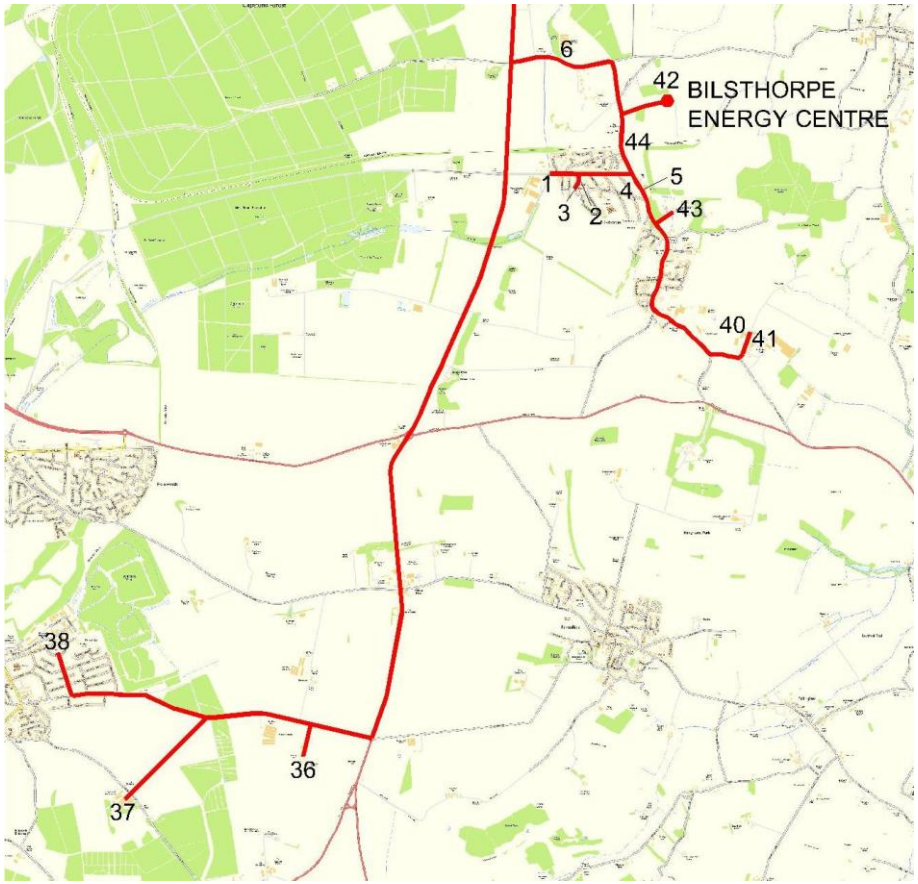
R1 formula	No heat export	1.4 MW heat export	Units
Electricity imported			
Parasitic load per tonne waste	336	336	kWh/t
Parasitic load	3,963	3,963	kW
Parasitic load	114,912	114,912	GJ/y
Start up electrical demand	70	70	% of parasitic load
Start Up Electricity	2,774	2,774	kW
Start Up Electricity	799	799	GJ/y
Parasitic load when no gasification assumed as % of parasitic load	20	20	% of parasitic load
Parasitic load when no gasification (20% of full parasitic load)	793	793	kW
Parasitic load when no gasification (20% of full parasitic load)	2,011	2,011	GJ/y
WFD Calculation			
Ew	1,482,518	1,482,518	GJ/y
Ep(electricity)	971,575	946,507	GJ/y
Ep(heat)	0	44,657	GJ/y
Ep (1)	971,575	991,164	GJ/y
Ef (2)	2,209	2,209	GJ/y
Ei(electricity)	7,307	7,307	GJ/y
Ei(heat)(3)	2,209	2,209	GJ/y
Ei	9,516	9,516	GJ/y
WFD ratio	**0.666**	**0.680**	
Pass or fail?	**pass**	**pass**	

