PARSONS BRINCKERHOFF

April 2015

SOUTH WEST EXETER DH NETWORK AND ENERGY CENTRE DESIGN

Devon County Council

287579A-BEL

Final

South West Exeter DH network and energy centre design

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Prepared for
Devon County Council

Prepared by
Parsons Brinckerhoff

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CONTENTS

EXECUTIVE SUMMARY

1.1.1 Parsons Brinckerhoff has undertaken load analysis for the proposed SW Exeter and Matford Park development areas. Based on this analysis, we have undertaken a preliminary design for a district heating network supplying heat to the development area from the Viridor EfW plant, with top up heat from a dedicated gas boiler energy centre (DHEC) located on the existing Cattle Market site to the north of the SW Exeter area.

1.1.2 Load analysis of SW Exeter and Matford Park shows an annual build-out heat load of 20.2GWh, with a design peak of 17MW. Existing loads within the vicinity of the proposed network were also contacted; however the loads of sufficient scale were either not interested in connection or not technically suitable (e.g. direct gas fired system)

1.1.3 Analysis shows that the majority of heat can be supplied from the interface at the Viridor EfW facility which, it is proposed, should feed a transmission main between the EfW and DHEC. The higher temperature and pressure water in the transmission main can then be stepped down at the DHEC to a suitable distribution temperature for supply into the development area (nominally 85°C).

1.1.4 We have designed for a 4MW connection between the EfW and the DHEC. This is sufficient to supply the majority of heat to the development area while minimising pipe diameter through the area between the EfW and the DHEC. Thermal storage capacity of nominally 300m^3 maximises the use of heat from the EfW interface, enabling peak lopping at times of high demand.

1.1.5 Delivery of heat into the development area requires extensive pipework due to the number of dwellings connected; and must overcome significant elevation change between the DHEC and the highest point on the network. Analysis concludes that DH system pressures can be maintained within 10barg, which is the maximum pressure that can be tolerated by standard DH interface equipment, by selecting larger diameter pipework on key sections of the DH network. This approach, which reduces frictional losses and therefore reduces pumping head, is preferable to additional pumping stations located within the development area as it does not require negotiation and acquisition of land from the developers and does not incur the cost of pumping station buildings and equipment. It means the network can be delivered as a single system, without hydraulic separation. There will be some increase in heat losses due to small pipe sections of increased diameter, but the extent of the larger diameter pipe is such that this impact would be minimal compared to the additional cost of the pumping stations.

1.1.6 Heat losses on a network of this size are considerable and design should ensure that they are minimised wherever possible. There are several things that can be done – and have been included in this assessment – to reduce heat losses. They are:

- Use maximum insulation DH pipework where possible;
- Use a double pipe system within plot level networks, where the pipe diameters are small enough to be available in double pipe. Double pipe has lower heat losses than the single pipe alternative;
- Operate the network at reduced flow temperature (nominally 70°C) outside of the heating season. Our analysis shows that the reduction in heat losses compensates for the increased pumping energy required through this period;

- Ensure return temperatures are as low as possible.
- We have assumed primary residential space heating return temperatures of 45°C. In order achieve this, the District Heating Project Group should continue to engage with the developers to ensure heating systems are designed appropriately. The lower temperatures will deliver significant savings in pipe cost, pumping energy reduction, heat loss reduction and avoiding the need for pumping stations.

1.1.7 Capital costs for the project have been developed through supplier quotations, industry guidelines and previous project experience. The total project cost is approximately £31m, of which more than 50 percent is pipe cost, which reflects the extent of the network required to meet the load, and maximum insulation specification proposed.

1.1.8 Maintenance costs have been included for the DH network and also the gas boilers in the DHEC. Replacement costs have also been included for the gas boilers in the DHEC.

1.1.9 It is noted that Viridor have stated a total of 7.4MW of heat is available from the EfW plant. We have designed for a 4MW supply to the DHEC, but have allowed space and cost for a 7.4MW DH-steam interface at the EfW and have included for a larger section of pipe on the transmission main running out of the EfW to which a future connection can be made. This future connection could be used to connect load towards the city centre and increase the heat sales from DH network.

1.1.10 We have also assessed the need for temporary packaged plant from information provided by developers and the local authorities. Buildings on the Matford Park development are expected to be occupied from 2015 onwards, so it will be necessary to supply at least some of those buildings from temporary plant. Initial developer plot plans propose that the first dwellings on SW Exeter will not be completed until 2017, so there is more time to develop the network, although it is likely that temporary plant will still be required for some areas. At this stage, it is not possible to offer further thoughts about the location, size and positioning of temporary plant; however it is recommended that developers are engaged early in their design process to discuss how temporary plant could be accommodated on their site, if required.

1.1.11 We have also assessed an alternative strategy wherein packaged plant is used instead of the wider DH transmission and distribution network up to 2019. We have assessed the likely impact on the project overall capital spend profile in this instance, delaying the build of the DHEC, transmission main, EfW heat interface and some of the distribution network.

1.1.12 The report concludes that a DH network serving the SW Exeter and Matford Park development areas with heat from the Marsh Barton EfW facility and top-up supply from a dedicated energy centre is technically viable.

1.1.13 In addition to this analysis, we have developed architectural design and layout for the DHEC as well as a schematic and layout for the plant inside.

SECTION 1

INTRODUCTION

2 INTRODUCTION

2.1 Background

Parsons Brinckerhoff have been commissioned by Devon County Council (DCC hereafter) to develop the design of infrastructure for a proposed district heating network serving south west Exeter.

This assessment follows a 2013 feasibility study, also by Parsons Brinckerhoff, which investigated the potential for decentralised energy within the wider Exeter area. The study concluded that the south west Exeter area presents an opportunity to supply a large area of primarily new development with low carbon heat. A new energy from waste (EfW) plant at Marsh Barton further enhances the opportunity as it is an ideal low carbon heat source in close proximity to the proposed heat network.

Planning permission for the new EfW plant requires the operator – Viridor – to use best endeavours to provide heat to the network as required; and spatial allowance has been made within the facility for connection to the system. Additional space is also available outside the facility for district heating infrastructure, for example circulation pumps and pressurisation.

In addition to heat from the EfW, an further heat source is required to supply the network when the EfW is unavailable, for example during routine maintenance. As such, a suitable location must be found for the positioning of a district heating energy centre.

2.2 Scope

This study assesses the availability, location, scale and timing of load for connection to a south west Exeter (SWE) heat network. Following consultation with planners, a high resolution (hourly) profile of heat demand across the year is developed for proposed new development for use in detailed energy balance modelling. Several existing loads were identified in the original feasibility study as being of a suitable scale to make them potentially viable for connection to a DH network. This study seeks to develop what is known about these existing loads to establish whether connection is feasible.

The high resolution heat demands are used in detailed energy balance modelling, which assesses the performance of heat production and ancillary plant, generating detailed energy balance data for use in operating cost analysis.

Locations for the district heating energy centre (DHEC), which will provide top-up and back-up heat to the network, are assessed for suitability, both strategically and from a planning perspective. Outline design of the DHEC building as well as plant layout is undertaken and presented with a costed, itemised schedule of plant for use in commercial case development.

District heating network analysis is undertaken to develop the optimum strategy for delivering heat from the EfW and DHEC to the connected loads. Routing, pipe sizing, operating temperatures, hydraulic separation and pumping strategy are assessed against site conditions and heat demands to determine the preferred network operating strategy.

The potential need, and strategic use of, packaged plant is assessed based on the known development of heat load and an approach for ensuring the availability of heat to early phase development is offered.

Finally, capital and maintenance and replacement costs for the scheme are provided.

SECTION 2

LOAD ASSESSMENT

3 LOAD ASSESSMENT

In developing annual heat loads for the proposed network the following methodology has been used.

In a July 2014 consultation response, Government stated:

We intend to set an on-site energy performance requirement at a level equivalent to level 4 energy standards of the Code for Sustainable Homes (the 'Code'). This represents an improvement on current Building Regulations' requirements of approximately 20% across the new homes build mix.

2013 Building Regulations required a 6 percent carbon reduction over the 2010 Regulations, which it is assumed all comes from fabric energy efficiency improvements compared to a 2010 compliant building.

2010 Regulations required a 25 percent carbon reduction over 2006 Regulations, all of which is also assumed to come from fabric energy efficiency improvements.

The Code for Sustainable Homes (CfSH) Technical Guide (2010) lists FEE standards in kWh/m^2/year required to achieve Code 4 standard for energy consumption. Using this figure and carbon reduction requirements from previous iterations of Building Regulations, we have extrapolated FEE standards for Building Regulations going back to 2006, as follows:

Table 3-1: Fabric energy efficiency standard improvement through time

Building Regulations	2006	2010	2013	2016	2019
Improvement	Base case: 2006 compliant building	25% over 2006 FEE	6% over 2010 FEE	Zero carbon: Code four. 20% over 2013 FEE	No change
FEE standard: semi detached (kWh/m^2/yr)	92	69	65	52	52

Note that the figures presented in Table 3-1 are for semi-detached, detached and end-terrace dwellings. The Code also provides a benchmark for flats and mid-terrace dwellings that has been used for 1-bed dwellings on the SW Exeter development.

Domestic hot water (DHW) consumption, which is not included in the CfSH benchmarks, has been calculated using the SAP methodology and is described in Section 3.1.1.

Non-domestic development will be required to achieve zero carbon from 2019 onwards. As such, we have used the same progression of FEE improvement as with domestic development, except with a 20 percent improvement in the 2013 standard delayed until 2019 Regulations introduction.

The non-domestic base case comes from CIBSE's TM46 guidelines benchmarks, which include both space heating and hot water consumption for buildings developed to 2006 Building Regulations standards.

3.1 South West Exeter development

3.1.1 *Domestic loads*

Buildings on the SW Exeter development are expected to come forward from 2017 onwards. We have assumed that dwellings built in 2017 will seek Building Regulations approval before the 2016 Regulations come into force. As such, we have used a 2013 FEE benchmark for dwellings in the first year of the SW Exeter development and the 2016 (Code level 4) FEE benchmark for every year thereafter on the basis that this is likely to be the minimum FEE standard for 2016 Building Regulations compliance.

Domestic hot water load on the development has been calculated using the SAP calculation methodology, which is based on 25 litres per person per day (L/P/D) plus 36 additional litres for the household. The number of household occupants has also been calculated using the SAP methodology. A heating requirement of 50°C has been used based on a cold water supply temperature of 10°C and a required DHW temperature of 60°C.

The total modelled annual heat load for domestic dwellings on the SWE development at build out is **16,180MWh** (of which 12,172MWh is space heating and 4,008MWh is DHW).

Phasing of domestic load has been based on information provided by developers and from the local planning authorities. A summary of the proposed build schedule is presented in Table 3-2. Note that this schedule includes dwellings within the Exeter City Council boundary in the north west corner of the development area.

Table 3-2: Proposed build-out schedule for SW Exeter development

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025
No. of dwellings completed	47	164	339	690	1042	1393	1744	2095	2446

Based on the proposed build schedule and the heat load benchmarks described previously, the following progression of domestic load through time has been calculated, split into space heating and hot water load. The corresponding data is presented in Table 3-3.

Figure 3-1: SW Exeter domestic annual load progression through time

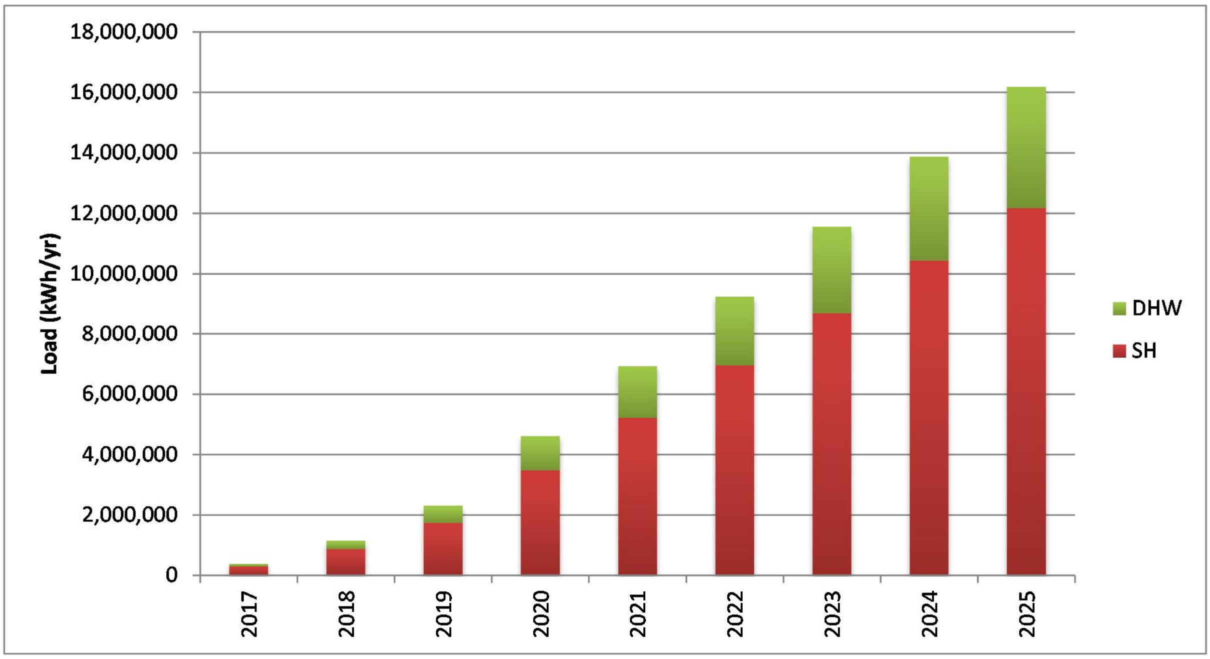

Table 3-3: SW Exeter annual load development through time

Load type	2017	2018	2019	2020	2021	2022	2023	2024	2025
SH (kWh)	289,808	869,423	1,738,847	3,477,693	5,216,540	6,955,387	8,694,234	10,433,080	12,171,927
DHW (kWh)	85,047	276,402	563,434	1,137,499	1,711,564	2,285,629	2,859,694	3,433,759	4,007,823
Total	**374,854**	**1,145,825**	**2,302,281**	**4,615,192**	**6,928,104**	**9,241,016**	**11,553,927**	**13,866,839**	**16,179,751**

Peak domestic loads for the development have been calculated using design peaks for a DH network of similar scale, in the SW region, as a proxy. We have assumed 40 W/m^2 for space heating peak up to and including 2017, with a 20 percent reduction from 2018 onwards as a result of improved building fabric performance triggered by the new Building Regulations, although it is noted that the cold start (peak) heat up requirement is unlikely to change significantly as a result of fabric improvements. The primary benefit of fabric improvements comes from a reduction in steady state heat losses.

The average peak space heating load for the development, based on the average floor area, is 3.8kW in 2017 and 3.1kW thereafter.

Peak DHW load has also been calculated using design information from the proxy development as a guide. The number of bathrooms in the dwelling dictates the hot water requirement and, therefore, the peak hot water demand. We have used the following assumptions in the modelling, which are based on the DHW plate heat exchanger sizes in a range of heat interface units (HIUs):

- 1 bathroom: 22.06kW
- 2 bathrooms: 33.7kW
- 3 bathrooms: 44.61kW

The number of bathrooms for dwellings on the SW Exeter development has been based on assumptions of the bathroom to bedroom ratio below. These are based on typical house types on the proxy development.

- 1-2 bedrooms = 1 bathroom
- 3-4 bedrooms = 2 bathrooms
- 5 bedrooms = 3 bathrooms

The average peak DHW load on the SW Exeter development, based on the number of each dwelling type (1 to 5 beds) is 33kW.

In order to calculate the total peak DHW demand on the network, we have used industry standard, Danish diversity factors, which account for the fact that on a system serving multiple dwellings, people will use their showers/baths at different times, thus the peak network load will not be the sum of the individual peak loads. Hot water consumption diversity has been studied in Denmark and the results used to develop a diversity curve for use in DH system modelling. The diversity curve used in the modelling is shown in Figure 3-2. A summary table is presented in Table 3-4.

Figure 3-2: DHW diversity curve used in modelling

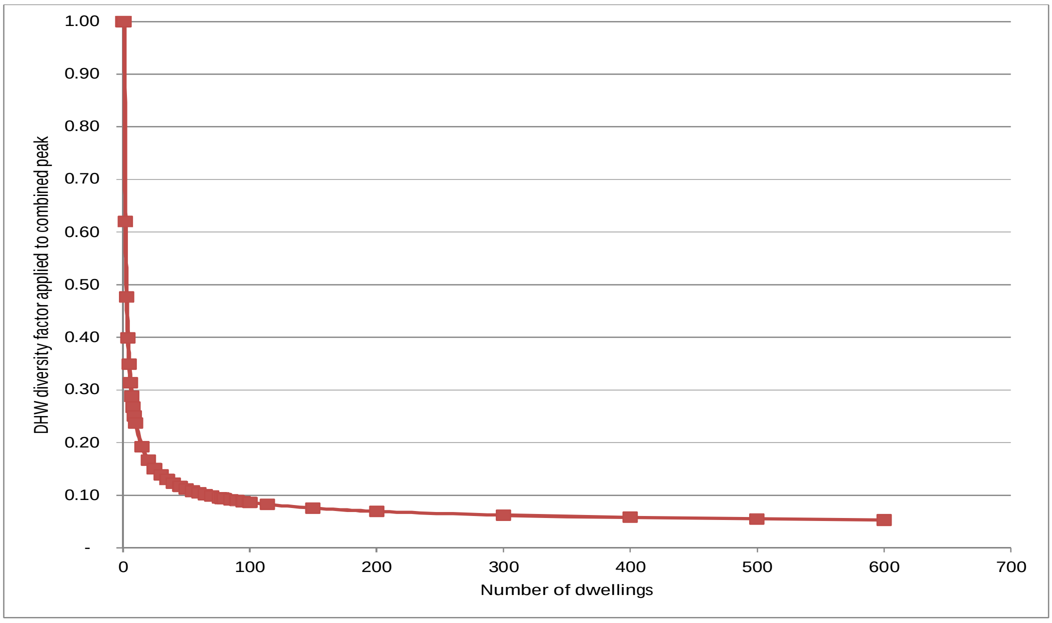

Table 3-4: Diversity factor summary table

Number of Dwellings	0	1	5	10	20	30	35	40	45	50	60	70	80	90	100	150	200	300	400	500	600
HW Diversity Factor	100%	100%	35%	24%	17%	14%	13%	12%	12%	11%	10%	10%	9%	9%	9%	8%	7%	6%	6%	5%	5%

The total, build out domestic peak load on the SWE development is **12.7MW**, of which 7.6MW is space heating load and 5.1MW is diversified DHW load. The progression of the peak load, which is a product of the number of dwellings built each year, is shown in Figure 3-3 and Table 3-5.

Figure 3-3: SW Exeter domestic peak load progression through time

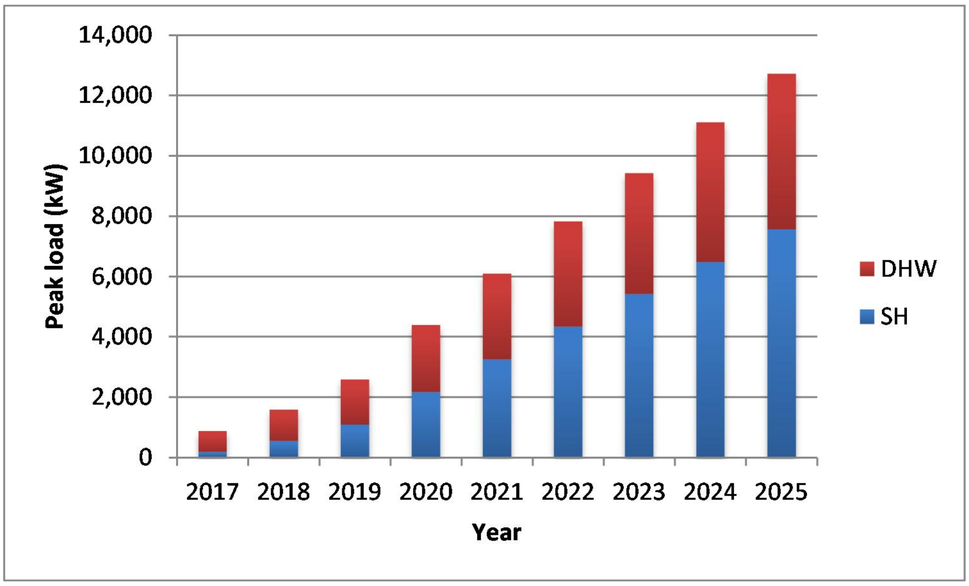

Table 3-5: SW Exeter peak load development through time

Load type	2017	2018	2019	2020	2021	2022	2023	2024	2025
SH (kW)	180	540	1,080	2,161	3,241	4,322	5,402	6,483	7,563
DHW (kW)	694	1,038	1,498	2,215	2,849	3,505	4,024	4,626	5,156
Total	**874**	**1,578**	**2,578**	**4,376**	**6,090**	**7,827**	**9,426**	**11,109**	**12,719**

3.1.2 Non-domestic loads

Non-domestic development load has been calculated using benchmarks extrapolated from CIBSE's TM46 guide, which was published in 2008, the benchmarks from which represent a 2006 Building Regulations compliant building.

We have extrapolated from TM46 benchmarks using the requisite carbon reductions from iterations in the Building Regulations to dictate improvements in fabric energy efficiency. (See the start of Section 3 for a description of the methodology used for determining heating benchmarks in non-domestic development.)

Phasing of non-domestic load at SWE has been informed by current planning information, which proposes the number of occupied dwellings that will trigger the various non-domestic developments.

The progression of annual non-domestic load through time, determined through the onset of non-domestic development as triggered by dwelling completion milestones, is shown in Figure 3-4, with the corresponding data presented in Table 3-6.

Figure 3-4: SW Exeter non-domestic annual load progression through time

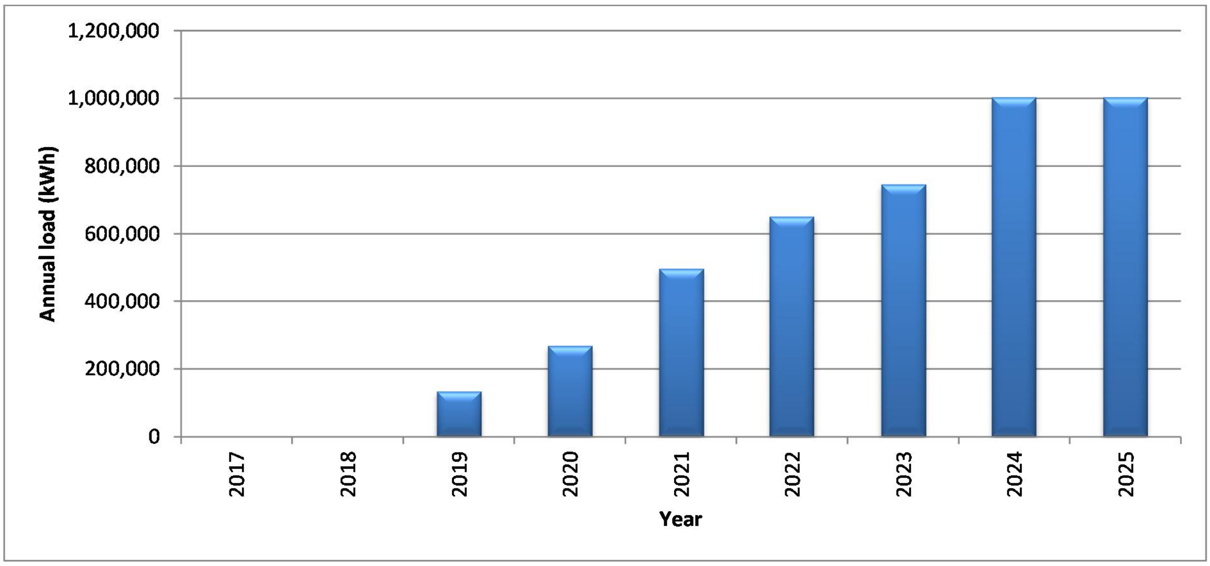

Table 3-6: SW Exeter commercial load development through time

Type	2017	2018	2019	2020	2021	2022	2023	2024	2025
Total (kWh)	**0**	**0**	**134,154**	**268,309**	**497,067**	**650,927**	**746,196**	**1,003,165**	**1,003,165**

Peak non-domestic loads on the SWE development have been calculated using benchmarks (W/m^2) from the 2014 BSRIA Blue Book. We have allowed a 10 percent reduction in peak load for development completed from 2021 onwards as a result of improved building fabric arising from the introduction of 2019 Building Regulations. It is assumed the development completed in 2020 will seek Building Regulations approval up to one year before beginning construction and can therefore seek approval under the 2016 Regulations.

The progression of peak non-domestic load through time is shown in Figure 3-5, with the corresponding data in Table 3-7.

Figure 3-5: SW Exeter non-domestic peak load progression through time

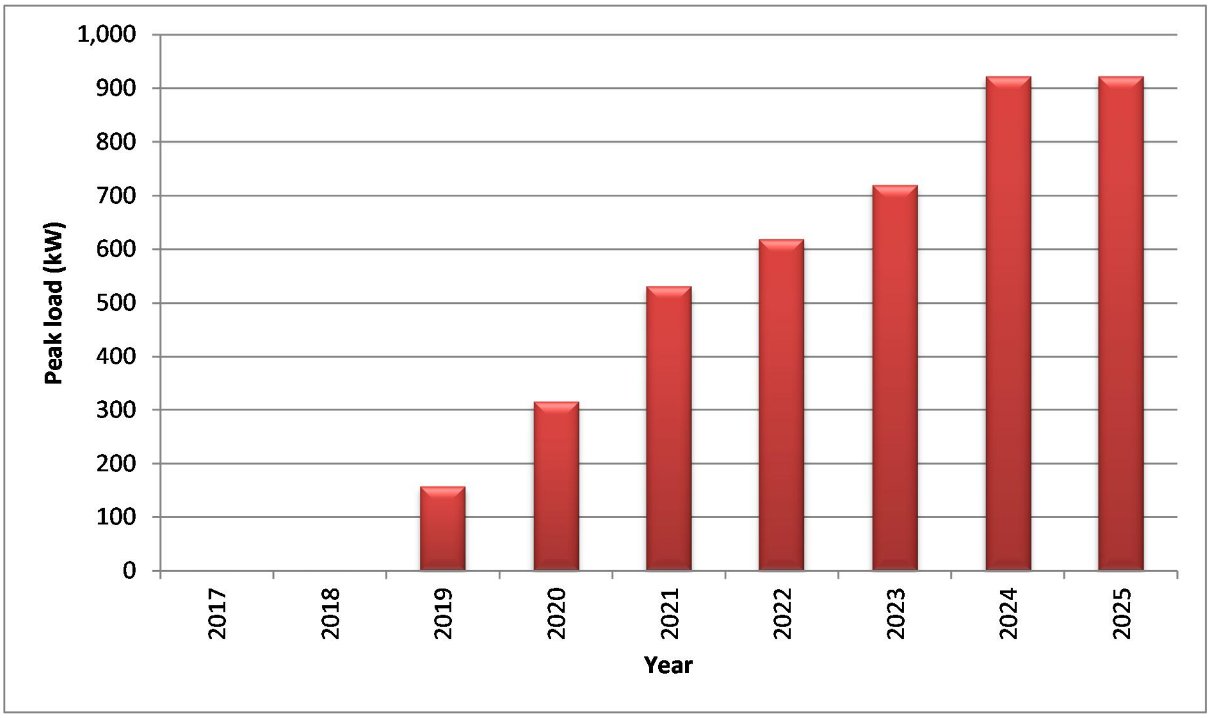

Table 3-7: SW Exeter non-domestic peak load progression through time

Type	2017	2018	2019	2020	2021	2022	2023	2024	2025
Total	0	0	158	316	531	619	720	922	922

3.1.3 *Combined loads*

The combined (domestic and non-domestic) annual and peak loads through time for SW Exeter are shown in Figure 3-6 and Figure 3-7. The modelled build-out annual heat load at SW Exeter is **17,183MWh**. The build-out peak is **13.6MW**.

Figure 3-6: SW Exeter combined annual load progression through time

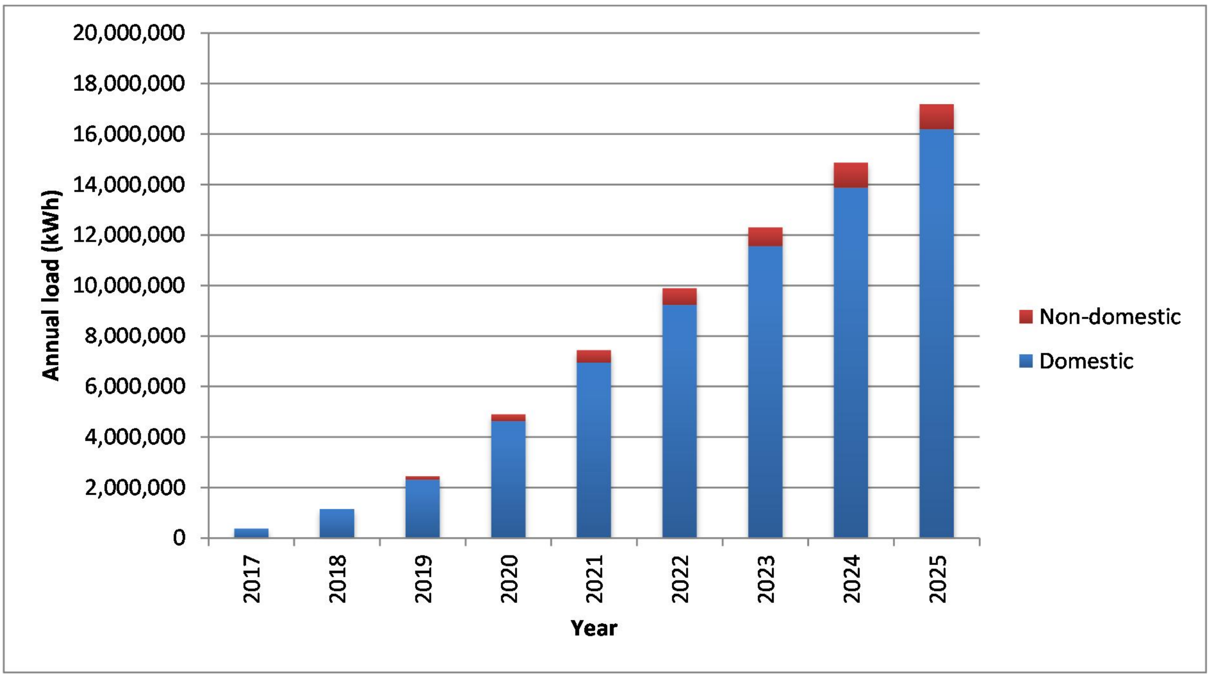

Table 3-8: SW Exeter combined annual load progression through time

Type	2017	2018	2019	2020	2021	2022	2023	2024	2025
Domestic (kWh)	374,854	1,145,825	2,302,281	4,615,192	6,928,104	9,241,016	11,553,927	13,866,839	16,179,751
Non-domestic (kWh)	0	0	134,154	268,309	497,067	650,927	746,196	1,003,165	1,003,165
Total	**374,854**	**1,145,825**	**2,436,435**	**4,883,501**	**7,425,171**	**9,891,943**	**12,300,123**	**14,870,004**	**17,182,916**

Figure 3-7: SW Exeter combined peak load progression through time

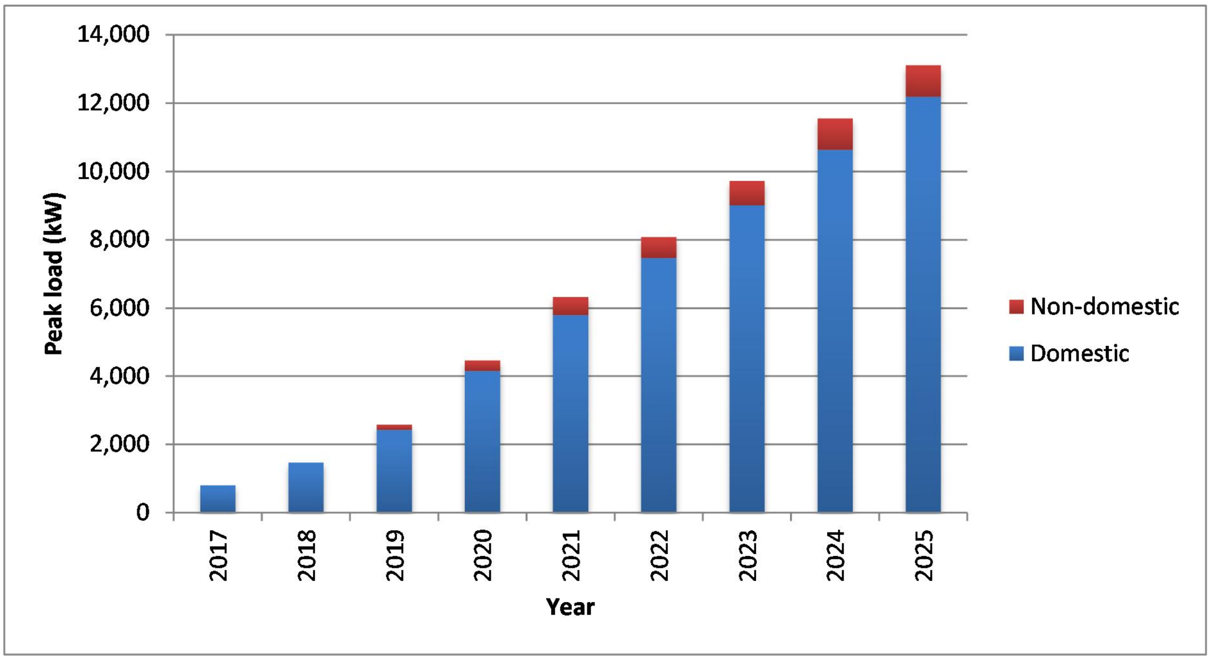

Table 3-9: SW Exeter combined peak load progression through time

Type	2017	2018	2019	2020	2021	2022	2023	2024	2025
Domestic (kW)	874	1,578	2,578	4,376	6,090	7,827	9,426	11,109	12,719
Non-domestic (kW)	0	0	158	316	531	619	720	922	922
Total (kW)	**874**	**1,578**	**2,736**	**4,692**	**6,622**	**8,446**	**10,146**	**12,031**	**13,642**

3.2 Matford Park

Load at Matford Park has been developed following consultation with the developer, Eagle One, and Exeter City Council, who have confirmed that the site has planning consent, services have been installed and the first plots are now completing. Development is expected to come forward at approximately 6,000m^2 per year until completion in approximately 2022, which is based on an 8 year build-out, beginning in 2015. The build-out floor area for the site is expected to be 46,500m^2. A build schedule by floor area and type, which is based on information provided by the developer and Exeter City Council, is presented in Table 3-10.

Table 3-10: Matford Park proposed build schedule by area

Usage type	2015	2016	2017	2018	2019	2020	2021	2022
	Cumulative floor area (m^2)							
Use Class A1 - Shops	86	215	344	473	602	731	860	1,000
Use Class A2 - Financial and Professional	52	129	206	284	361	439	516	600
Use Class A3 - Restaurants and Cafes	26	65	103	142	181	219	258	300
Use Class A4 - Drinking Establishments	26	65	103	142	181	219	258	300
Use Class A5 - Hot Food Take Aways	26	65	103	142	181	219	258	300
Gym	26	65	103	142	181	219	258	300
Creche	17	43	69	95	120	146	172	200
Car dealership	860	2,151	3,441	4,731	6,022	7,312	8,602	10,000
Office space	1,441	3,602	5,763	7,925	10,086	12,247	14,409	16,750
Light industry and general industrial	720	1,801	2,882	3,962	5,043	6,124	7,204	8,375
Storage/distribution	720	1,801	2,882	3,962	5,043	6,124	7,204	8,375

As described previously, non-domestic buildings will be expected to be Zero Carbon from 2019. As such, we have assumed that non-domestic development completed up to and including 2020 will be constructed to lower FEE standards based on the assumption that buildings completed in 2020 will seek Building Regulations up to a year before beginning construction, meaning they can seek approval in late 2018, begin construction in late 2019, completing in late 2010. We assume that no further FEE standard improvement will be required for non-domestic buildings between 2013 and 2016 Regulations. We have assumed that the 2019 Regulations will require a 20 percent improvement in FEE standards over a 2013 and 2016 compliant building, which mirrors the rate of improvement in new domestic buildings, albeit with a three year delay in the Zero Carbon requirement (2019 for non-domestic instead of 2016 for domestic).

Based on the proposed build schedule presented in Table 3-10 and the benchmarks calculated using the methodology described herein, we have calculated heat load progression for Matford Park, as shown in Figure 3-8, with the corresponding data in Table 3-11.

Figure 3-8: Matford Park annual load progression through time by usage type

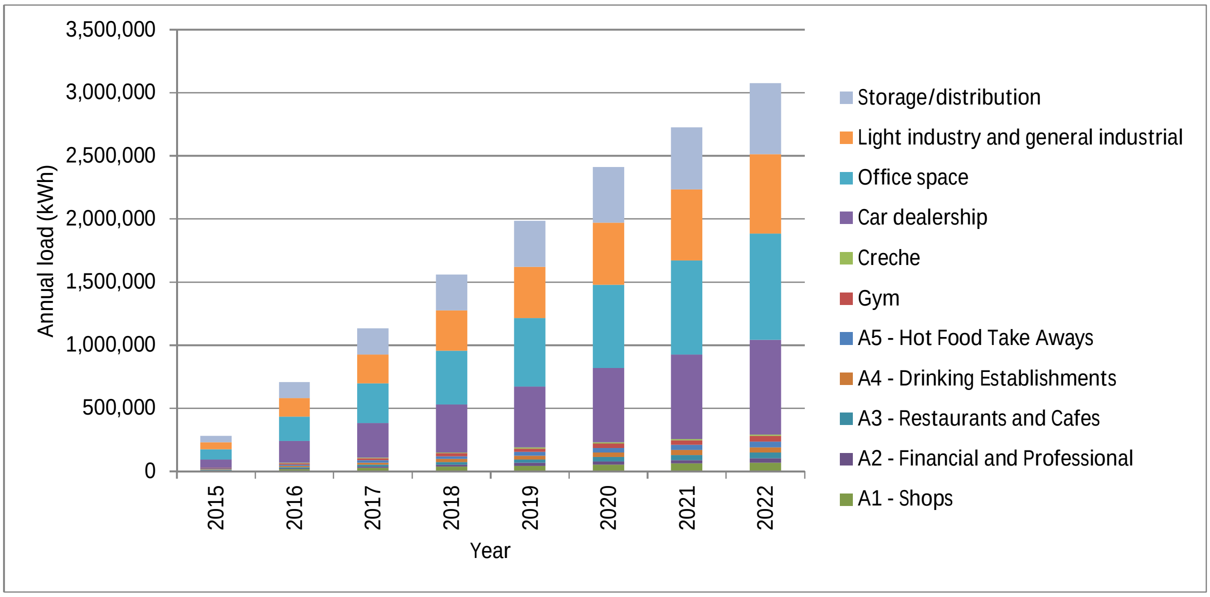

Table 3-11: Matford Park annual load progression through time by usage type

Type	2015	2016	2017	2018	2019	2020	2021	2022
A1 - Shops	6,551	16,378	26,206	36,033	45,860	55,687	63,057	71,042
A2 - Financial and Professional	2,775	6,937	11,099	15,261	19,423	23,585	26,707	30,088
A3 - Restaurants and Cafes	4,278	10,694	17,111	23,527	29,944	36,360	41,173	46,386
A4 - Drinking Establishments	4,046	10,116	16,186	22,255	28,325	34,395	38,947	43,879
A5 - Hot Food Take Aways	4,278	10,694	17,111	23,527	29,944	36,360	41,173	46,386
Gym	3,815	9,538	15,261	20,984	26,707	32,429	36,722	41,371
Creche	1,156	2,890	4,625	6,359	8,093	9,827	11,128	12,537
Car dealership	69,368	173,419	277,471	381,523	485,574	589,626	667,665	752,206
Office space	77,461	193,652	309,843	426,034	542,225	658,415	745,559	839,964
Light industry and general industrial	58,095	145,239	232,382	319,525	406,668	493,812	559,169	629,973
Storage/distribution	51,640	129,101	206,562	284,022	361,483	438,944	497,039	559,976
Total (kWh)	**283,464**	**708,659**	**1,133,854**	**1,559,050**	**1,984,245**	**2,409,440**	**2,728,337**	**3,073,808**

The calculated completed development annual heat load is **3,074MWh**.

As with non-domestic load on the SW Exeter development peak loads for Matford Park have been calculated using benchmarks (W/m^2) from the 2014 BSRIA Blue Book. We have allowed a 10 percent reduction in peak load for development completed from 2021 onwards as a result of improved building fabric arising from the introduction of 2019 Building Regulations. It is assumed the development completed in 2020 will seek Building Regulations under the 2016 Regulations.

The Matford Park peak load progression through time is presented in Figure 3-9, with the corresponding data in Table 3-12.

Figure 3-9: Matford Park peak load progression through time by usage type

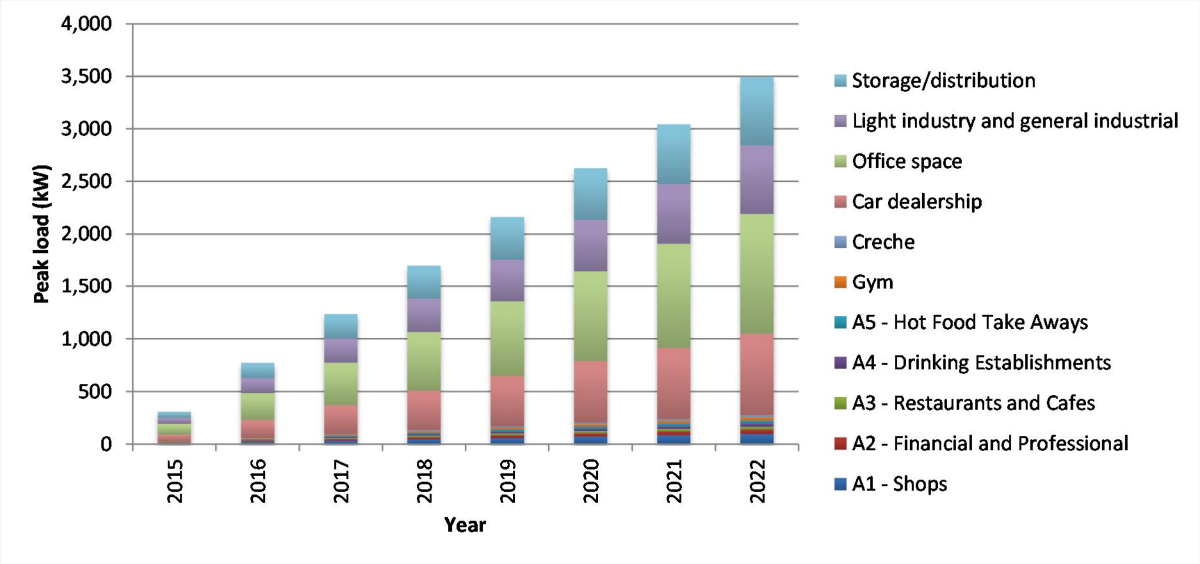

Table 3-12: Matford Park peak load progression through time by usage type

Type	2015	2016	2017	2018	2019	2020	2021	2022
A1 - Shops	9	22	34	47	60	73	85	97
A2 - Financial and Professional	4	9	14	20	25	31	36	41
A3 - Restaurants and Cafes	3	6	10	14	18	22	25	29
A4 - Drinking Establishments	3	6	10	14	18	22	25	29
A5 - Hot Food Take Aways	3	6	10	14	18	22	25	29
Gym	3	6	10	14	18	22	25	29
Creche	1	4	6	8	10	13	15	17
Car dealership	69	172	275	378	482	585	678	778
Office space	101	252	403	555	706	857	993	1,141
Light industry and general industrial	58	144	231	317	403	490	568	652
Storage/distribution	58	144	231	317	403	490	568	652
Total (kW)	**309**	**772**	**1,236**	**1,699**	**2,163**	**2,626**	**3,043**	**3,495**

3.3 Existing loads

The previous feasibility study identified three existing loads in the vicinity of the EfW plant that would be potentially viable for connection to a DH scheme. At the project inception meeting, it was agreed with the client project team that these three loads should be considered for connection to the scheme, but that there are no additional loads in the vicinity of the proposed scheme that would be suitable for connection. As such, only the three loads identified in the previous study have been investigated. They are:

- Polestar: A magazine and brochure printing facility located on the Marsh Barton trading Estate directly west of the EfW plant;

- Hendy Van and Truck: A vehicle hire company located across the road to the north of the EfW facility;

- EIC Group: A metal finishing facility located approximately half a mile south west of the EfW facility.

A summary of the loads used in the feasibility study is presented below.

Figure 3-10: Existing loads summary

Name	Annual load (MWh)	Peak load (kW)	Supply
Polestar	1,200	300	HW
EIC	2,800	1,750	Steam
Hendy V&T	304	400	HW

We made contact with all three of the organisations above to establish the nature and scale of their heating demand and to confirm the compatibility with, and interest in connecting to a district heating scheme.

3.3.1 *EIC*

In discussion with EIC, their Director explained that the site steam system heats multiple process hot water baths via heating coils. The hot water baths operate at between 20°C and 60°C, so it is feasible that the DH network could supply the facility; however it was noted that they have recently invested £150k in a new steam boiler, so the appetite for connection to a hot water DH network is minimal. The only circumstances under which EIC would consider connection to the system would be if heat could be supplied at a rate that would enable them to overhaul their steam system to operate with hot water at a very attractive payback period (three years was mentioned). Given that the possibility of offering a heat price so attractive that it pays for a complete overhaul of the EIC heating system in a very short period of time is highly unlikely, EIC have been excluded from the design exercise that follows.

3.3.2 *Polestar*

Polestar were also contacted to discuss the possibility of connection. Their Facilities Manager advised that they would be interested in connecting to the network and offered a description of their heating requirements.

The facility has three gas boilers, each serving a separate central heating system within an office-based area of the site. The boilers, which are 186kW, 80kW and 73kW, are not located in a central plant room, so a separate connection would be required for each boiler location. The systems served by the boilers are 82/71 heating circuits assumed to be of 3-port, fixed speed operation. In addition to the central heating system, the factory area is heated by direct-fired gas heaters, which would not be suitable for connection to a DH network. There are also six electric hot water heaters located around the site, all of which are very small and are therefore considered to be unsuitable for connection on the basis that they are of an inappropriate scale for connection to a DH network.