Appendix B – Consumer locations and proposed pipe routes

Option 1: Location of all consumers within 10 km radius of Bilsthorpe



Option 2: Centre Parcs



Option 3: Bilsthorpe and southwest consumers

Appendix C - Consumer details

Consumer details for entire district heating network								
Map No (colours match section 5.1	Heat user	Description of unit type	Total area	Heat usage per area	Annual usage	Average heat capacity	Final spur length	Pipe size
			m2	kW/m 2/yr	MWh	kW	m	DN (mm)
1	Strawson	Typical	700	65	46	6	100	DN25
2	Miners Welfare	Typical	1725	65	112	14	150	DN25
3	Bilsthorpe Library	Typical	288	115	33	4	100	DN25
4	Bilsthorpe Young Persons Centre	Typical	468	115	54	7	100	DN25
5	Welspek	B1 Small offices	400	65	26	3	100	DN25
6	Possible chicken farm	Industrial	8000	320	2560	320	100	DN65
7	Sherwood forest Centre Parcs (main facility buildings)	Leisure pool centre	6000	573	3438	430	500	DN100
7B	Sherwood forest Centre Parcs (983 accommodation units)	Residential detached (130m2)	127790	100	12779	1597	29490	DN25
8	Business E Centre	B1 Large offices	500	65	33	4	200	DN25
9	Newark New Ollerton Superstore	A1 Superstore	5100	200	1020	128	100	DN40
10	Centre Parcs Ltd	B1 Large offices	2115	65	137	17	200	DN25
11	RiskDisk Offices	B1 Small offices	975	65	63	8	100	DN25
12	Netto	A1 Superstore	2200	200	440	55	100	DN32
13	Firecrest UK Ltd	B1 Large offices	4500	65	293	37	700	DN25
14	Eclectic Energy Ltd	B2 Industry processes	825	320	264	33	50	DN25
15	Cannon Fire Protection	B2 Industry processes	825	320	264	33	50	DN25
16	Rail Order	B1 Small offices	825	65	54	7	50	DN25
17	Sherwood forest crematorium	B2 Industry processes	450	320	144	18	200	DN25
18	Wellow House School	C1 Primary school	2125	113	240	30	400	DN25
19	S&E Timber Supplies	B2 Industry processes	4875	320	1560	195	530	DN50
20	A1 Bridge Flue Systems	B2 Industry processes	3240	320	1037	130	200	DN40

21	Additional buildings on Boughton Ind. Est.	B1 Light industry	13500	65	878	110	520	DN40
22	UK Coal - Thoresby Colliery	B2 Industry processes	5000	320	1600	200	700	DN50
23	King Edwin Primary School	C1 Primary school	3600	113	407	51	1800	DN32
24	South Forest Leisure Complex	Leisure pool centre	5016	573	2874	359	1100	DN65
25	Garibaldi College	Secondary school	8700	108	940	117	1850	DN40
26	Crown Farm Industrial Estate	B1 Light industry	153265	65	9962	1245	100	DN100
27	Tesco Extra	A1 Superstore	12426	200	2485	311	400	DN65
28	Mansfield Industrial Estate	B1 Light industry	54186	65	3522	440	200	DN65
29	Asda Mansfield Superstore	A1 Superstore	7680	200	1536	192	2400	DN50
30	Unusual Bunkers	B1 Light industry	2405	65	156	20	900	DN25
31	Thoresby Hall Hotel	C1 Business hotel	6000	260	1560	195	3850	DN50
32	Clipper Logistics Group	B1 Large offices	23400	65	1521	190	50	DN50
33	Evans Business Centre	B1 Large offices	22950	65	1492	186	500	DN50
34	Hanson Brick Ltd	B2 Industry processes	31200	320	9984	1248	600	DN100
35	The Minster School	Primary/secondary school	1800	113	203	25	100	DN25
36	Baulker Farm	Residential detached	17655	59	1042	130	100	DN40
37	Haywood Oaks Farm	Residential detached	400	59	24	3	950	DN25
38	Blidworth Industrial Estate	B1 Light industry	19250	65	1251	156	1500	DN50
39	St Andrews Hotel Nottinghamshire	C1 Business hotel	420	260	109	14	100	DN25
40	Noble Foods Ltd	B1 Light industry	7090	65	461	58	50	DN32
41	Yeasley Group	B1 Light industry	17340	65	1127	141	50	DN50
42	Bilsthorpe business park	B1 Light industry	4458	65	290	36	100	DN25
43	Brailswood road industrial estate	B1 Light industry	5084	65	330	41	330	DN25
44	Bilsthorpe business park development	B2/B8 Industry processes	16000	217	3472	434	100	DN65
45	Southhall Minster	C1 Church	3000	80	240	30	100	DN25
	TOTAL				**72036**	**9008**	**51970**	

Trunk piping to supply the complete district heating network				
Trunk piping		Total heat capacity	Trunk length	Pipe size
	Dependents	kW	m	DN (mm)
T1	All apart from 42	8968	350	DN200
T2	1,2,3,4,5,35,40,41,43,44,45	865	170	DN100
T3	1,2,3,4,5,35,40,41,43,45	431	150	DN65
T4	1,2,3	24	250	DN25
T5	2,3	18	35	DN25
T6	4,5,35,40,41,43,45	407	150	DN65
T7	35,40,41,43,45	400	400	DN65
T8	35,40,41,45	359	1100	DN65
T9	40,41	198	120	DN50
T10	35,45	55	9300	DN32
T20	6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,36,37,38,39,46	6611	1000	DN200
T21	25,26,27,28,29,36,37,38,39	2609	3650	DN125
T22	36,37,38	290	3900	DN65
T23	37,38	159	1200	DN50
T24	25,26,27,28,29,39	2319	7050	DN125
T25	25,26,27,28,29	2306	200	DN125
T26	25,26,29	1555	1900	DN125
T27	25,26	1363	400	DN100
T30	7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,30,31,32,33,34,46	3682	1700	DN150
T31	8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,30,31,32,33,34	3252	1400	DN150
T32	8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,30,31,32,33,34	2893	2770	DN150
T33	22,23	251	1800	DN50
T34	30,31	215	1700	DN50
T35	8,9,10,11,12,13,14,15,16,17,18,19,20,21,32,33,34	2428	1000	DN125
T36	19,20,21,32,33,34	2059	2550	DN125
	TOTAL		**44245**	

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