Polestar do not meter gas consumption from the boilers, so it is not possible to confirm the annual boiler gas demand given that there is also significant gas consumption for the direct-fired heaters. The boilers serve office spaces which are occupied for normal midweek working hours, so it reasonable to assume a load factor[1] of 20-25 percent based on the assumption that the building fabric is of average thermal efficiency. If we assume that the boilers are oversized by 10-20 percent this suggests an annual heat load of between 474MWh and 668MWh depending on actual load factor and boiler oversizing. This gives an average across the assumed values of approximately 571MW, which is significantly lower than the value used in the feasibility study (1,200MWh).

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[1] A load factor typically expresses (via a percentage figure) the relationship between annual energy demand and peak hourly demand. It represents the degree to which a load is continuous, where a 100% load factor would represent a demand that does not vary over the 8760 hours of an annual period. Load factor (%) = Annual demand (kWh p.a.) / (Peak demand (kW) * 8760). This relationship can be used to make estimates of total annual consumption from a known peak demand, or vice versa.

There are several factors that make the Polestar connection potentially unattractive for connection to the DH network.

- Each of the Polestar boilers is in a separate location and serves a separate circuit, meaning three separate interfaces with the DH network would be required;

- The DH network will operate at higher temperatures and pressures in the section between the EfW plant and the DHEC (see Section 6.3.2), heat interface equipment (heat exchangers) would need to be higher specification than if the connections were designed for 90°C supply;

Given the complexity and, therefore, higher cost of connecting the Polestar facility, as well as the reduced heat load (from that which was used in the feasibility study), it is unlikely that the connection would be viable; however this cannot be confirmed without payback analysis. We have excluded the Polestar demand from further analysis due to the uncertainty around its connection.

3.3.3 *Hendy Van & Truck*

The Facilities Manager for Hendy Van and Truck informed us that heat supply at the facility is entirely from direct-fired gas heaters, so it is not compatible with a DH network. As such, they have been excluded from further analysis.

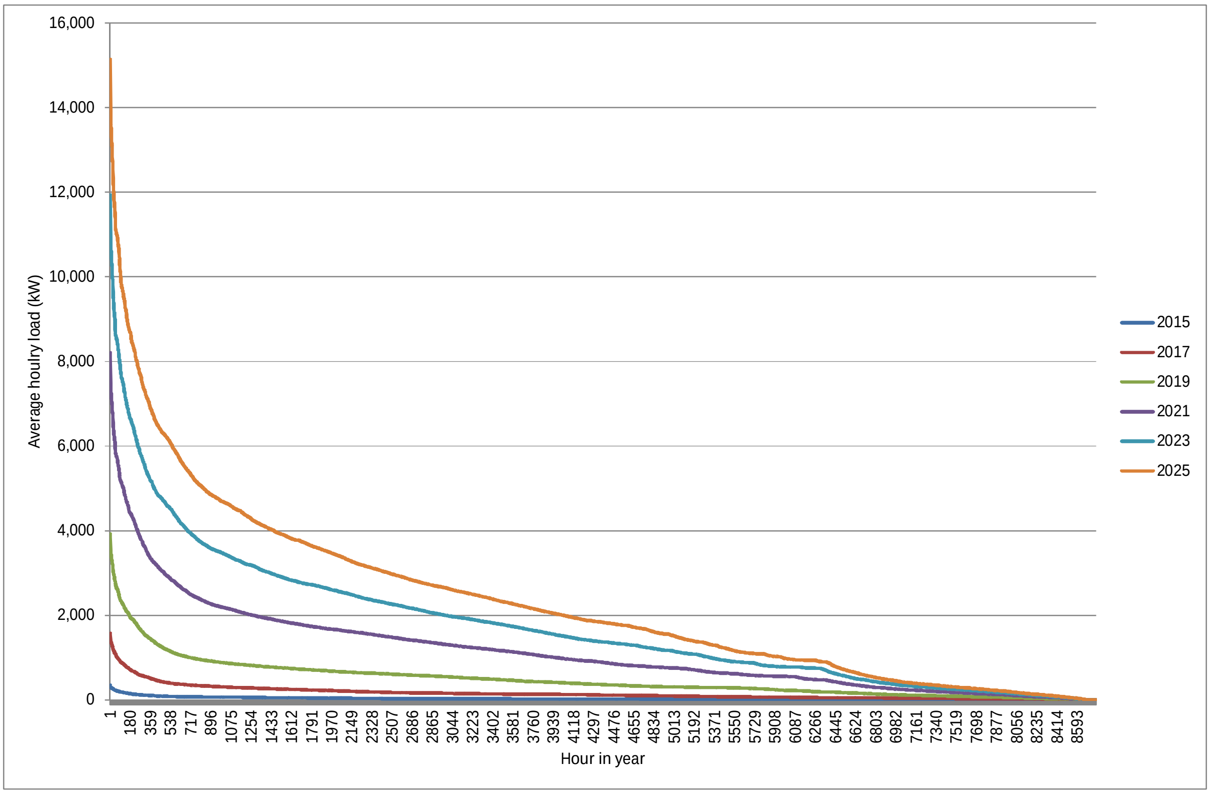
3.4 Load profiles

In order to model the operation of plant at the EfW and DHEC, we have used in-house load profiling software to distribute the annual loads presented in Sections 3.1, 3.2 and 3.3 across the year at hourly resolution.

The software separates annual heat load into space heating and hot water demand and distributes those loads across the year according to user-defined 24-hour load profiles for different building usage types. The space heating demand is linked to ambient degree day series data whereas the hot water demand is not varied seasonally.

With demand distributed across 8760 hours in the year, a load duration curve is generated by listing the hourly heat load in order of size. Load duration curves for the combined SW Exeter and Matford Park heat demands are presented in Figure 3-11.

Figure 3-11: DH network load duration curves through time



The profiles show how load develops through time, with baseloads in the hundreds of kilowatts until 2020 to 2021. At full build-out in 2025, demand rarely exceeds the maximum available heat output from the EfW (7.4MWth), which suggests a smaller heat supply from the EfW combined with suitable thermal storage capacity would be sufficient to ensure the bulk of heat is supplied from the EfW while maintaining a smaller pipe diameter from the EfW to the development area. This is investigated in more detail in Section 5.1.

The annual heat load on the fully developed DH network is **20,257MWh**. The design peak load is approximately 17MW, based on the peaks calculated in Sections 3.1 and 3.2; however the peak shown in Figure 3-11 is slightly lower – 15.4MW – as our load profiling software distributes load across each hour of the year, so the peak shown in Figure 3-11 is an average hourly peak rather than the instantaneous peak. Note that the plant sizing in this report is based on the design peak, i.e. 17MW.

SECTION 3

ENERGY FROM WASTE HEAT SUPPLY

4 ENERGY FROM WASTE HEAT SUPPLY

4.1 Conditions of supply

The Viridor EfW facility is designed to process up to 60,000 tonnes of municipal waste per year, which will be incinerated to raise high pressure steam. The steam will be passed through a two-stage steam turbine, generating up to 3.5MWe of electricity.

In a Section 106 agreement accompanying the development of the facility, the local planning authority requires that Viridor are *'…to use best endeavours to use and market the energy generated from the incineration process.'*

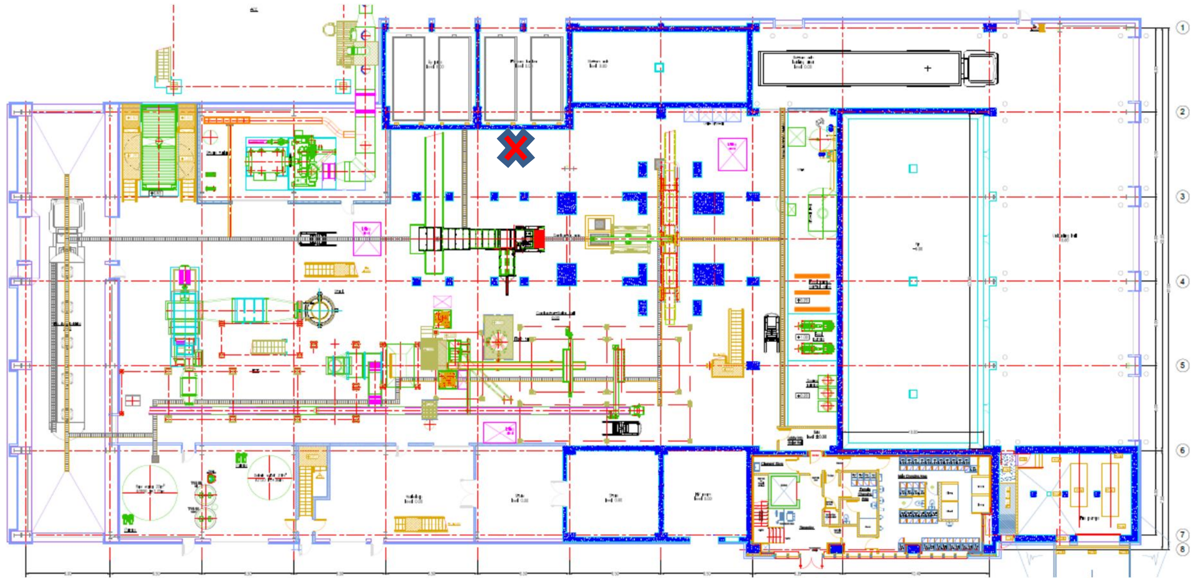
A steam extraction point has been provided between the two stages of the steam turbine with up to 12.5 tonnes per hour available for a district heating network which equates to approximately 7.4MWth of heat. Steam is supplied at 3.7 barg. At maximum heat offtake, the turbine's electrical generation would reduce to approximately 2.2MWe, which Viridor advises is enough to meet the plant's own electrical demands and still export some power to the grid, without defaulting on their Power Purchase Agreement boundaries.

Viridor advise that the plant will operate on a 24/7 basis, with heat available to the DH network for 7,450 hours per year, although in reality this may be higher. Once a year, there will be a two week shutdown period for routine maintenance.

4.2 Connection arrangement

Steam will be supplied to the DH network via pipework supplied by Viridor up to a demarcation point within the EfW facility, as shown in Figure 4-1.

Figure 4-1: EfW plant ground floor layout showing steam supply demarcation point (red 'X')



The steam offtake from the turbine is controlled with a modulating steam valve, which is already installed and supplies heat to the feedwater tank as required. The addition of a supply to the DH heat interface means that the turbine control valve will need to ensure adequate heat is supplied to the feedwater tank as demand from the DH network increases.

During a site visit to the plant, it was determined that the condensate return tank would be the most appropriate point of connection for the return from the DH heat exchanger. The tank has been designed for a condensate return temperature of 45°C. From the condensate return tank, water is passed through a flue gas economiser, where it is heated to 90°C prior to reaching the boiler feedwater tank. The DH network will return temperatures in the region of 60°C to the EfW plant which, when injected into the condensate return tank, will raise the temperature of the water above the design temperature of 45°C. This increase in temperature reduces the energy transfer from the flue gas economiser, meaning more heat is rejected to atmosphere and the overall system efficiency is reduced. This impact could be minimised by sub-cooling the condensate return before it is fed into the condensate return tank.

The condensate return tank is shown in Figure 4-2 with available connection points indicated at the top.

Figure 4-2: EfW condensate return tank with available connection points at top

Beyond the demarcation point, it shall be the responsibility of the DH scheme owner/operator to supply the additional infrastructure required to deliver heat to the network, which will include:

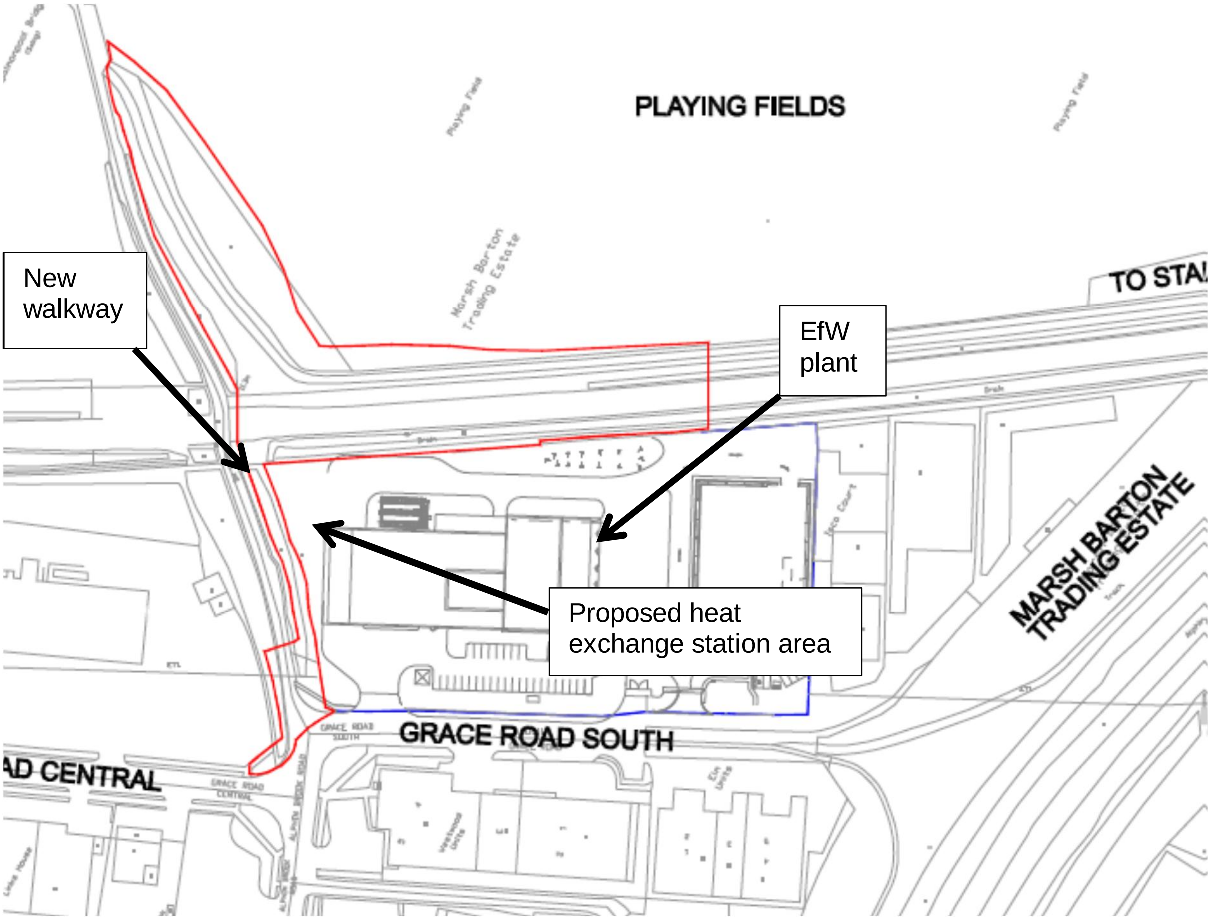
- Additional steam pipework from demarcation point to EfW heat exchanger
- DH interface control valve
- Steam to hot water heat exchanger (shell and tube)
- EfW to DH network controls interface
- Condensate return pipework from heat exchanger to EfW hot well

- Condensate return pumps

Viridor will be able to supply power to equipment located within the EfW plant (e.g. additional controls and steam valve to the heat exchanger). Electrical demands for equipment located outside of the main building, e.g. pumps, can be supplied from the EfW plant at a cost to be agreed with Viridor.

Viridor have leased a small area of land on the boundary of the main EfW facility so that steam-DH interface equipment can be installed. The area is directly adjacent to Alphin Brook Road, which runs over the railway line to the north of the EfW plant. Planning documents for the new Marsh Barton railway halt show how a walkway serving the halt will further reduce the size of the available space, as shown in Figure 4-3.

Figure 4-3: Land area for new Marsh Barton railway halt

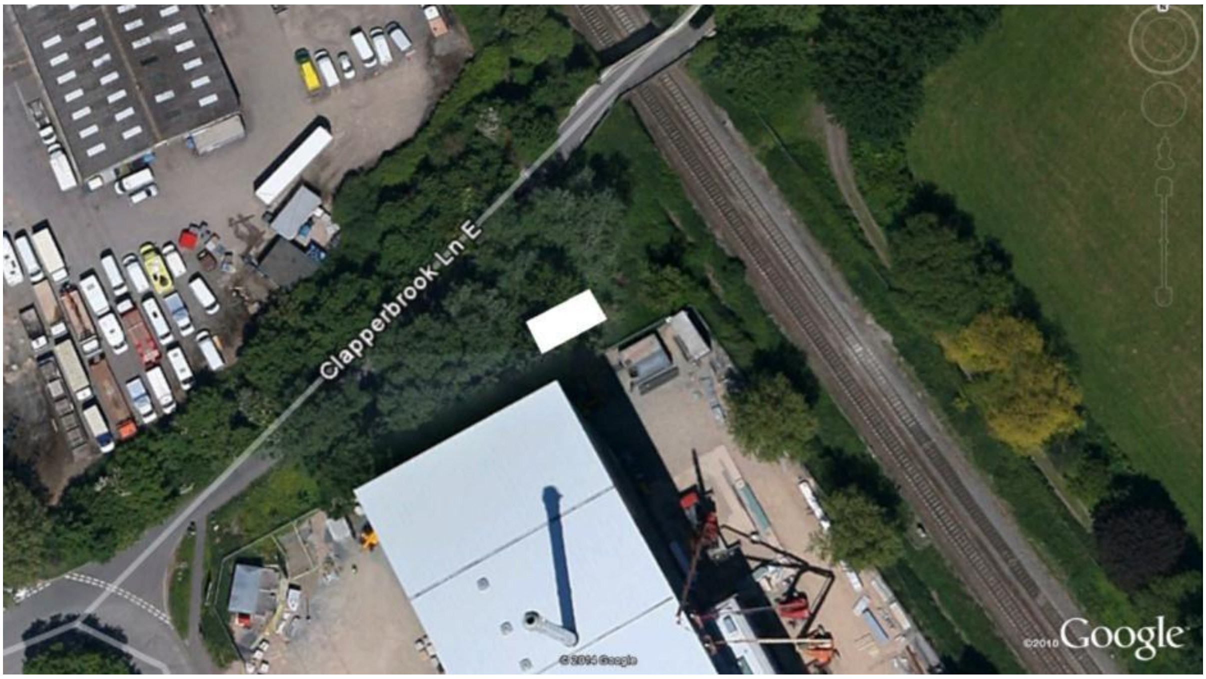


It is anticipated that there will be sufficient space for a minimal amount of interface equipment in a small compound in the area identified, although it will not be possible to locate all of the necessary equipment there. Additional equipment such as expansion and pressurisation vessels and water treatment will have to be located at the DHEC; however, pumps and heat exchanger(s) must be as close to the EfW condensate return tank as possible to minimise the steam infrastructure required to connect the EfW supply to the DH interface.

Parsons Brinckerhoff sourced a budget quotation and indicative skid dimensions for the steam interface from a contractor. The skid dimensions would be in the region of 5 x 2 x 3 metres (length x breadth x height). Allowing for a pump set and clearance for access, an enclosure of approximately

10 x 5 metres footprint would be suitable for the steam interface container at the EfW plant. These dimensions are shown on the available land area in Figure 4-4.

Figure 4-4: Indicative steam interface container at EfW plant



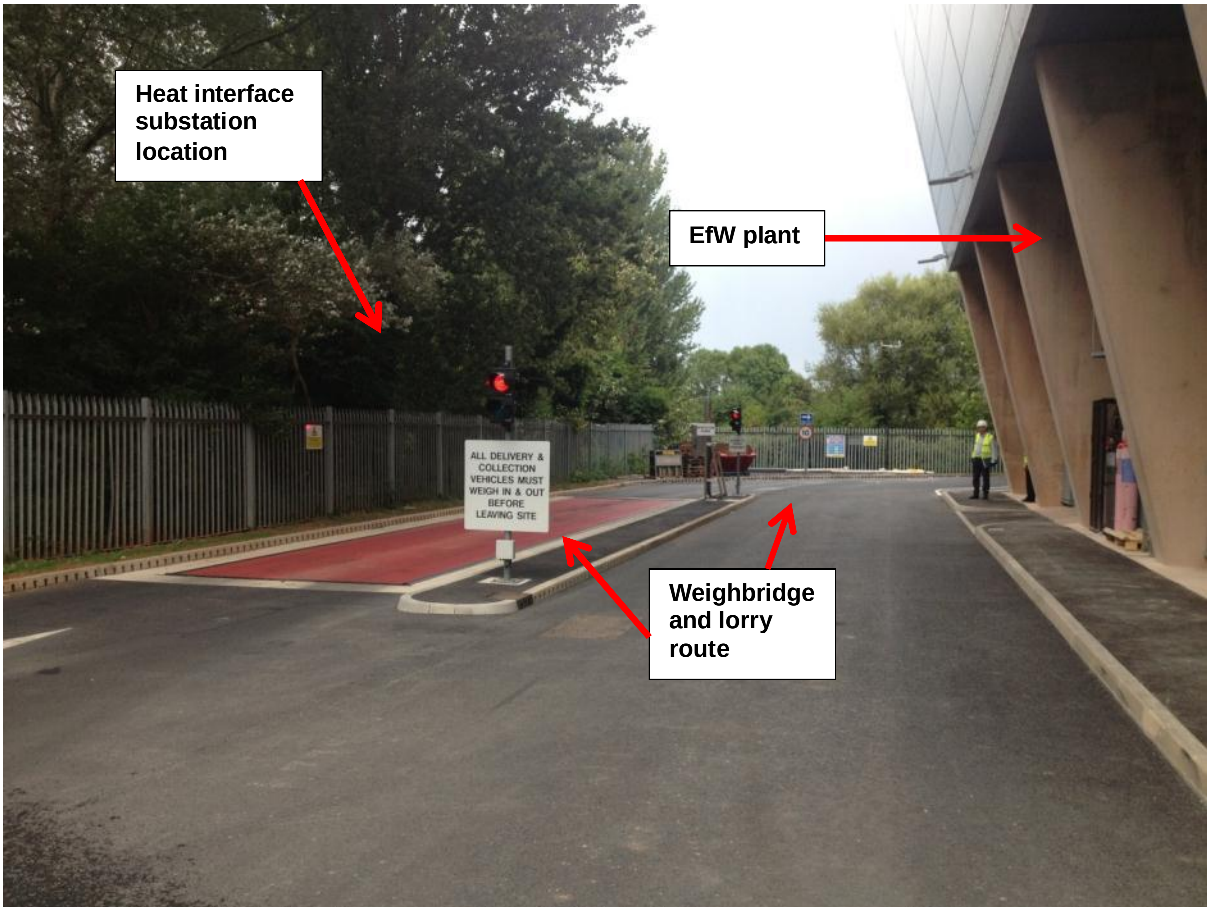
Based on the available space shown in Figure 4-3 and the proposed footprint for the DH-steam interface substation container shown in Figure 4-4, it is clear that there is enough space to accommodate the steam interface container on the land adjacent to the EfW plant. Note that the exact size and positioning of the container should be determined at later stages of design.

It is also noted that there is no obvious alternative to the area identified above as there is no space within the EfW plant itself and we are advised that the new DCC waste transfer station to the east of the EfW plant also has no space available. It is therefore important, as the substation design is developed further, that designers, DCC planners and Viridor work together to ensure the viability of this position is retained through the construction of the railway halt.

We have assessed the most suitable route for pipework from the existing steam pipe demarcation point within the EfW to the proposed heat exchange substation outside the facility. Given the availability of space within the plant and the position of the condensate return tank to which the interface return should connect, the most appropriate route is to take the steam pipework from the flanged connection point supplied by Viridor, which is at ground level, up and over the top of the turbine room and the condensate return tank, which is on the 5 metre slab, and out towards the fly ash loading area where the pipe would drop down to ground level at the edge of the EfW building. There is sufficient space on the walls of the facility for bracketry to support the additional pipework as it runs along this route.

Viridor noted that, once outside the building, the pipe should be buried in the concrete area between the EfW and the heat exchange substation as this is the route for lorries entering the facility so it would not be feasible to run the pipe above ground, as shown in Figure 4-5.

Figure 4-5: Area between EfW and proposed heat interface substation location



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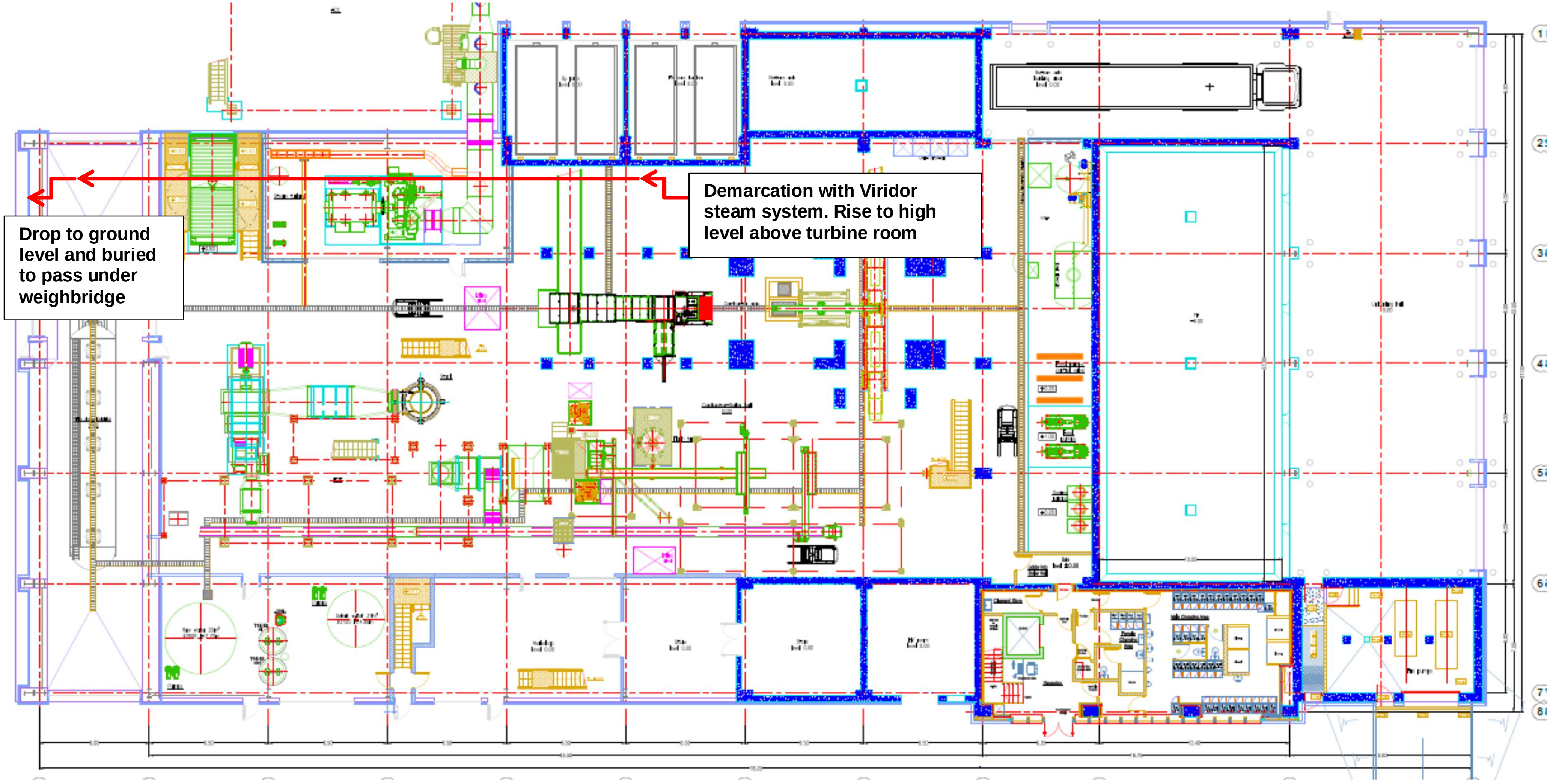
The proposed route for the steam pipe within the EfW is shown in Figure 4-6.

Figure 4-6: Steam pipe route inside EfW



Demarcation with Viridor steam system. Rise to high level above turbine room

Drop to ground level and buried to pass under weighbridge

SECTION 4

DISTRICT HEATING ENERGY CENTRE

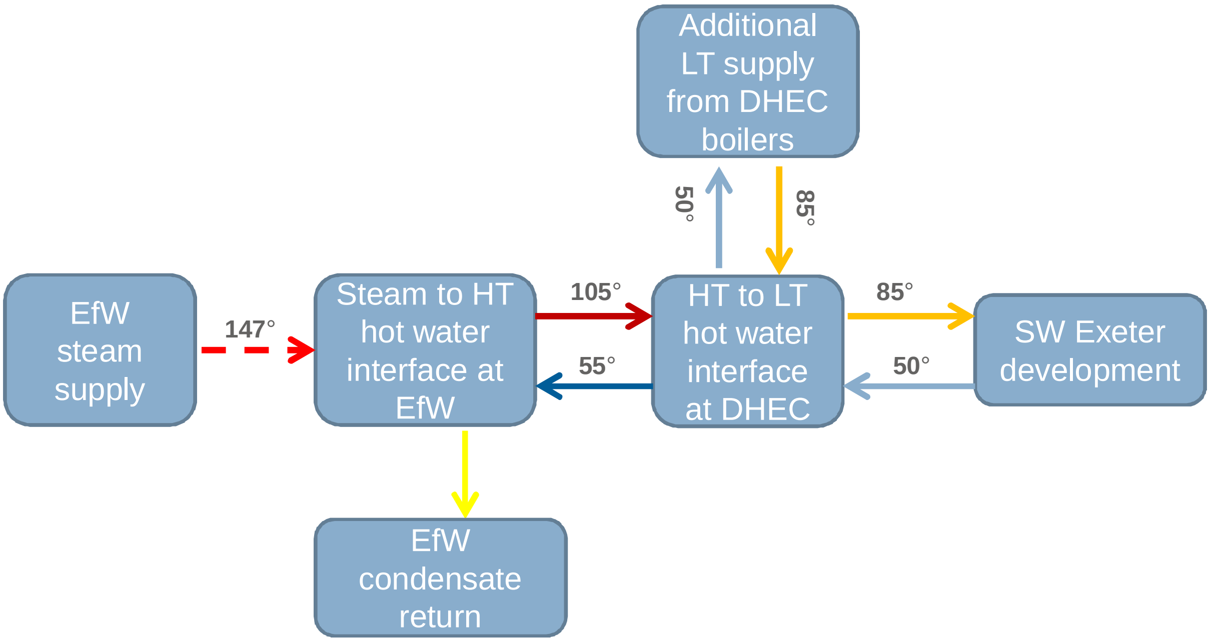
5 DISTRICT HEATING ENERGY CENTRE

5.1 Heat supply from EfW

The highest point on the SW Exeter development is approximately 50 metres above the EfW plant, meaning significant static pressurisation is required to overcome the change in altitude. Given the distances involved and the change in altitude, it would not be possible to serve the development with a single hydraulic distribution system, which is limited to a maximum total system pressure of 10 barg[2].

One means of alleviating some of the pressure issues across the network would be to make use of the higher temperature available from the EfW steam supply and to run a transmission main between the EfW plant and the SWE development. The higher temperature and pressure water in the transmission main can then be stepped down at the DHEC to suitable temperature and pressures for distribution to dwellings in the development. This approach separates the heat supply out into three hydraulically separate systems – the EfW steam system; the transmission main; and the distribution network, as shown in Figure 5-1. Note that secondary system return temperatures shown in Figure 5-1 are discussed in Section 6.3.4.

Figure 5-1: Process diagram of heat supply



As well as reducing total system pressure at any given point on the network, running the transmission main between the EfW plant and the DHEC allows for a reduction in pipe diameter as a result of the higher temperature differential between flow and return, which in turn reduces network costs. It also makes installation easier in sections of network where the pipe is installed in the existing road network.

In addition to running a high temperature transmission main between the EfW and DHEC, an opportunity has been identified to further reduce the cost of pipework by using thermal storage at the

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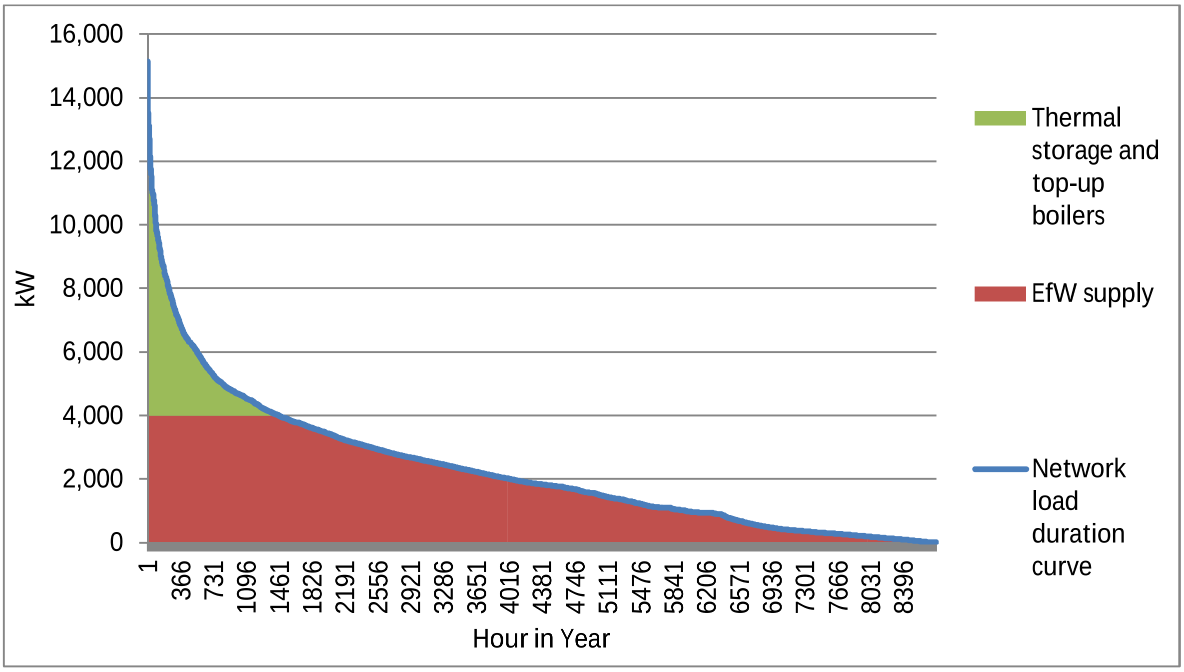
[2] Although DH pipework is rated to at least PN16, heat interface units installed into dwellings are unable to withstand system pressures above 10barg.

DHEC to maximise the use of heat from the EfW without requiring all of the available 7.4MW heat supply. This approach means smaller pipes can be installed between the EfW and DHEC and that there is additional capacity at the EfW for supply to future loads and/or DH networks. It also means that steam offtake at the EfW is less susceptible to rapid spikes in demand at peak heat loads, instead transferring the provision of peak heat to the DHEC side of the network heat supply.

Based on the load duration curve for the built-out heat network, a heat supply from the EfW of 4MW would mean approximately 85 percent of demand could be met from the EfW (not allowing for plant offline time). When combined with adequate thermal storage, the majority of load would be served with heat from EfW, as shown in Figure 5-2.

Figure 5-2: Notional heat supply from a 4MW EfW connection with thermal storage



Note that in sizing the interface at the EfW, we have future-proofed the heat supply by allowing for up to 7.4MW of heat transfer across the heat exchanger. The section of transmission main running out of the proposed heat exchange substation has also been sized to take 7.4MW up to the junction of Grace Road Central so that a future connection running north towards the town centre can be connected here as required. The section that has been future-proofed is shown in green on Figure 5-3. The pipe in this section is 200mm in diameter, dropping down to 125mm downstream of this point. Note that the cost of the future proofed pipework is broken out from the cost of the rest of the transmission main in Appendix B.

Figure 5-3: Transmission main pipe section sized for future heat demand (green)

5.2 Location options

A review of available public sector land was undertaken with three options being considered for potential DHEC locations. They are:

- The cattle market site, owned by Exeter City Council;
- The school site on the SW Exeter development area;
- The Matford Park development.

Those three sites are shown on the map below.

Figure 5-4: Potential energy centre locations

Planning assessment has been undertaken for all three of the proposed locations. A copy of the planning report is included in Appendix A.

Based on the planning report, an assessment matrix has been developed for the quantitative assessment of the options. The matrix is presented in Table 5-1.

Table 5-1: DHEC location decision matrix

	Criteria	Energy Centre Location 1 - Cattle Market site	Comments	Energy Centre Location 2 - Secondary school site	Comments	Energy Centre Location 3 - Matford Park	Comments
Site Issues	Site availability	5	Area owned by ECC.	3	Site is reserved for educational facility. Land for EC would have to be negotiated with local education authority.	2	Matford Park is a new development site and space for the energy centre would need to be leased.
Planning / Environmental issues	Noise Impact	5	Proposed location is in the corner of a working cattle market yard. Noise is unlikely to be in an issue.	2	Positioning the EC next to an educational facility means noise is a serious issue.	2	The proposed development has relatively high density development. Adjacent buildings likely to be susceptible to noise from the EC.
	Vibration Impact	5	No impact envisaged	5	No impact envisaged	5	No impact envisaged
	Air quality Impact	3	Flues may have impact on office space on the other side of the drainage channel adjacent to the EC.	2	Flues will be close to the new educational facility on the same site.	2	Flues will be close to the high desnity commercial development on Matford Park.
	Visual Impact	4	The site is well screened by vegetation. Minimal visual impact.	1	The EC would be located within the grounds of a new educational facility. Visual impact is a major concern.	3	The EC will be located within a new commercial development, which is expected to dominate the landscape.
	Ecology	3	Close to designated nature and landscape areas. Areas of woodland and dense habitat 40m south of the site. Nitrate vulnerable zone. Otters have been spotted on the adjacent drainage channel.	3	Site is designated within a TOP grouping, meaning careful consideration would need to be given to the existing vegetation. Site also identified as suitable habitat for Cirl Bunting so full ecological surveys and cooperation with RSPB & Natural Engaldn required. . The site forms part of a wider redvelopment area so these issues would arise as part of the wider development.	4	Site in close proximity to Exe Estuary SSSI Impact Zone; however it has already been approved for a range of commercial uses, so is unlikely to present problems arising from impact on environment.
	Surface Water Drainage	3	Site is within Flood Zone 3 and next to a drainage channel, meaning careful consideration would be required for drainage strategy.	5	The site is not within a flood zone and there are no watercourses in close proximity.	4	The site is on a low lying flood plain; however it has already been approved for a range of commercial uses, so is unlikely to present problems arising from impact on environment.
	Cultural Heritage	4	Area directly south of the site - Knowle Hill - is specified under local policy as being important to the landscape setting of the city.	4	Land directly to the south of the A30 is a Designated Scheduled Monument. Heritage assessment work required to confirm impact.	5	Area directly south of the site is specified under local policy as being important to the landscape setting of the city; however it has already been approved for a range of commercial uses, so is unlikely to present problems arising from impact on landscape.
	Ground Contamination	5	No issues envisaged	5	No issues envisaged	5	No issues envisaged
	Planting	5	As the site is well hidden, it is envisaged that no additional planting will be required	2	Enhanced landscaping is likely to be required as the location is on a site designated for a new educational facility.	2	Enhanced landscaping is likely to be required as the location is on a new commercial development.
Construction issues	Asbestos	5	No issues envisaged	5	No issues envisaged	5	No issues envisaged
	Topography / Leveling of site	4	Site is on an existing hard surfaced area on the cattle market site. Minimal issues envisaged.	5	Site is part of a wider development area. No additional levelling envisaged.	5	Site is part of a wider development area. No additional levelling envisaged.
	Allowable area for energy centre	5	No issues envisaged	3	Site may be constrained by proximity of site boundary to new educational facility.	3	Site may be constrained by proximity of site boundary to new commercial development.
DH routing issues	DH pipework	2	DH pipe would enter/exit the EC via the land adjoiining a draingage channel to the north west of the EC site.	4	Proposed site is part of a wider development area. Pipework should be installed as part of the development, minmising issues associated with routing and installation.	4	Proposed site is part of a wider development area. Pipework should be installed as part of the development, minmising issues associated with routing and installation.
	Strategic positioning	3	Sits at the boundary of the development area so transmission main pipe costs minimised; however it would significanty increase the cost of the tranmission main if it was routed in the soft dig land to the east of the railway line.	3	Would significantly lengthen the transmission main, making it significantly more expensive. Height relative to SWE development means static pressure on distribution network would be lower, potentially avoiding need for pumping stations on distribution network.	4	Sits on northern boundary of SWE development, reducing length and cost of transmission main.
Commercial risks	Land use	4	Proposed area within Cattle Market site is currently used for lorry parking so there is a loss of lease revenue; however this could be recovered through charge(s) to DHEC owner/operator.	4	Land is part of a proposed educational campus devlopment. Land use is likely to be negotiated with Devon County Council - a project partner - so cost is anticipated to be minimal..	2	Land would be leased from private developers making it the highest cost option of the three.
	Cost of construction	3	Ground is concreted but will require foundations for the new energy centre. Access is already available, which will have a positive impact on construction cost.	2	Ground will be prepared as part of the wider development, but may require additional preparation for building foundations depending on the alternative use. Construction will require access routes currently not planned for.	3	Ground will be prepared as part of the wider development, but may require additional preparation for building foundations depending on the alternative use. Access routes will be provided already.
	Utility connections	3	Utilities already within vicinity of the proposed location. Unclear whether there is sufficient capacity within existing utilities to accommodate energy centre demands.	2	New utilities connections will be required to this part of the educational facility development.	3	Utilities have already been installed into Matord Park, although there is a risk that they are insufficient to meet the additional demands of the energy centre.
	TOTAL	71		60		63	

The results of this analysis show that the cattle market site is the preferred location by some margin. The final decision on energy centre location lies with DCC; however we would suggest that the cattle market is the simplest in terms of space acquisition and cost; the lowest visual impact; does not sit within a development site; and is strategically well positioned between the EfW and the SW Exeter development, which minimises the cost of the transmission main.

Within the Cattle Market site, there are several options for positioning the energy centre. A site visit with Exeter City Council planners identified space at the front and the back of the site that could potentially be used, as shown in Figure 5-5.

Figure 5-5: Potential EC locations within Cattle Market site

Arrow shows raised house close to location 1

There are pros and cons for each of the locations proposed above. Option 1 is the immediately obvious choice given its proximity to the soft dig land next to the drainage channel, through which it is proposed the transmission main will run (see Section 6.1.2); however upon visiting the site, it is was noted that it is close to a raised house, shown with the orange arrow in Figure 5-5, which may cause issues with flue gases and noise. A photograph of Option 1, taken during the site visit, is presented in Figure 5-6.

Figure 5-6: Cattle Market EC Option 1

By moving the energy centre further into the Cattle Market site, the impact on the existing dwelling is mitigated, as shown in Option 2. This does mean a small amount of additional pipework as the energy centre is further away from the proposed network route through the drainage channel; however this would be minimal.

Option 3 is currently used to store vehicles for a nearby car dealership so the land is likely to be straightforward to release for alternative use. Because it backs onto a road and is surrounded by industrial estate, noise may also be less of an issue. Aesthetically, this site may be less attractive as it would be clearly visible from the road. A photograph of Option 3, taken during the site visit, is presented in Figure 5-7.

Figure 5-7: Cattle Market EC Option 3

The location of the energy centre within the Cattle Market site should be confirmed following further discussions with the Cattle Market operator and occupants of nearby buildings; however following a site visit and meeting with Exeter City Council planners, we propose that options two and three are likely to be the most viable. Option one, despite being the most attractive location technically, is likely to have a negative impact on the nearby dwelling and may therefore not be viable.

SECTION 5

DISTRICT HEATING NETWORK DESIGN

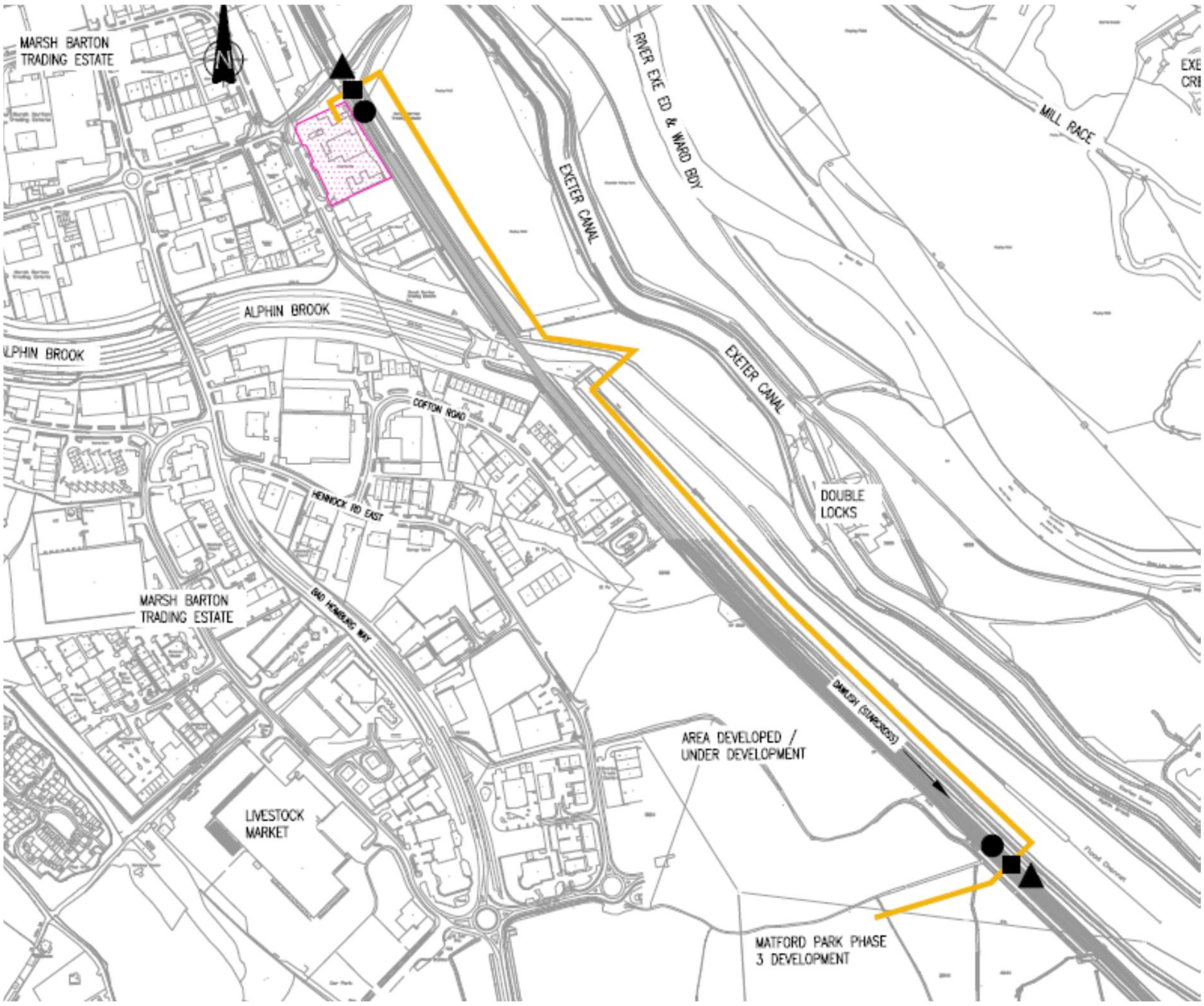
6 DISTRICT HEATING NETWORK DESIGN

6.1 DH routing

6.1.1 *Option to use soft dig land on east of railway line*

Previous assessment of the potential for a DH network serving the SW Exeter development has considered the possibility of utilising the green space to the east of the railway line to route the district heating pipework from the EfW to the SW Exeter development. The route assessed in a 2012 report for the University of Exeter is shown in Figure 6-1.

Figure 6-1: Potential DH route through soft dig land to the east of the railway line



In order to cross the railway line, the study concluded that two pipe bridges would be required – one to get from the EfW to the east side of the railway line and one to get back towards Matford Park and SW Exeter. Excluding the cost of pipework, the study concluded that the two pipe bridges and a temporary access bridge required to undertake the works would come to a total cost of nearly £600k excluding any preliminaries and contingency.

It is also noted that the study reports initiation of conversations with Network Rail regarding permissions (Basic Asset Protection Agreement [BAPA] and Easement) for the proposed works.

These conversations were on the basis of a low temperature (90°C or below) network and it is noted that Network Rail would look less favourably on a high temperature, pressurised transmission main, as is proposed.

We are advised by Exeter City Council that an easement has been provided for the DH network route into the Matford Park development, as shown in Figure 6-2. It is our understanding that the project team have excluded the possibility of serving the network from the opposite side of the railway line, as shown by the pipe easement, which shows pipe entering the development from the west.

Figure 6-2: Pipe easement through Matford Park

In addition to the above, Section 5.2 concluded that the cattle market site is the preferred location for the DHEC. This is important in the context of selecting a route for the transmission main as it makes the route on the other side of the railway far less attractive given the additional pipework required to get from the east side of the railway line to the cattle market. The transmission main cannot be used to serve load directly due to the higher temperatures and pressures, so it must delivered first to the DHEC, where it can be stepped down and delivered to heat customers via the separate distribution network. As such, routing the pipe on the other side of the railway would mean significant extra pipework in order to deliver heat to the DHEC, without the benefit of serving demands en-route.

The difference in cost for a metre of 150mm diameter DH pipe installed into soft dig land rather than hard dig is approximately £230[3]. For a network section of approximately 1km, this equates to a saving of approximately £230k, which would not come close to covering the cost of the pipe bridges. Given the preferred location of the DHEC, the existing pipe easement route, the cost of the pipe bridges and the fact that Network Rail are likely to look less favourably on a high temperature transmission main

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[3] Prices provided by a DH installation contractor for the purposes of this study.

running across their assets, the option to run the transmission main along the soft dig land to the east of the railway line has been excluded from further consideration.

6.1.2 *Proposed route – transmission main*

The proposed transmission main network route is shown in Figure 6-3.

Figure 6-3: Preferred transmission main route

The route runs south down Hennock Road Central before branching off alongside a drainage channel, where pipe installation would be into soft dig land, towards the livestock market. Upon surveying the area, it was concluded that there would be sufficient space in the land to the side of the drainage channel to install 150mm DH pipe, as shown in Figure 6-4.

It is noted that the routing the pipework alongside the drainage channel and Bad Homburg Way, which also has drainage ditches running alongside it, is likely to require the input of the Environment Agency as well as the planning authority. These areas are located within a flood zone and would therefore require a flood risk assessment as per the watercourse consents. There are options to avoid routing along the soft dig land in the drainage channel; however Bad Homburg Way is integral in delivering heat from the EfW plant to the DHEC.

Figure 6-4: Soft dig land adjoining drainage channel

Should it be determined in planning that the drainage channel route cannot be taken, there is an alternative to continue along Hennock Road Central and branching off down Matford Park Road and into the Cattle market from the back, as shown in Figure 6-5.

Figure 6-5: Transmission main alternative route

This route would add cost to the network as it would involve more hard-dig along the transmission main route, but it does offer an alternative should it be required.

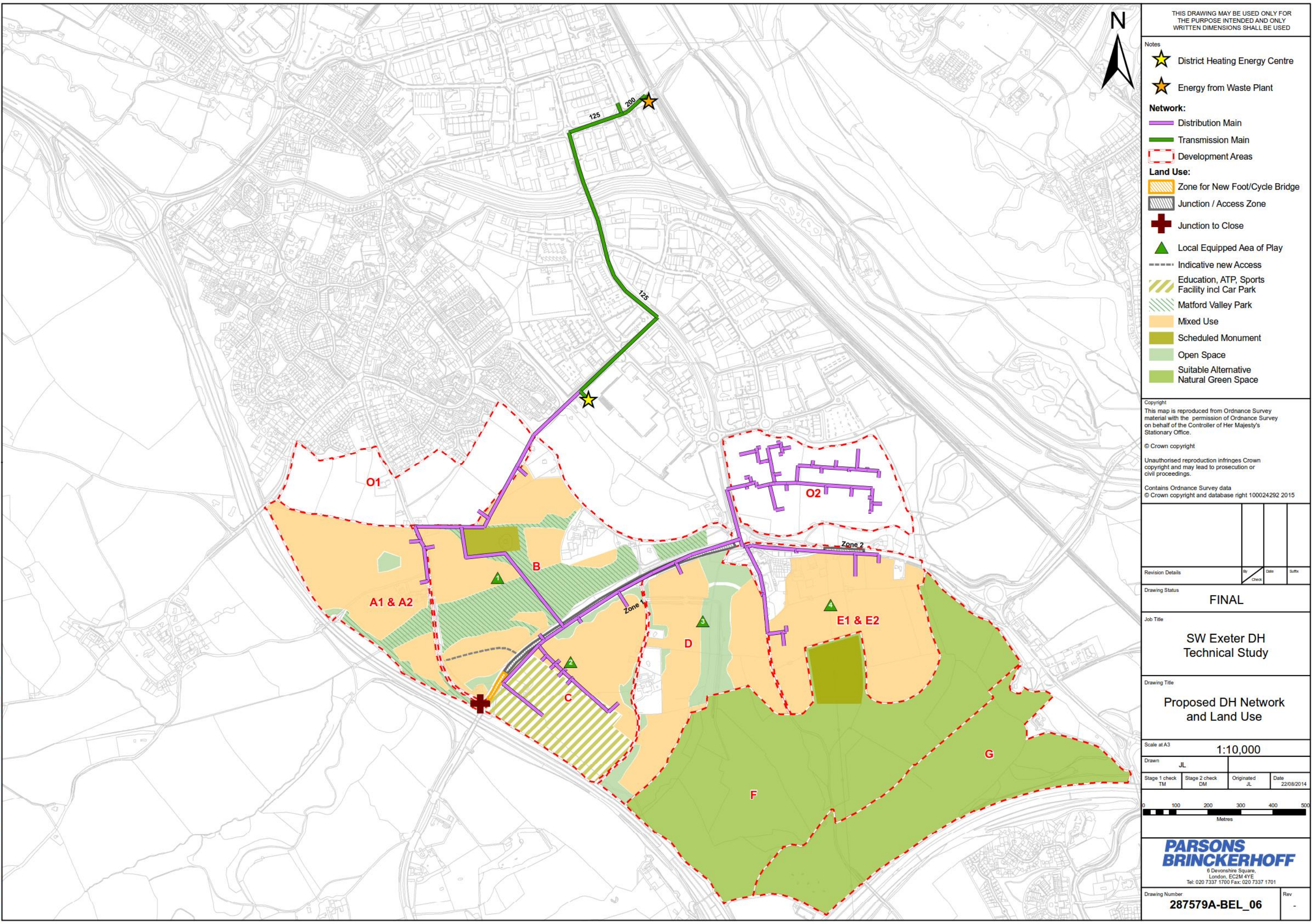
There is one notable obstacle along the proposed transmission main route, which is the drainage channel on Hennock Road Central, as shown in Figure 6-6. A road bridge allows traffic to pass over the channel; however the transmission main would be required to pass underneath the drainage channel – probably using a thrust bore installation. This is not a significant obstacle, but would add additional cost to the transmission main cost. This has been included in the capital costing presented in Section 8.1.

Figure 6-6: Road bridge over drainage channel on Hennock Road Central

6.1.3 *Proposed route – distribution main*

The route for the distribution main is notional as the infrastructure within the SW Exeter development is currently undefined. A route has been shown for the purposes of DH network modelling and costing; but the design of the network should be updated as development layout plans are finalised. The modelled DH route is shown in Figure 6-7.

Figure 6-7: Notional distribution main route



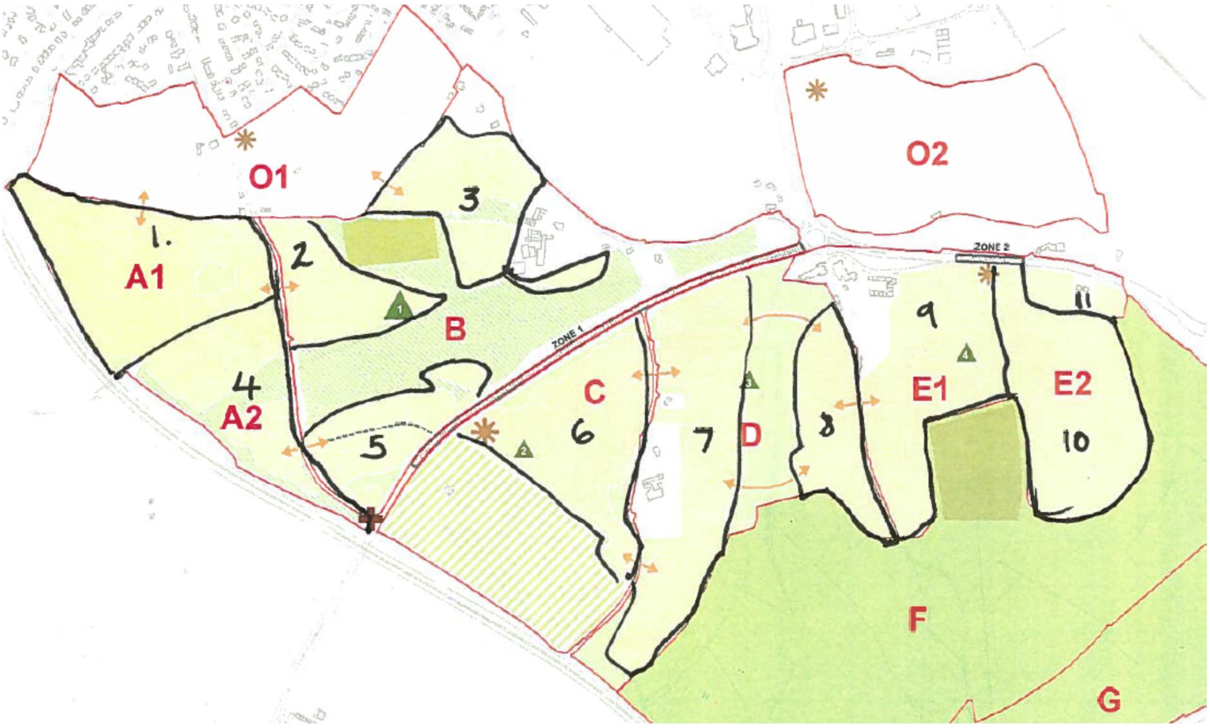
6.1.4 *Plot level network design*

The distribution network presented in Figure 6-7 shows a single node on each of the development areas indicated in Figure 6-8, which was guided by information provided by developers and the local planning authority. This represents current thinking around the location of development. The map is accompanied by estimated dwelling numbers for each of the numbered areas, as shown in Table 6-1.

Table 6-1: Dwelling numbers per SW Exeter development area

Area	Total no. dwellings
1	301
2	84
3	140
4	200
5	122
6	260
7	230
8	138
9	250
10	230
11	65
O1	426
Total	**2446**

Figure 6-8: SW Exeter development numbered areas provided by Teignbridge Council



In order to calculate the cost, pressure loss, heat losses and system volume of each of the numbered areas, we have used design information from the proxy development. Information from models used in designing three of the plot level networks on that development has been used to extrapolate network cost and performance characteristics on a per-dwelling basis, which have then been applied to SW Exeter according to the number of dwellings in each development area.

The average values from the proxy development models used in the SW Exeter modelling are presented in Table 6-2. Note that the pipe costs used in the proxy development modelling are for soft dig installation. It is assumed that DH installation at SW Exeter can be programmed along with the wider infrastructure works such that roads would not need to be reopened in order to install the pipework and soft dig costs are therefore appropriate. Temperatures used in the models are aligned with those assumed for the SW Exeter secondary systems, as follows:

- Flow temperature: 85°C
- Space heating return temperature (primary side): 45°C
- DHW return temperature (primary side): 25°C

We have used heat loss factors (W/m) and pipe costs for **double pipe** with maximum insulation so as to minimise the heat losses from the pipework. The heat loss benefit of double pipe is discussed in Section 6.3.5.

Table 6-2: Key network features from proxy development network design

Network	Pipe cost (£/dwelling)	Dyanmic losses (m/dwelling)	System vol (m^3/dwelling)	Heat losses (kWh/dwelling)
A	£5,363	0.043	0.028	1,212
B	£7,424	0.125	0.035	1,398
C	£6,014	0.088	0.041	1,583
D	£5,256	0.042	0.019	1,281
E	£5,298	0.055	0.026	1,290
Average	**£5,523**	**0.062**	**0.029**	**1,385**

These average values have been multiplied by the number of dwellings in each of the areas shown in Figure 6-8 to calculate realistic costs, pressure loss and system volumes for the SW Exeter plot local DH networks.

6.2 Constraints and operating principles

The topography of the land within the SW Exeter development runs from approximately five metres above sea level at the northern edge of the site, which is approximately the same height as the EfW plant, to approximately 54 metres above sea level at the southern tip of area E2 and the western tip of area A1, as shown in Figure 6-9. This is a total elevation change of approximately 50 metres across the distribution network, requiring static pressurisation of more than 5 barg.

Figure 6-9: Topographical overlay of SW Exeter development area

Such a significant elevation change brings complexity to the design of a DH network as there are limitations on the pressures that can be tolerated. System pressures within local distribution networks should not exceed 10barg and it is important that heat interface units (HIUs) selected for connected dwellings are suitably specified and able to tolerate the network design pressures. Not all units are the same and some are unable to tolerate higher system and differential pressures.

Given that static pressurisation would need to be in the region of 5.5barg in order to overcome elevation changes, the network pumping strategy is particularly important in order to maintain system pressures below 10barg on the distribution network.

There are several options for doing this, as summarised in Table 6-3.

Table 6-3: DH system potential operating principles

Option	Description	Pros	Cons
1	High temperature transmission main from EfW to DHEC. Step down to local distribution network at DHEC.	- Hydraulic separation between transmission and distribution systems relieves some pressure issues. - Higher temperature trasnmission main allows for smaller pipe diameters from EfW to DHEC	- Distribution network would still require significant pressurisation due to elevation change within SWE. - Hydraulic separation between transmission main and DHEC means additional equipment is required. Additional cost.
2	Forward pumping station to reduce system pressures	- Compatible with transmission main or single temperature option, with or without hydraulic separation. - Can be used to manage system pressures within the SWE development.	- Additional cost. - Temperature degradation if hydraulic separation is used.
3	Increased pipe sizing	- Reduces frictional losses on DH network - Reduces pumping energy at fixed flow rate due to reduced frictional losses - Potentially avoids need for pumping station(s)	- Larger pipe diameter is more expensive (although not significantly with contractor buying power) - Higher heat losses

Section 5.2 concluded that the preferred DHEC location is the cattle market site. The elevation of the site is similar to the EfW site, meaning that static pressurisation on the distribution network would still be above 5 barg.

Section 5.1 presented the benefits of using a transmission main to deliver heat from the EfW to the DHEC. The hydraulic separation in this approach will reduce frictional losses on the distribution network; however the significant elevation change within the SWE development means that further measures are likely to be required in order to maintain tolerable system pressures.

Of the operating principle options presented in Table 6-3, it is concluded that a transmission main between the EfW and the DHEC – option 1 – offers multiple benefits to the scheme and has therefore been included in the network design that follows. The two options pertaining to the distribution network (2 and 3) both have pros and cons; however it is assumed that it would be preferable to avoid the need for pumping stations (option 2) if possible, as this would require the acquisition of land from developers. Although option 3 – increased pipe diameters – does incur additional costs, both in heat losses and material costs, the impact of selecting a larger diameter pipe along key sections of main spine is unlikely to be significant relative to total network capital and operating costs, but would potentially make a big difference to the frictional losses. This will be assessed in the analysis that follows.

6.3 Network modelling

6.3.1 *Pressure and velocity modelling limits*

In sizing the district heating pipework, we have used the following maximum allowable pressure drops and velocities for different pipe diameters. They are based on industry guidance for velocities to avoid noise, erosion and excessive pressure loss.

Table 6-4: Pipe sizing design parameters

Nominal pipe diameter (mm)	Max allowable pressure drop (pa/m)	Max allowable velocity (m/s)
25	100	1
32	100	1
40	100	1
50	150	1
65	150	1
80	150	2.5
100	150	2.5
125	200	2.5
150	200	3
200	200	3
250	200	3.5
300	200	3.5

6.3.2 *Transmission main flow temperature*

The transmission main has been modelled at 105°C flow temperature. Based on the modelled distribution main return temperatures (see Section 6.3.3) and allowing for a 5°C heat loss across the heat exchanger at the DHEC, pipe diameter on the transmission main is 200mm in the future-proofed section coming out of the heat interface substation, dropping down to **125mm** beyond this point. If the transmission main operated at 90°C, a 150mm pipe would be required, so the increase in temperature delivers a cost saving to the project.

Modelling also shows that increasing the transmission main flow temperature to 120°C would not facilitate a further reduction in pipe diameter without exceeding the maximum allowable pressure loss or velocity (see Section 6.3.1).

It is noted that during periods of low demand, the transmission main could be operated at lower flow temperature in order to maintain a suitable flow rate through the pipework. This would also reduce heat losses during these periods.

6.3.3 *Distribution main temperatures*

In modelling the performance of a DH network, we have used the following inputs.

- Primary flow temperature: 85°C
- Domestic space heating primary return temperature: 45°C
- Domestic hot water (DHW) primary return temperature: 25°C
- Non-domestic load primary return temperature: 55°C

A space heating primary return temperature of 45°C requires secondary system heating designs that are configured to maximise flow-return temperature differentials. Traditional domestic heating systems operate at 82/71 flow-return; however there is widespread recognition of the need to ensure lower return temperatures to maximise the performance of district heating systems. A 2013 CIBSE document[4] highlights the benefits to DH systems of lower return temperatures:

"*If new building services are specified to operate in conjunction with a DH supply, there is the potential to optimise the design to the benefit of the DH system. Ultimately this will lead to lower energy supply costs and lower* CO_2 *emissions, even though the initial cost for the building services may be slightly higher… Typical space heating circuit temperatures of 60-70°C flow and 40°C return should be considered.*"

As such, we have assumed that developers on the SW Exeter development can be engaged at the earliest opportunity to ensure that secondary systems can be designed for lower operating temperatures, with the use of larger surface area radiators and underfloor heating. Note that the impact on the network of developers installing traditional operating temperature secondary systems would be larger pipe diameters on the DH network and a subsequent increase in the cost of the network.

In modelling space heating return temperatures at 45°C we have assumed a 40°C secondary system return with a temperature degradation of 5°C across the heat exchanger within the HIU.

6.3.4 *System pressures*

There is very little change in elevation between the EfW and DHEC. As such, the primary pressure issue within the transmission main is ensuring the system is sufficiently pressurised to maintain a flow temperature of 105°C without flashing into steam. The saturation pressure of water at 105°C is 0.195 barg. We have therefore assumed static pressurisation of 2 barg, which is sufficient pressure to maintain water at 105°C with a margin for resilience and additional pressurisation to avoid cavitation on the pumps.

Without fully designed plot level local DH networks, it is not possible to determine the index node[5] on the network. We have used the average per-dwelling pressure loss from the proxy development network design to calculate the likely pressure loss within the individual development areas (see Figure 6-8), as presented in Table 6-5.

Table 6-5: SWE development modelled plot level pressure loss

Area	No. of dwellings	Pressure loss (metres head)
1	301	18.6
2	84	5.2
3	140	8.7
4	200	12.4
5	122	7.5
6	260	16.1
7	230	14.2
8	138	8.5
9	250	15.4
10	230	14.2
11	65	4.0
O1	426	26.3

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[4] *Combined Heat and Power for Buildings: AM12* (CIBSE, 2013)

[5] The index node is the point on the network requiring the greatest pumping head to deliver the required flow rate to the heat load. It is a product of the frictional losses within the pipework between the pumping source and the heat load and defines the network pumping requirement.

Based on the number of dwellings in each of the development plot areas and their distance from the cattle market energy centre (see Figure 6-8), the index run is likely to be in plot 9 or 10. Table 6-5 shows the pressure loss on plots 9 and 10 is calculated at 15.4 metres on plot 9 (250 dwellings) and 14.2 metres of head on plot 10 (230 dwellings). By combining the calculated plot level pressure losses with the pressure loss up to the corresponding nodes on the modelled pipeline, the pressure loss across the network is 55.7 metres of head from the energy centre to the furthest point on plot 9; and 54.7 metres of head from the energy centre to the furthest point on plot 10. As such, it is concluded that index node is likely to be on plot 9.

Allowing for an additional 0.5 barg (5 metres) of pressure loss across the heat exchanger on the index node, it is concluded that the total pressure on the DH network is as shown in Table 6-6.

Table 6-6: System pressures across index run on SW Exeter distribution network

Pressure	Metres of head
Static pressurisation	55
Frictional losses through pipew ork	55.7
Frictional loss through index heat exchanger	5
Total	**116**

It is therefore concluded that system pressures at peak load would exceed 10 barg (approximately 100 metres of head) at peak load, assuming no further pressure reduction measures (increased pipe sizing or intermediate pumping station). As such, we have investigated the impact of increasing pipe diameters on the index run on frictional losses through the pipework.

By increasing the diameter of the pipe in the first 1.7km of trench (3.4km of pipe, flow and return), frictional losses through the pipework fall from 55.7 to 34.6 metres of head, which reduces total system pressures to 95 metres of head (approximately 9.5 barg), as shown in Table 6-7.

Table 6-7: System pressures across SW Exeter distribution network with strategic diameter increase

Pressure	Metres of head
Static pressurisation	55
Frictional losses through pipew ork	35
Frictional loss through index heat exchanger	5
Total	**95**

As such, it is concluded that system pressures can be kept within acceptable limits through appropriate pipe sizing; however it must be emphasised that the network modelled in this study will vary from the final design, which cannot be confirmed until layouts for the individual development plots are known. As such, it is essential that DH designers are engaged at the earliest opportunity once the layout is confirmed to progress detailed design.

6.3.5 *Distribution network heat losses*

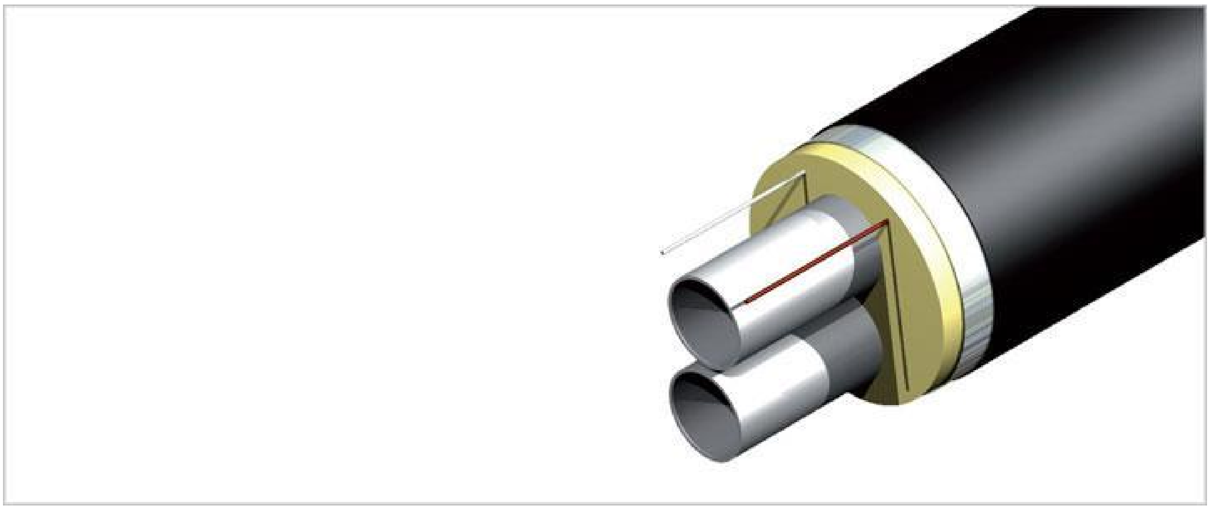
Because the network serves a high number of small heat loads (i.e. domestic properties), significant pipework is required to connect all of them to the DH network. Heat losses in district heating are a product of the level of pipework insulation, the temperature within the system and the length of the pipe system. Therefore a network with a very high ratio of pipework to heat load would have higher heat losses than one with a lower ratio.

The two obvious means of reducing heat losses are to minimise the pipe diameter where possible and to maximise pipe insulation. It has already been noted that sections of the distribution network may need to be sized slightly bigger in order to minimise frictional losses; however there are options for maximising the insulation performance of the pipework.

DH pipe systems are supplied as pre-insulated steel pipes with poly-urethane insulation inside a plastic casing. The pipes can be supplied with varying levels of insulation and it is recommended that higher specification insulation is selected for SW Exeter, given the extent of the network.

In addition to insulation thickness, DH pipework can be supplied as single or double pipe. The single pipe system consists of separate pre-insulated flow and return pipes, whereas the double pipe system includes a flow and return pipe within the same pre-insulated casing, as shown in Figure 6-10.

Figure 6-10: Double pipe system



Heat losses within a double pipe system are significantly reduced compared to the single pipe alternative. The following is taken from heat loss data provided by a pipe manufacturer and shows the relative heat loss performance of single and double pipe systems. The losses are determined at a differential of 65°C between the average flow-return pipe temperature and the ambient ground temperature.

Figure 6-11: Double pipe system heat losses by diameter with 65°C temperature differential

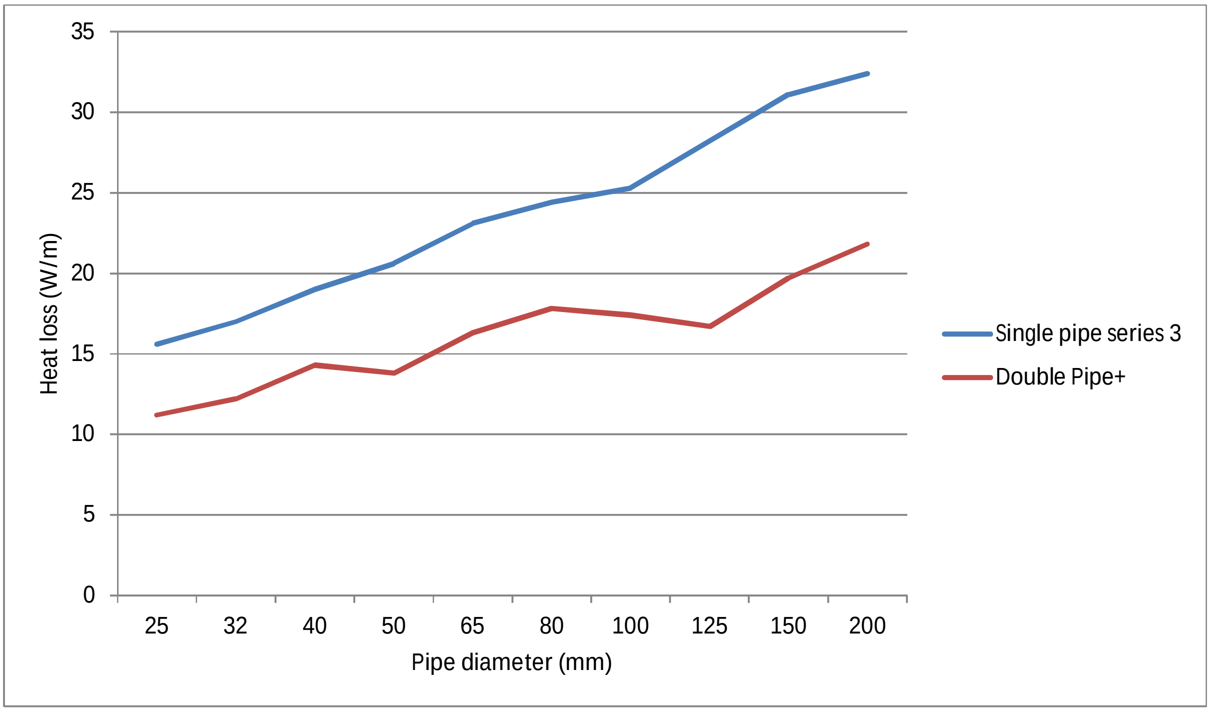


Figure 6-11 shows how heat losses in the single pipe system are between 33 percent and 69 percent higher than the double pipe system, depending on pipe diameter. The average difference across all diameters is 46 percent. On a DH system with extensive pipe infrastructure, opting for a double pipe system would therefore deliver a significant reduction in heat losses.

It is noted that double pipe systems are only available up to 150mm diameter pipe, so it would not be possible to use the system across the entire distribution network, where modelling shows the pipe diameters are up to 300mm (see Table 6-10). The preferred approach would therefore be to use a single pipe system on the main distribution network, dropping down to a double pipe system within the individual development plot areas.

A summary of modelled heat losses on each section of the network is presented in Table 6-8. Note that individual dwelling connections are likely to be in a flexible pipe system due to the significantly reduced cost of flexible pipework compared to single or double steel pipe and the extent of pipework required for connecting dwellings to the DH mains. Heat losses through flexible pipe systems are also relatively low, so heat losses are not worsened by the use of this system.

Table 6-8: SW Exeter DH network heat losses

Network section	Annual losses: 85°C flow temp (MWh/yr)
Transmission main	317
Distribution main (modelled)	1,095
Plot level (extrapolated from proxy development)	3,387
Total	**4,800**

These results show how network heat losses, even with the highest specification DH pipework insulation and using double pipe on the plot level networks, are considerable – approximately 24 percent of the annual heat load on the network.

As discussed previously, the primary factors in the determination of heat losses in a DH network are system temperatures, pipework insulation and the length of the pipework. Given the distribution of load within a housing development, there is little that can be done to reduce the extent of the pipework relative to the heat load besides ensuring routing is optimised to minimise pipework. We have already made allowance in the modelling and associated costs for maximum DH pipework insulation and using double pipe on the plot level networks. The other thing that can be done to reduce losses is to operate the network at lower temperature during periods of low demand.

At low heat loads in a variable flow DH system with a fixed flow temperature, the distribution pumps modulate down to reduce the flow rate through the system; however if the flow temperature is reduced, the temperature differential between the DH pipe and the ambient ground temperature is reduced, which reduces heat losses. Note that this approach would mean additional pumping energy consumption as the flow rate at lower flow temperature is greater than if the flow temperature was higher.

In order to demonstrate the impact of reduced temperature operation, we have modelled the main distribution network (i.e. excluding plot level pipework) with a 70°C flow temperature.

- At 85°C flow temperature, heat losses on the modelled distribution main are 1,095MWh (see Table 6-8);

- At a flow temperature of 70°C, the annual heat losses on the modelled distribution network reduce to 914MWh.

Therefore a flow temperature reduction to 70°C delivers a 16 percent reduction in heat losses. This is based on the modelled distribution main only, so by applying the same 16 percent reduction to the losses on the plot level networks (3,387MWh), this would equate to an annual reduction of 543MWh, making the total annual heat loss saving on the distribution network including the plot network 725MWh.

As discussed, a reduction in flow temperature at a given load means an increase in flow rate, so reducing the flow temperature should only be done at lower heat loads so as to avoid excessive flow through the pipes. If we assume that load is sufficiently low for the flow temperature to be reduced to 70°C from May to September (four months, or one third of the year) and apply a 16 percent reduction across one third of the overall heat losses through this period, annual heat losses reduce by 240MWh, as shown in Table 6-9.

Table 6-9: Heat loss reduction with 70°C flow temperature May-September

Network section	Annual losses: 85°C flow temp (MWh/yr)	Annual losses: 70°C flow temp May-Sept (MWh)
Transmission main	317	317
Distribution main (modelled)	1,095	1,037
Plot level (extrapolated from proxy development)	3,387	3,206
Total	**4,800**	**4,560**

A 240MWh saving in heat losses should be assessed against the increased cost of pumping energy through the same period. We have modelled the pumping energy increase arising from reducing the flow temperature from May to September and determined that an additional 57MWh of pumping energy would be required annually.

If it assumed that pumping energy is supplied from electricity at 10p/kWh, the additional cost of pumping energy due to reduced flow temperature for four months is £5,700 a year.

If it is assumed that heat losses are supplied from gas boilers of 86 percent efficiency at 3.5p/kWh for gas, the cost of meeting that demand is approximately £9,750.

As such, it can be concluded that it is preferable to operate the DH network at reduced flow temperature through periods of lower demand. Indeed, it may be possible to extend the period of time for which this is done; however this should be assessed once the scheme becomes operational.

Total annual losses from the proposed DH design and operating strategy are: **4,560MWh**, which is 23 percent of the total heat demand on the network.

6.4 Pipe sizes and costs

A summary of pipe sizes and costs for the DH network is presented is Table 6-10. A DH installation company supplied cost per metre values for different pipe diameters. Given the scale of the project and the extent of pipework required to serve a residential development such as SW Exeter, the most cost effective solution would be for an ESCo with significant buying power to deliver the scheme. The costs supplied for the purposes of this study have come from a medium-sized DH installer and, as such, are considered higher than would be the case if a large ESCo was involved. As such, we have applied a 20 percent reduction to the DH installer's costs on the assumption that the appointed ESCo would be able to leverage significant buying power to reduce costs. The costs presented in Table 6-10 were discussed with a large ESCo contact and it was agreed that they are in the right order of magnitude for a project of this scale with the prices available to a large ESCo.

Note that we have assumed all 25mm pipe sections within the models are connections to individual dwellings and will be made in Aluflex, which is appropriate for connecting residential properties to DH networks and is cheaper than using steel pipe.

As described in Section 6.1.3, we have assumed maximum specification insulation on the pipe system; and that double pipe is used within plot level networks. This is to minimise the significant heat losses on the network and therefore reduce operating costs through time; however it does mean that the capital cost of the network is higher than it would be if single pipe at a lower insulation specification were used.

Table 6-10: SW Exeter DH network pipe extent and cost

Network section	Pipe system	Nominal pipe diameter (mm)	Total trench length - flow and return (m)	Cost (£k)
Transmission main	Single pipe	125	1,313	878.8
	Single pipe	200	114	90.2
Distribution main	Single pipe	25	167	£36.8
	Single pipe	32	255	£79.7
	Single pipe	40	0	£0.0
	Single pipe	50	936	£345.6
	Single pipe	65	566	£225.1
	Single pipe	80	847	£351.6
	Single pipe	100	777	£358.2
	Single pipe	125	567	£283.9
	Single pipe	150	323	£179.8
	Single pipe	200	0	£0.0
	Single pipe	250	1,035	£755.9
	Single pipe	300	649	£512.7
Plot networks	Double pipe with aluflex	N/A	N/A	£13,508.2
TOTAL NETWORK COST				**£17,606.5**

Note that pipe sizes are not presented for the individual plot/area networks within the SW Exeter development because we have extrapolated average costs and operational characteristics for these areas from the proxy development design models. This process gives us a cost per connected dwelling from these detailed design models. We have taken the average cost per connected dwelling across all the detailed design models (£5.5k – see Table 6-2) and multiplied it by the number of dwellings in each of the plots on the SW Exeter development. This is preferable to creating a number of notional plot layouts because those models have been used to assess real development layouts and are therefore considered a more realistic representation of plot level DH networks.

A summary of the plot level network cost for the SWE development area (see Figure 6-8), as calculated using the methodology described above, is presented in Table 6-11.

Table 6-11: Plot level pipe cost for SW Exeter development area

Area	No. of dwellings	Cost (£k)
1	301	£1,662
2	84	£464
3	140	£773
4	200	£1,105
5	122	£674
6	260	£1,436
7	230	£1,270
8	138	£762
9	250	£1,381
10	230	£1,270
11	65	£359
O1	426	£2,353

Pipes on the modelled distribution and transmission networks have been sized based on appropriate maximum velocities and pressure loss from industry guidelines. Some pipe sizes have been increased in order to keep system pressures below 1.barg (see Section 6.3.4). Pipe sizing design parameters are presented in Table 6-12.

Table 6-12: Pipe sizing pressure and velocity parameters

mm nominal diamter	Max allowable pressure drop (pa/m)	Max velocity (m/s)
25	100	1
32	100	1
40	100	1
50	150	1
65	150	1
80	150	2.5
100	150	2.5
125	200	2.5
150	200	3
200	200	3
250	200	3.5
300	200	3.5
350	200	3.5
400	200	3.5

SECTION 6

ENERGY BALANCE MODELLING

7 ENERGY BALANCE MODELLING

7.1 Plant sizing

DHEC boilers have been sized for peak heat supply at final build-out on the modelled DH network – 17MWth. It is noted that boilers can be introduced in modular fashion as required by the onset of load on the network.

The EfW supply to the development has been sized at 4MW, with 300m3 of thermal storage to maximise the use of heat from the EfW (see Section 7.2). As discussed previously, this allows for reduced pipe costs on the transmission main and also means there is additional capacity at the EfW interface for additional future loads (see Section 5.1).

Initial line, pump, thermal store and boiler sizes are indicated on the schematic presented in Appendix D. Note that these sizes are indicative based on the load analysis and return temperatures presented in this report. Sizing should be revisited iteratively as the development planning is further defined.

7.2 Energy balance inputs

Energy balance modelling has been undertaken for the supply of heat to the DH network using our in-house modelling software. Key plant outputs and fuel inputs are modelled against hourly heat loads, as developed with our load profiling software described in Section 3.4.

The energy balance model allows the user to define the nature and scale of heat sources as well as modelling the performance of thermal storage and back-up/top-up boiler plant. It generates a detailed breakdown of all energy inputs and outputs, which can then be used for detailed operating cost analysis.

Key plant inputs in the energy balance modelling that follows are shown in Table 7-1.

Table 7-1: Key plant sizing

Plant	Scale	Fuel input	Efficiency	Availability
EfW heat supply	4MWth	Not modelled	Not modelled	7,450 hours/year
DHEC boilers	17MWth	Gas	86%	8760 hours/year
DHEC thermal storage	300m^3	N/A	N/A	8760 hours/year

7.3 Parasitic loads

In addition to the heat generation plant and thermal storage, we have made allowance for electrical consumption from the following ancillary plant

- Transmission main distribution pumps
- Transmission main heat exchanger shunt pump (secondary side)
- EfW heat interface substation control cabinet
- DHEC network main distribution pumps
- DHEC gas boiler shunt pumps
- DHEC heat exchanger shunt pumps
- DHEC control panel
- DHEC gas booster and burner supply pumps
- Ventilation

Parasitic loads have been modelled to respond to the relevant primary plant output, where applicable, i.e. modulating in line with boiler or heat exchanger operation down to a minimum turndown level.

The annual parasitic load is shown alongside annual heat load through time in Figure 7-1. The corresponding values are shown in Table 7-2.

Figure 7-1: Parasitic and heat load development through time

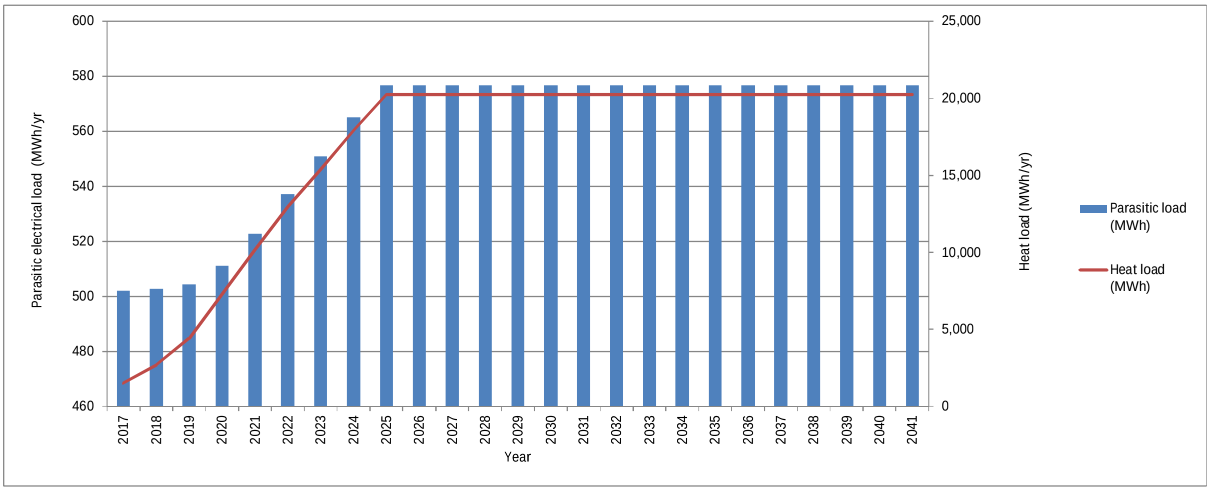


Table 7-2: Parasitic and heat load development through time

Energy	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Parasitic load (MWh)	502	503	504	511	523	537	551	565	577	577	577	577	577	577	577
Heat load (MWh)	1,509	2,705	4,421	7,293	10,154	12,966	15,374	17,944	20,257	20,257	20,257	20,257	20,257	20,257	20,257

NB: Values from 2031 remain unchanged

The modelling shows that parasitic loads increase through time to some extent, as the DH network grows and there is increased pumping energy, boiler operation and ventilation. However it also shows how, in the early stages of the network, parasitic loads are proportionally higher compared to the network heat demand. This is because parasitic loads are not directly proportional to heat load on the network.

Some of the ancillary plant are wholly independent of heat load – for example control cabinets – and most of the rest are only partly related to heat load – for example pumps, which have minimum turndown levels.

It should be noted that the parasitic loads presented here are based on a high level assessment of parasitic plant sizes and power consumption. Future iterations should seek to refine this assessment as the design is progressed.

7.4 Energy balance results

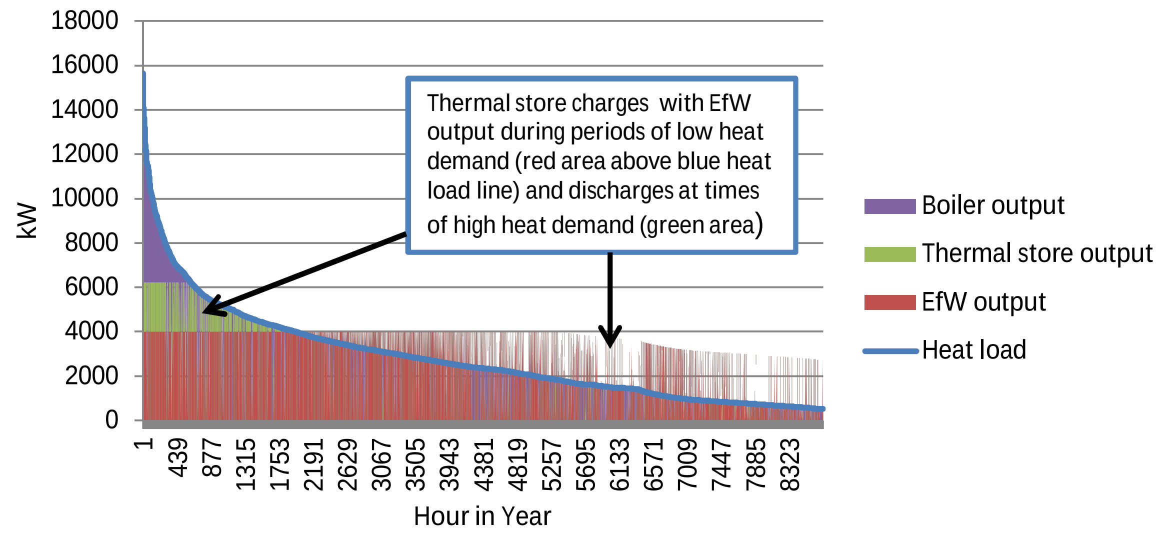
Based on the load inputs presented in Section 3 and the plant inputs presented in Section 7.1, we have modelled the performance of the SW Exeter DH network. The results of this modelling are shown in Table 7-3.

Table 7-3: Energy balance results

Input/output	Annual quantity at build-out
Heat load (MWh)	20,257
Distribution losses (MWh)	4,560
Heat from EfW (MWh)	20,621
% heat met by EfW	83%
Heat from gas boilers (MWh)	4,196
Gas boiler fuel input (MWh)	4,879
Parasitic electrical demand (MWh)	577
Carbon emissions (tonnes CO_2/yr)	2,322

The results in Table 7-3 show how heat from the EfW plant meets most of the demand on the network. Figure 7-2 shows heat supply relative to the load duration curve.

Figure 7-2: DH network heat supply relative to load duration curve



The chart shows how thermal storage maximises the use of heat from the EfW as it is charges during periods of low heat demand and discharges stored EfW heat when demand is above 4MW, as shown in green. This reduces the requirement for boiler heat, shown in purple.

7.5 Carbon saving

In calculating the emissions from the DH network, we have used the following emissions factors.

Table 7-4: Emissions factors used in carbon analysis

Fuel	Emissions factor ($kg/CO_2/kWh$)	Source
Heat from EfW	0.047	SAP 2012
Natural gas	0.216	SAP 2012
Electricity import	0.519	SAP 2012

In order to assess the carbon reduction performance of the network, we have modelled a carbon base case in which heat is supplied from individual gas boilers, assumed to be located in the individual dwellings. As such, we have excluded all heat losses and parasitic loads from this analysis. The results of the analysis are presented in Table 7-5.

Table 7-5: DH network carbon reduction comparison with base case

Option	Build-out annual emissions (tonnes CO_2)	Percentage reduction against base case
Base case	5,089	▨
DH with 300m^3 TS	2,322	54%

The results show how the DH scheme delivers a significant carbon reduction over the base case, despite the heat losses on the DH network and the energy centre parasitic load. This is a product of the very low carbon heat available from the EfW and the high level of EfW heat utilisation.

The average dwelling annual heat demand on the network is 6,615kWh. The carbon content of the heat on the DH scheme is therefore 0.12kgCO_2/kWh. This includes losses and parasitic energy centre loads. The carbon content of heat from the base case is 0.25kgCO_2/kWh. As such, the average dwelling CO_2 emissions are 0.8 tonnes per year on the DH network and 1.66 tonnes per year under the base case.

SECTION 7

CAPITAL AND OPERATING COSTS

8 CAPITAL AND OPERATING COSTS

8.1 Capital costs

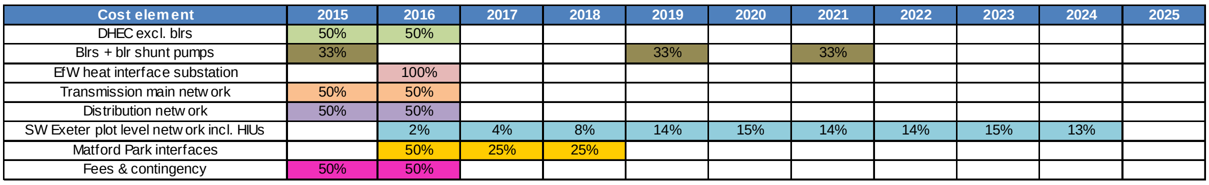
The capital cost of the SW Exeter DH system has been developed using budget quotations from suppliers, industry cost guidelines (Spons 2014) and PB's previous project experience.

Costs for the DHEC building have been assessed as part of the design process for the building.

Note also that we have used hard dig costs for the transmission main, except for soft dig land alongside the drainage ditch. For the distribution main and plot level network, we have used soft dig costs as development area is currently greenfield land.

A capital spend profile has been developed on the basis of an assumed project start date, the early development of essential heat infrastructure and the phased development of network infrastructure in line with SW Exeter and Matford Park development. The percentage onset of key scheme elements used in the analysis that follows is shown in Figure 8-1.

Figure 8-1: Delivery of key DH scheme elements



Cost element	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
DHEC excl. blrs	50%	50%									
Blrs + blr shunt pumps	33%				33%		33%				
EfW heat interface substation		100%									
Transmission main network	50%	50%									
Distribution network	50%	50%									
SW Exeter plot level network incl. HIUs		2%	4%	8%	14%	15%	14%	14%	15%	13%	
Matford Park interfaces		50%	25%	25%							
Fees & contingency	50%	50%									

It is assumed that Matford Park will initially need to be served from temporary plant (see Section 8.2) as it is highly unlikely that the network would be sufficiently developed in time to serve those loads from the DH network.

A summary of the total capital costs for each of the elements shown in Figure 8-1 is presented in Figure 8-2 and Table 8-1.

Figure 8-2: Capital costs by project element

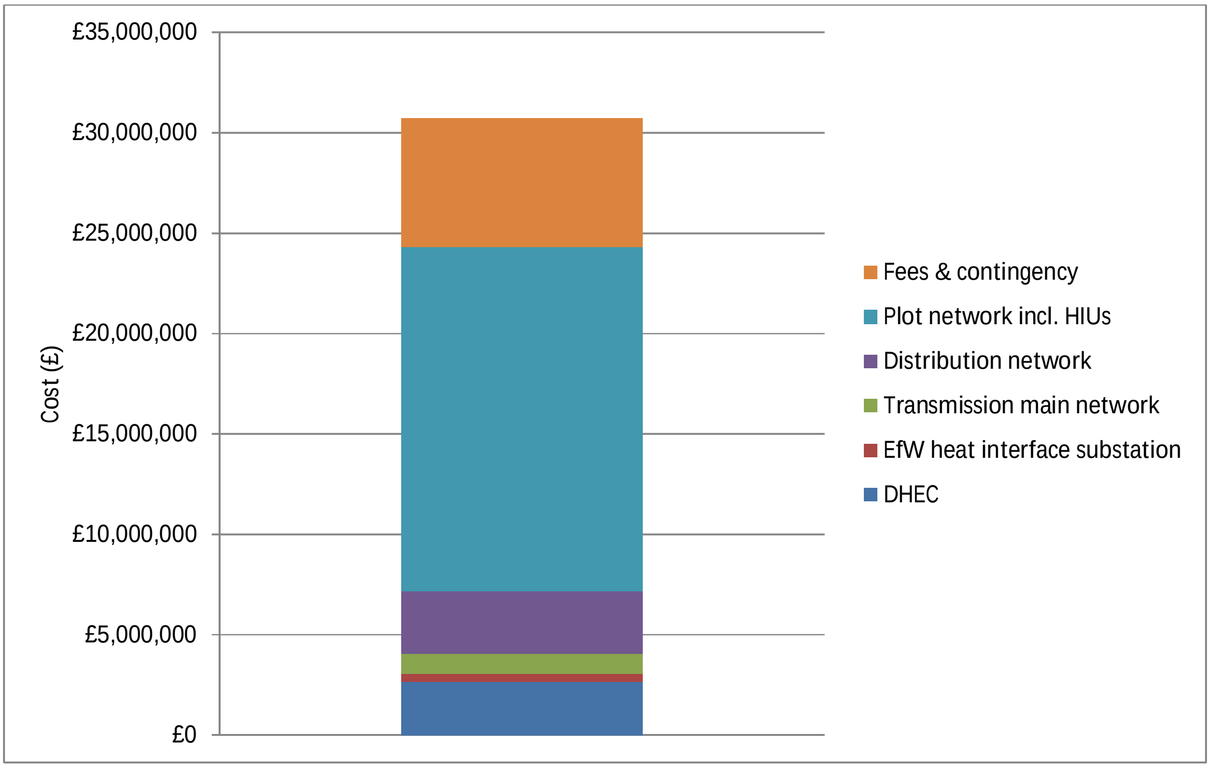


Table 8-1: Capital costs by project element

Cost element	Cost
DHEC	£2,652,803
EfW heat interface substation	£412,743
Transmission main network	£968,930
Distribution network	£3,129,407
Matford Pk skids	£249,917
Plot network incl. HIUs	£17,125,118
Fees & contingency	£6,420,764
TOTAL	**£30,959,682**

Based on these costs and the delivery of key DH scheme elements, the capital spend profile of the proposed scheme is presented in Figure 8-3. The data table is presented in Table 8-2.

As described in Section 6.4, we have assumed maximum specification insulation on the pipe system; and that double pipe is used within plot level networks in order to minimise heat losses and therefore reduce operating costs through time. Capital costs for the pipe system could be reduced somewhat by selecting a lower insulation specification, single pipe system, although this would lead to increased operating costs.

Figure 8-3: Project capital spend profile

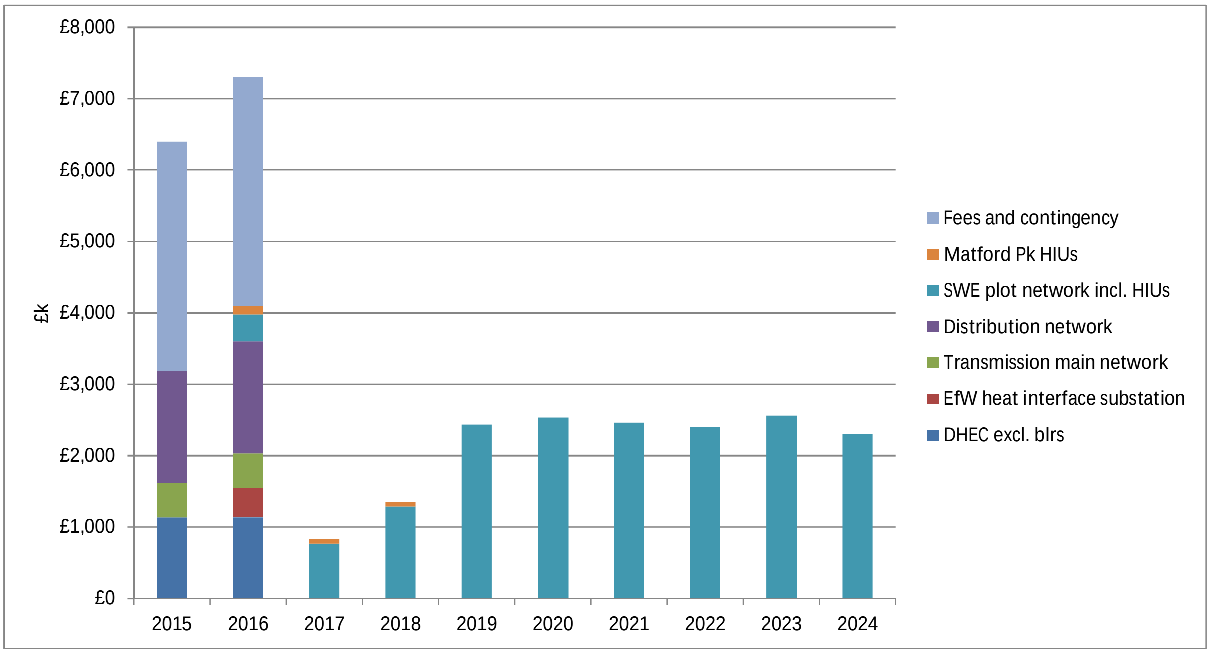


Table 8-2: Project capital spend profile

Cost element	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
DHEC excl. blrs	£1,137.0	£1,137.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Blrs + blr shunt pumps	£126.2	£0.0	£0.0	£0.0	£126.2	£0.0	£126.2	£0.0	£0.0	£0.0	£0.0
EfW heat interface substation	£0.0	£412.7	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Transmission main network	£484.5	£484.5	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Distribution network	£1,564.7	£1,564.7	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
SWE plot network incl. HIUs	£0.0	£373.6	£768.4	£1,286.3	£2,438.8	£2,533.1	£2,458.5	£2,400.1	£2,561.2	£2,305.1	£0.0
Matford Pk HIUs	£0.0	£125.0	£62.5	£62.5	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Fees and contingency	£3,210.4	£3,210.4	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Total	**£6,522.8**	**£7,307.9**	**£830.9**	**£1,348.7**	**£2,565.1**	**£2,533.1**	**£2,584.7**	**£2,400.1**	**£2,561.2**	**£2,305.1**	**£0.0**
Cumulative total	**£6,522.8**	**£13,830.7**	**£14,661.6**	**£16,010.3**	**£18,575.4**	**£21,108.5**	**£23,693.2**	**£26,093.3**	**£28,654.6**	**£30,959.7**	**£30,959.7**

Note that a full capital cost breakdown is presented in Appendix B.

8.2 Temporary packaged plant

8.2.1 *General information*

Given the timeframe for development, it is unlikely that a DH network serving the SW Exeter and Matford Park development areas would be operational in time to serve some of the early phase development, particularly on Matford Park, where some buildings are expected to be occupied from 2015.

In order to ensure that opportunities to connect buildings to the DH network are not missed due to differences in the development schedules of the DH network and the development areas, temporary heat supply solutions can be made available to those buildings until the primary scheme is live.

Temporary packaged plant is available in the form of gas or oil-fired mobile boilers. They are generally supplied with expansion and pressurisation equipment as well as distribution pumps. They can be connected to DH pipework via drain vents on the system; however pressure loss through these narrow vents is relatively high and should be considered when selecting temporary pumps to feed the system.

It is important to determine the maximum number of dwellings that must be served by the packaged plant so as to avoid under-sizing either the boilers or the pumps. It is also important that plot level DH network design accounts for the strategic positioning of isolation valves. Once the plot level layout and build schedule is known, isolation valve positions should be determined based on which sections of network will require heat first. This avoids the need to fill and 'liven up' sections of network with no load attached until it is necessary. It also avoids, or minimises, the need for 'hot tapping' into a live network as new dwellings are completed.

Depending on the build schedule of individual plots, it may make more sense to use smaller packaged plant initially, for example to serve a small number of show homes, before switching to a larger unit, or additional modular units, as more houses are developed.

It is not possible at this stage to determine which areas of SW Exeter will require packaged plant although the first dwellings are likely to come forward around 2017. It would be prudent to advise early stage developers to ensure space is made available for packaged plant as required. Plant varies in size according to scale, but the following provides a basic indication of size based on kilowatt output.

Table 8-3: Indicative packaged plant dimensions

Packaged plant size (kW)	Length (m)	Width (m)	Height (m)
100	2	1.4	1.8
250	3.2	2.2	2
500	4.4	2.4	2.6
1,200	5.5	2.3	2.5

If oil-fired boilers are used, space will also be required for a fuel tank adjacent to the packaged boiler plant. The size of the required tank will vary according to the size of the boiler; the scale and profile of the heat load; and the frequency of oil deliveries; however the following summarises the sizes within a range of fuel tanks supplied by an established UK packaged boiler plant supplier.

Table 8-4: Indicative fuel tank dimensions

Fuel tank capacity (litres)	Length (m)	Width (m)	Height (m)
1000	1150	1150	1330
3000	1340	1550	2300
6500	3020	2470	1340

It seems likely that part of the development at Matford Park will precede the DH network and DHEC completion. As such, serious consideration should be given at this stage to how that load will be met from temporary packaged plant. The development area is not very large and the buildings are all commercial, so finding somewhere to position temporary packaged plant is unlikely to be an issue. It is recommended that Matford Park developers are engaged as soon as possible to discuss the proposed scheme and make allowance for temporary packaged plant as required.

8.2.2 *Impact on capital spend profile*

Temporary packaged plant presents an opportunity to delay the capital spend on some of the key network elements – specifically the DHEC, the EfW heat interface, the transmission main and the distribution mains (plot level DH network would still be required). There is an additional cost for the temporary plant itself; however on a whole life cost basis, this may be preferable if significant project costs can be delayed into the future.

We have assessed the potential impact of using temporary packaged plant in the early stages of development to delay large parts of the capital spend. We have used the calculated peak load through time for each the development plots highlighted by Teignbridge Council (see Figure 6-8) and for Matford Park to assess the annual requirement for temporary plant on each development plot.

The peak heat load through time across the development plots and Matford Park is shown in Table 8-5.

Table 8-5: Peak heat load through time across SW Exeter development plots and Matford Park

Area	2015	2016	2017	2018	2019	2020	2021
1	0	0	89	170	287	504	715
2	0	0	59	79	120	193	250
3	0	0	65	103	174	277	377
4	0	0	75	141	214	359	497
5	0	0	57	94	152	251	335
6	0	0	85	160	403	740	1129
7	0	0	75	141	235	405	562
8	0	0	64	101	172	273	372
9	0	0	81	154	266	449	638
10	0	0	75	141	235	405	562
11	0	0	46	68	97	163	210
O1	0	0	103	226	380	674	974
Matford Park	0	0	100	250	250	800	800
Total	**0**	**0**	**974**	**1,828**	**2,986**	**5,492**	**7,422**

In order to cost the temporary packaged plant, we have used previous quotations for packaged plant on existing heat networks as a proxy. The costs for packaged plant used in the assessment, based on the scale of the plant, are presented in Table 8-6.

Table 8-6: Weekly packaged plant hire costs used in modelling

kW rating	Cost/wk
100	£111
250	£278
280	£311
500	£556
600	£667
800	£889
1200	£1,334
1500	£1,668
1200*2	£2,668
1500*2	£5,336

We have also included delivery, installation, commissioning and removal costs of £4,500 per unit, also based on previous supplier quotations.

Based on this analysis, the calculated annual spend on temporary packaged plant is presented in Table 8-7.

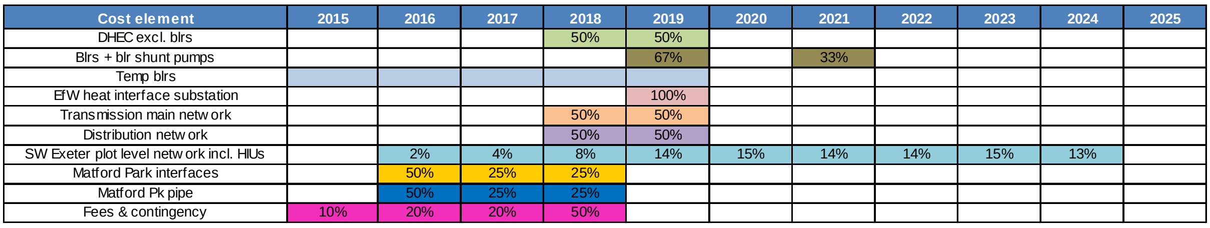
Table 8-7: Potential annual spend on temporary packaged plant

Year	2015	2016	2017	2018	2019	2020	2021
Total	**£33,403**	**£50,745**	**£197,236**	**£304,801**	**£346,217**	**£649,080**	**£740,912**

This analysis shows that the cost of the plant would rise significantly in 2020. Table 8-5 shows that there is a significant increase in peak load in 2020 compared to 2019, which leads to a significant increase in packaged plant requirement and, therefore, cost. As such, we have revised the capital spend profile to delay the cost of some of the key project costs until 2018-2019 and included the cost of temporary plant through the same period, as shown in Table 8-7 up to 2020.

The change in percentage onset of key scheme elements as a result of the packaged plant is presented in Figure 8-4.

Figure 8-4: Delivery of key DH scheme elements with temporary packaged plant



Cost element	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
DHEC excl. blrs				50%	50%						
Blrs + blr shunt pumps					67%		33%				
Temp blrs	■	■	■	■	■						
EfW heat interface substation					100%						
Transmission main network				50%	50%						
Distribution network				50%	50%						
SW Exeter plot level network incl. HIUs		2%	4%	8%	14%	15%	14%	14%	15%	13%	
Matford Park interfaces		50%	25%	25%							
Matford Pk pipe		50%	25%	25%							
Fees & contingency	10%	20%	20%	50%							

The resulting project capital spend profile is presented in Figure 8-5 and Table 8-8.

Figure 8-5: Project capital spend profile with temporary packaged plant

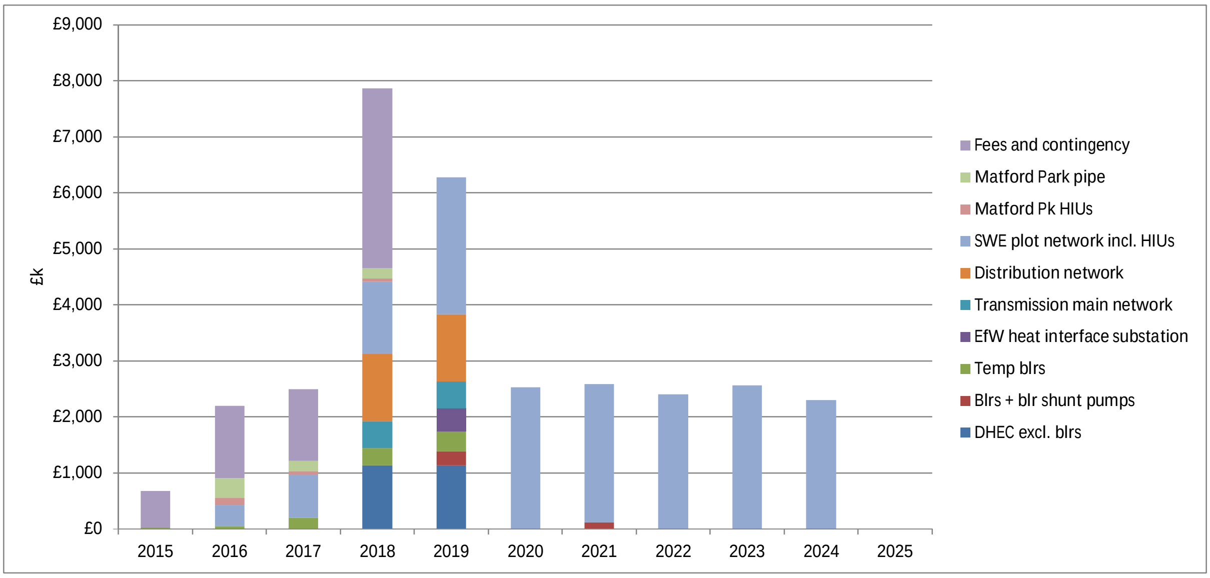


Table 8-8: Project capital spend profile with temporary packaged plant

Cost element	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
DHEC excl. blrs	£0.0	£0.0	£0.0	£1,137.0	£1,137.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Blrs + blr shunt pumps	£0.0	£0.0	£0.0	£0.0	£253.7	£0.0	£125.0	£0.0	£0.0	£0.0	£0.0
Temp blrs	£33.4	£50.7	£197.2	£304.8	£346.2	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
EfW heat interface substation	£0.0	£0.0	£0.0	£0.0	£412.7	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Transmission main network	£0.0	£0.0	£0.0	£484.5	£484.5	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Distribution network	£0.0	£0.0	£0.0	£1,201.7	£1,201.7	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
SWE plot network incl. HIUs	£0.0	£373.6	£768.4	£1,286.3	£2,438.8	£2,533.1	£2,458.5	£2,400.1	£2,561.2	£2,305.1	£0.0
Matford Pk HIUs	£0.0	£125.0	£62.5	£62.5	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Matford Park pipe	£0.0	£363.0	£181.5	£181.5	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Fees and contingency	£642.1	£1,284.2	£1,284.2	£3,210.4	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Total	**£675.5**	**£2,196.4**	**£2,493.7**	**£7,868.7**	**£6,274.8**	**£2,533.1**	**£2,583.5**	**£2,400.1**	**£2,561.2**	**£2,305.1**	**£0.0**
Cumulative total	**£675.5**	**£2,871.9**	**£5,365.6**	**£13,234.3**	**£19,509.1**	**£22,042.2**	**£24,625.6**	**£27,025.7**	**£29,587.0**	**£31,892.1**	**£31,892.1**

Note that the total project capital cost is increased by over £900k as a result of the use of packaged plant; however, as discussed previously, this may be offset by the benefit of significantly delaying a large amount of the capital spend.

A comparison of cumulative capital spend, with and without temporary packaged plant is presented in Figure 8-6 and Table 8-9.

Figure 8-6: Cumulative capital spend comparison - with and without temporary packaged plant

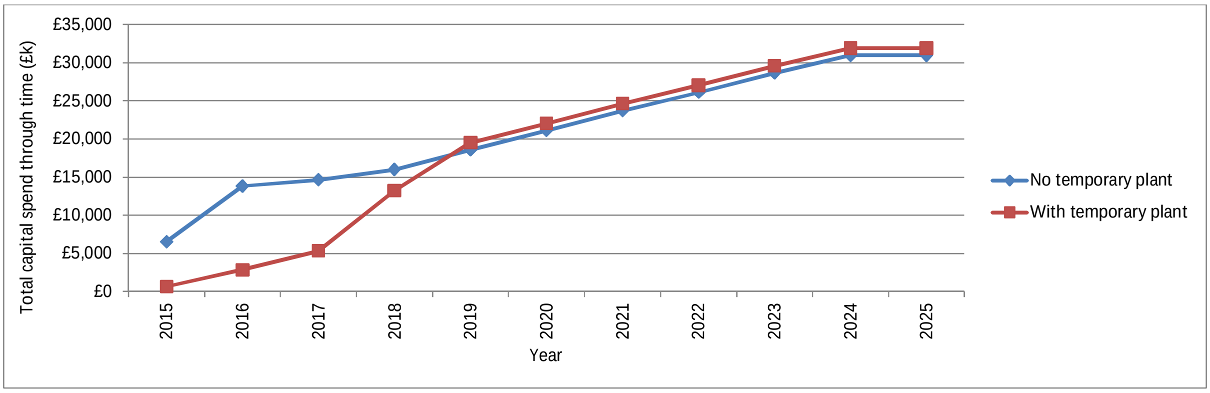


Table 8-9: Cumulative capital spend comparison - with and without temporary packaged plant

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
No temporary plant	£6,522.8	£13,830.7	£14,661.6	£16,010.3	£18,575.4	£21,108.5	£23,693.2	£26,093.3	£28,654.6	£30,959.7	£30,959.7
With temporary plant	£675.5	£2,871.9	£5,365.6	£13,234.3	£19,509.1	£22,042.2	£24,625.6	£27,025.7	£29,587.0	£31,892.1	£31,892.1

8.3 Maintenance costs

We have allowed for maintenance of plant in the DHEC, the EfW heat interface substation and also for the DH network. Maintenance rates used are as follows:

Table 8-10: Maintenance rates used in operating cost analysis

Item	Annual maintenance cost
DHEC boilers	£10k
Tranmission main network	0.5% of transmission main cost
Distribution main network	0.5% of distribution main cost

8.4 Boiler replacement

Boiler replacement costs have been included at 100 percent of the initial capital cost after 20 years. See Appendix B for a detailed breakdown of capital costs.

8.5 Operating cost through time

Based on the economic inputs described in Sections 8.1 to 8.4, annual operating costs have been calculated for the scheme. Operating costs from 2015 to 2050 are presented in Table 8-11. Note that these costs have not been indexed. We have used the capital spend profile with no temporary plant included. We have also included parasitic electrical demands, heat supply from the EfW and boiler gas consumption (including from temporary boilers on Matford Park prior to scheme completion).

Table 8-11: Project annual operating cost through time

Item	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Capex (£k)	£6,522.8	£7,307.9	£830.9	£1,348.7	£2,565.1	£2,533.1	£2,584.7	£2,400.1	£2,561.2	£2,305.1	£0.0	£0.0
Maintenance cost (£k)			£37.1	£43.9	£56.1	£68.7	£81.0	£93.0	£105.8	£117.4	£117.4	£117.4
Boiler replacement (£k)			£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Boiler gas consumption (MWh)	356.0	889.9	62.5	227.1	505.5	998.1	1,527.2	2,182.2	2,873.4	3,787.6	4,879.3	4,879.3
Heat from EfW (MWh)			1,794.6	3,118.6	4,981.2	8,076.5	11,126.0	14,008.1	16,364.0	18,726.2	20,621.0	20,621.0
Parasitic electricty (MWh)			502.0	502.8	504.4	511.0	522.9	537.3	550.9	565.1	576.7	576.7

Item	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Capex (£k)	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Maintenance cost (£k)	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4
Boiler replacement (£k)			£0	£0	£0	£0	£0	£0	£0	£330	£0	£0
Boiler gas consumption (MWh)	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3
Heat from EfW (MWh)	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0
Parasitic electricty (MWh)	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7
	353.75		1597.12832									

Item	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Capex (£k)	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0	£0.0
Maintenance cost (£k)	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4	£117.4
Boiler replacement (£k)	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Boiler gas consumption (MWh)	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3	4,879.3
Heat from EfW (MWh)	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0	20,621.0
Parasitic electricty (MWh)	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7	576.7

SECTION 8

DISTRICT HEATING ENERGY CENTRE DESIGN

9 DISTRICT HEATING ENERGY CENTRE DESIGN

9.1 Structure

Plan, elevation and section drawings of the DHEC are provided in Appendix C. The design is based on spatial requirements of the energy centre plant, basic facilities for operatives working in the energy centre and following a site visit and consultation with Exeter City Council planners.

9.2 Plant

Plant layouts and a schematic of the DHEC, including line, vessel and pump sizes are presented in Appendix D.

SECTION 9

CONCLUSIONS AND RECOMMENDATIONS

10 CONCLUSIONS AND RECOMMENDATIONS

Parsons Brinckerhoff has undertaken load analysis for the proposed SW Exeter and Matford Park development areas. Based on this analysis, we have undertaken a preliminary design for a district heating network supplying heat to the development areas from the Viridor EfW plant with top up heat from a dedicated gas boiler energy centre located on the existing Cattle Market site. Boilers in the energy centre are sized to meet peak heat load.

Opportunities to connect the DH network to existing loads (identified with the client project team) in the vicinity of the EfW plant have been investigated; however each of the possible heat customers contacted is unsuitable for connection, either due to the scale of the demand versus the cost of connection, or the willingness to connect.

The availability of heat from the EfW plant, and the scale of the demand, is such that the majority of demand can be met with low carbon heat from the EfW. This is further enhanced by the use of thermal storage at the DHEC, allowing for continued use of EfW heat at times of lower demand on the DH network.

We propose that a transmission main between the EfW plant and the DHEC provides an opportunity to minimise pipe diameters in this section of the network. This offers a cost benefit and facilitates installation in an area where sections of the network will be buried under existing roads. The higher temperature (we have modelled 105°C) and pressure in the transmission main means it is not suitable for supply directly into the dwellings and businesses in the two development areas. We have therefore designed for a second interface at the DHEC, where the transmission main supplies a hydraulically separate distribution network operated at 85°C.

It is noted that there is no obvious alternative to the area identified for a substation at the EfW plant. It is therefore important, as the substation design is developed further, that designers, ECC planners and Viridor work together to ensure the viability of this position is retained through the construction of the railway halt.

Network sizing has been undertaken for the distribution network using a combination of hydraulic modelling for the main distribution system and proxy information taken from a similar scale network, also in the Exeter area, for which Parsons Brinckerhoff have undertaken detailed plot level design.

The elevation changes within the development areas present a level of engineering complexity as significant static pressurisation is required, limiting the pumping head that is available to overcome frictional losses. Options for maintaining allowable system pressures have been assessed, with increased pipe sizes on key sections of the network preferred over downstream pumping stations as it does not require the negotiation and acquisition of development land and is considered the cheaper option.

We have assumed that developers can be engaged to ensure dwelling heating systems are capable of delivering low space heating return temperatures. We have modelled 40°C space heating return temperatures, as recommended by CIBSE (see Section 6.3.3). This assumption is integral to the design presented in this study, so it is essential that developers are aware of the need to ensure their heating system designs are compatible with the DH network.

Heat losses are also a significant factor on a network with such significant pipe infrastructure. We have assessed options for minimising these losses and recommend a number of measures. Pipework can be supplied with a range of insulation thicknesses; we recommend that the maximum insulation thickness is used, although it is noted that this increases the overall diameter of the pipe system, so may not be possible where there are multiple other buried services. In addition to insulation thickness, we recommend the use of a double pipe system on plot level networks as heat losses in this system are significantly lower than in the single pipe alternative. Double pipe is not available in large (above 150mm) diameters, hence it is not suitable for larger DH mains. Finally, we recommend that the flow temperature on the distribution network is reduced through the summer months as it minimises heat losses by reducing the temperature differential between the DH flow and the surrounding (ambient) ground temperatures. Our analysis shows that the saving in heat losses more than compensates for the additional pumping energy required due to the lower flow temperature (and therefore higher flow rate) through this period.

We have developed a detailed capital cost summary using quotations, industry guideline prices and previous project experience. This is presented alongside annual operating costs, plant replacement cycles and annual maintenance.

It is also noted that the scale of demand on the DH network and the proposed design means that there is spare heat (approximately 3.4MW) available from the EfW plant. We have made allowance in costing and EfW heat interface sizing for taking additional heat from the EfW plant to that which is required for the SW Exeter network. The transmission main exiting the interface substation at the EfW plant has been oversized to facilitate the supply of heat north towards the city centre if loads can be identified, either as a connection to another DH network or directly to additional heat customers. With a potential supply of 7.4MW from the EfW and a maximum of 4MW supply to the DHEC, there is up to 3.4MW of heat available for additional loads.

SECTION 10

APPENDICES

11 APPENDICES

11.1 Appendix A – Planning assessment

Exeter Energy Network – Planning and Environmental Constraints

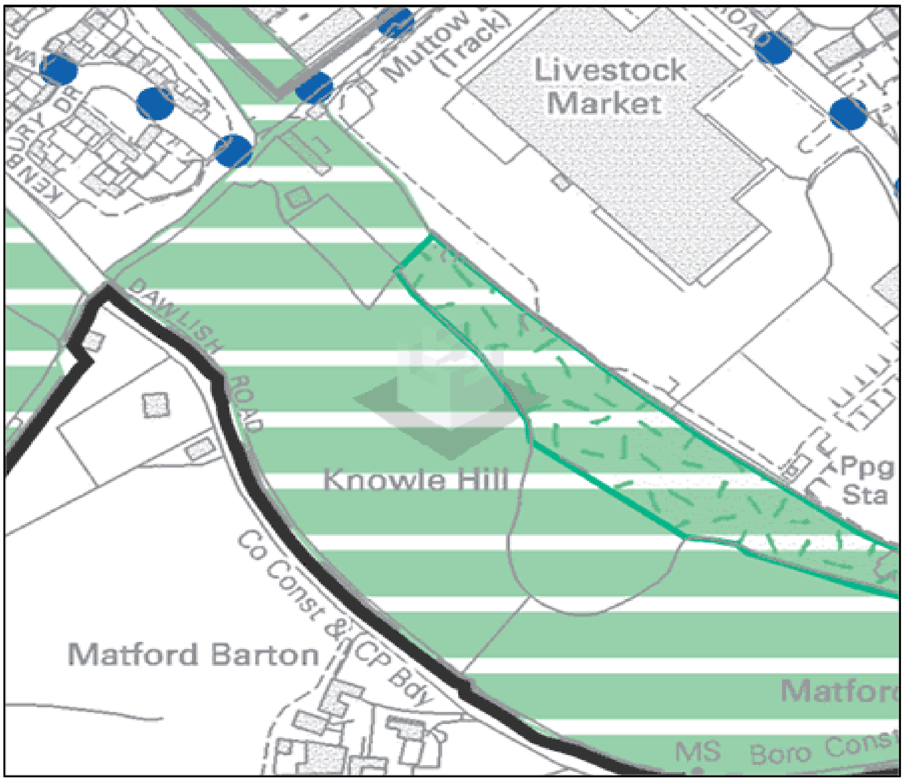
This section provides an overview of the land use planning polices and environmental constraints, which could affect the planning process for developing of an Energy Centre at any of the 3 possible sites.

Livestock Market EC

Planning – Exeter City Local Plan Saved Polices

The following Exeter City Local Plan policies relate to the proposed site:

- T5 - Cycle route running around the north-west corner of the Livestock Market (indicated by the blue dots).
- LS1 – Development which would harm the landscape setting of the city will not be permitted. Proposals should maintain local distinctiveness and character. The area directly to the south of the Livestock Market falls under Policy LSI (indicated by the green stripes).
- LS4 – Development that would harm a site of Nature Conservation Importance or Site of Local Interest for Nature will only be permitted if: the need for the development outweighs the conservation importance or appropriate mitigation is provided. A small area to the south-east of the Livestock Market is designated has having a Local Interest (indicated by the dark green section).



Exeter City Local Plan (Saved Policies T5, LS1 and LS4)

Environmental Constraints

The following environmental constraints have been identified:

- Nitrate Vulnerable Zone
- Woodland BAP (Biodiversity Action Plan) Priority Habitat directly to the south west of the Livestock Market.
- In Flood Zone 3 and on a flood plain.
- Drainage ditch running directly behind the Mutton Lane (Track) 30m north west of the Livestock Market.
- Areas of woodland and dense habitat 40m south of the site.
- Close to residential properties in Alphington approximately 100m to the west of the proposed site.
- Close to designated nature and landscape areas.

Summary

The development of an Energy Centre at the Livestock Market site is likely to have a negative impact on existing landscape and local nature designations. The site is also in close proximity to residential properties, which could be affected by noise and odour generated during operation of the Energy Centre.

The site is well screen by vegetation, but careful design mitigation would be required to minimise the impacts on the landscape and local biodiversity.

The site is within Flood Zone 3 meaning careful consideration would be required for the Energy Centre's Drainage Strategy.

Planning permission would be possible.

Matford Park EC

Planning – Exeter City Local Plan Saved Polices

The following Exeter City Local Plan policies relate to the proposed site:

- E1 – The north-west edge of the site is a designated Employment Site.
- E3 – The loss of employment land or premises will not be permitted where it would harm business or employment opportunities.
- LS1 and T5 explained for the Livestock Market Site above.

Exeter City Local Plan (Saved Policies E1, E3, LS1 and T5)

Environmental Constraints

The following environmental constraints have been identified:

- Nitrate Vulnerable Zone
- In Flood Zone 3 and lies on a flood plain.
- The site is located 100m north west of the River Exe SSSI Impact Risk Zone (note not in SSSI).
- Designated Coastal and Floodplain Grazing Marsh BAP Priority Habitat
- Agricultural land Grade 4.

Summary

The proposed site is designated for employment in the Local Plan. An Energy Centre would support this designation by creating jobs in the local community.

The proposed site does sit within a locally designated landscape area, meaning careful consideration would be required in the design to mitigate any negative impacts. The site is on a low lying flood plain and is overlooked by the Devon Motel and A379. However, work has already begun on developing the site for car showrooms which will dominate the view once built.

The site is in close proximity to the Exe Estuary Special Site of Scientific Interest (SSSI) Impact Zone. Careful consideration of any negative impacts on the SSSI would be required to support any planning submission.

The site is Grade 4 agricultural land, however, the site is already being developed for industrial and retail uses.

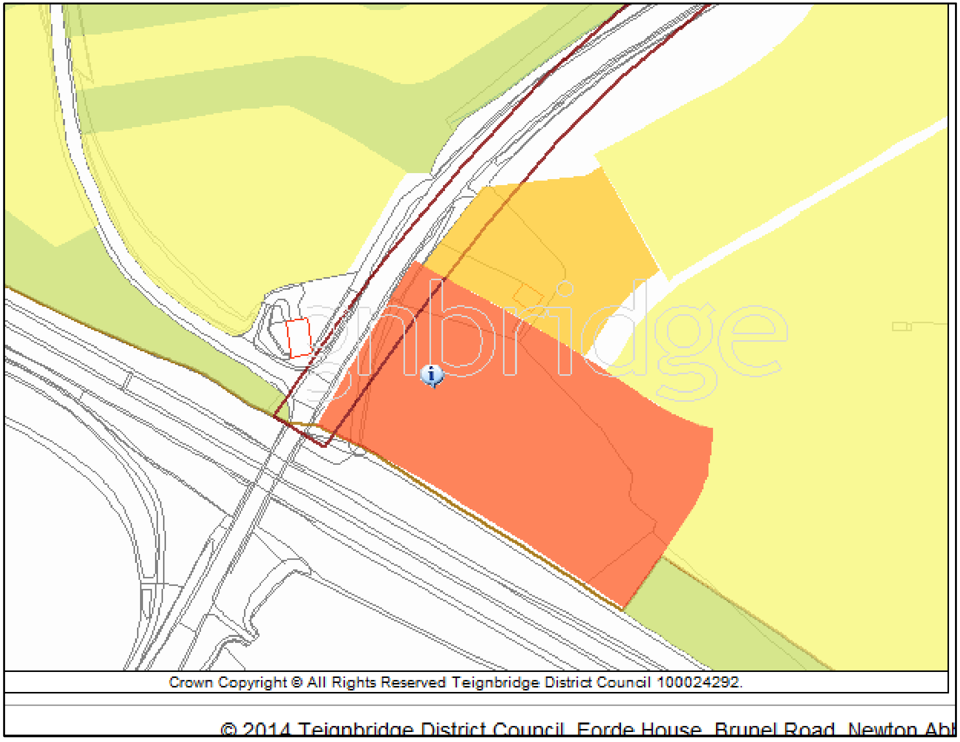
Planning permission would be possible.

School Site EC

Teignbridge District Local Plan (2013 – 2033)

The following Teignbridge District Council Local Plan policies relate to the proposed site:

- Tree Preservation Order (TPO) Group Ref E2/42/09.
- Proposed Draft Retail Class A1.
- Proposed Draft Residential Class C3.
- Designated site for a Park and Ride.



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Teignbridge District Local Plan (2013 – 2033)

Environmental Constraints

The following environmental constraints have been identified:

- Land directly to the south of the A30 is a Designated Scheduled Monument. This is described as an enclosure.
- The habitat has been recognised as suitable for Cirl Bunting. Would require full ecological surveys and cooperation from the RSBP and Natural England.
- No water courses in close proximity.
- Not within a flood zone.

Summary

The site has been identified as a future location for both retail and residential developments. These have not yet been approved by Teignbridge District Council. The site is allocated in the Local Plan for a Park and Ride site. This is encouraging that the Council agree that the site is suitable for development, although the class of development has not been confirmed.

The site is designated within a TPO grouping, meaning careful consideration would need to be given to the existing vegetation and trees on site.

The site is not within a Flood Zone and there are no watercourses within close proximity.

Heritage assessment work would be required to ensure the development does not have a negative impact on the Scheduled Monument designation. This is unlikely as the designation sits on the opposite side of the A30.

Bird surveys would be required due to the presence of Cirl Bunting.

Planning permission would be possible.

11.2 Appendix B – Capital cost breakdown and detailed energy centre building cost

Note that the building costs presented in the second table are included in the capital cost breakdown in the first table (under DHEC building).

Item	Size/specification	Cost	Notes
Preparation of land for heat interface substation		£2,000	Assumption
Heat interface substation weatherproof enclosure		£30,000	Assumption
3 x distribution pumps (duty/duty/standby)	3 x 19 l/s @ 500kPa	£31,608	Armstrong quote for 8000 Series pump. Includes £300 per pump for installation from Spons
Packaged steam interface		£148,665	Skid includes 7.4MW heat exchanger, controls interface, pump to condensate return. Quote from ICI.
Steam pipework including condensate return		£195,470	Quote from ICI. Includes additional 10% installation
Electrical connection		£5,000	Assumed supply from EfW electrical system
Degassing for transmission main		£25,000	Based on Gateshead contractor quotations
Sidetream filter for transmission main		£20,000	Based on Gateshead contractor quotations
Dosing for transmission main		£5,000	Based on Gateshead contractor quotations
Pressursiation/expansion for transmission main		£44,273	TA Hydronics quote
Duplex filter for transmission main		£50,000	Based on Gateshead contractor quotations
3 x gas boilers		£330,000	Based on £20/kW on 16.5MW. Supported by Gateshead installed cost - £235k for 14MW uncommissioned.
3 x gas boiler shunt pumps	3 x 66l/s @ 150kPa	£48,731	Armstrong quote for 8000 Series pump. Includes £300 per pump for installation from Spons
2 x plate heat exchangers	2 x 60% of 4MW	£30,000	Quote from Alfa Laval
2 x heat exchanger shunt pumps	2 x 31 l/s @ 200kPa	£28,054	Armstrong quote for 8000 Series pump. Includes £300 per pump for installation from Spons
4 x DH distribution pumps (duty/duty/duty/standby)	4 * 34.5 l/s @ 500kPa	£59,574	Armstrong quote for 8000 Series pump. Includes £300 per pump for installation from Spons
Heat meters		£15,000	Assumed meters on PHEs and gas boilers at £3k per meter
Flue system		£30,000	3 x boiler flues. Assumed £500/m installed cost from Spons on 600mm flues at 10 metres total height + additional £5k for fittings.
Degassing for distribution main		£25,000	Based on Gateshead contractor quotations
Sidetream filter for distribution main		£20,000	Based on Gateshead contractor quotations
Duplex filter for distribution main		£50,000	Based on Gateshead contractor quotations
Dosing for distribution main		£5,000	Based on Gateshead contractor quotations
Pressursiation/expansion for distribution main		£44,273	TA Hydronics quote
Thermal storage vessels	2 x 150m^3	£240,000	Based on previous supplier quotations
Pipework inside DHEC		£50,000	Assumption supported by Gateshead quotations
Gas sniffer		£10,000	Assumption
Gas connection to DHEC		£50,000	Based on previous project quotations
Water connection to DHEC		£20,000	Assumption
HV interface within DHEC		£120,000	Includes a single transforemer with connection point for back-up generator for resilience
BMS control system		£100,000	Assumption
System commissioning		£25,000	Based on Gateshead contractor quotations
Fittings, furnishings, toilet etc		£20,000	Assumption
Lighting and fire alarm system		£50,000	Assumption
Transmission main installed pipework		£878,764	Excludes future-proofed section allowing additional load connection towards City Centre & soft dig down drainage channel nr DHEC
Future-proofed pipework section		£90,166	Future proofed section to allow additional load connection
Distribution main installed pipework		£3,129,407	Includes double pipe on plot level network and flex pipe dwelling connections for domestic loads
Plot network installed pipework		£13,508,152	
HIUs for 2,446 dwellings		£3,551,036	Includes HIUs, heat meters, flushing bypass, data collection hardware, commissioning. Supplied by Wilson Energy for 2446 dwellings.
Matford Park HIUs		£249,917	
SWE non-domestic HIUs		£65,929	Based on £65/kW from recent non-domestic load connection quotations + 10% for increased resilience.
Building costs		£1,137,900	Developed by QS from architect's drawings
Mechanical design fees @ 5%		£1,144,277	
Electrical design fees @ 5%		£2,750	
DHEC structural design fees @10%		£113,790	
Contingency @ 20%		£5,159,947	
TOTAL SW EXETER DH SCHEME COST		**£30,959,682**	

EXETER ENERGY CENTRE

BUDGET ESTIMATE

ELEMENTAL SUMMARY Gross Internal Floor Area 656 m^2

Element		Cost	£/m2
0	Facilitating works	£ -	£ -
1	Substructure	£ 137,500	£ 210
2.1	Frame	£ 82,000	£ 125
2.2	Upper Floors	£ -	£ -
2.3	Roof	£ 126,300	£ 193
2.4	Stairs and ramps	£ -	£ -
2.5	External walls	£ 141,000	£ 215
2.6	Windows and external doors	£ 130,000	£ 198
2.7	Internal walls and partitions	£ 28,400	£ 43
2.8	Internal doors	£ 7,500	£ 11
3.1	Wall finishes	£ 8,900	£ 14
3.2	Floor finishes	£ 9,300	£ 14
3.3	Ceiling finishes	£ 3,000	£ 5
4	Fittings, furnishings and equipment	£ 1,300	£ 2
5.1	Sanitary installations	£ 900	£ 1
5.2	Services equipment	£ -	£ -
5.3	Disposal installations	£ 600	£ 1
5.4	Water installations	£ 10,000	£ 15
5.5	Heat source	£ -	£ -
5.6	Space heating and air conditioning	£ 55,800	£ 85
5.7	Ventilation	£ 1,600	£ 2
5.8	Electrical installations	£ 98,400	£ 150
5.9	Fuel installations	£ -	£ -
5.10	Lift and conveyor installations	£ -	£ -
5.11	Fire and lightning protection	£ -	£ -
5.12	Communication, security and control systems	£ -	£ -
5.13	Builder's work in connection with services	£ 4,500	£ 7
6	Prefabricated buildings and building units	£ -	£ -
7	Work to existing buildings	£ -	£ -
8.1 - 8.5	External works	£ 14,200	£ 22
8.6	External drainage	£ 21,600	£ 33
8.7	External services	£ -	£ -
8.8	Minor building works and ancillary buildings	£ -	£ -
	Sub-total	**£ 882,800**	**£ 1,346**
9	Preliminaries	£ 163,500	£ 249
10	Main contractor's overheads and profit	included	
	Sub-total	**£ 1,046,300**	**£ 1,595**
11	Project/ design team fees	£ -	£ -
12	Other development/ project costs	£ -	£ -
13	Risks	£ 91,600	£ 140
14	Inflation	£ -	£ -
15	VAT	£ -	£ -
	Total Estimated Construction Cost	**£ 1,137,900**	**£ 1,735**

11.3 Appendix C – DHEC plan, elevation and section drawings

REV	DATE	DESCRIPTION	BY	CHK	APR

PARSONS BRINCKERHOFF

QUEEN VICTORIA HOUSE, REDLAND HILL
BRISTOL, BS6 6US

t: 44 - 117 933 9300
f: 44 - 117 933 9250

Exeter Power

Exeter Energy Centre

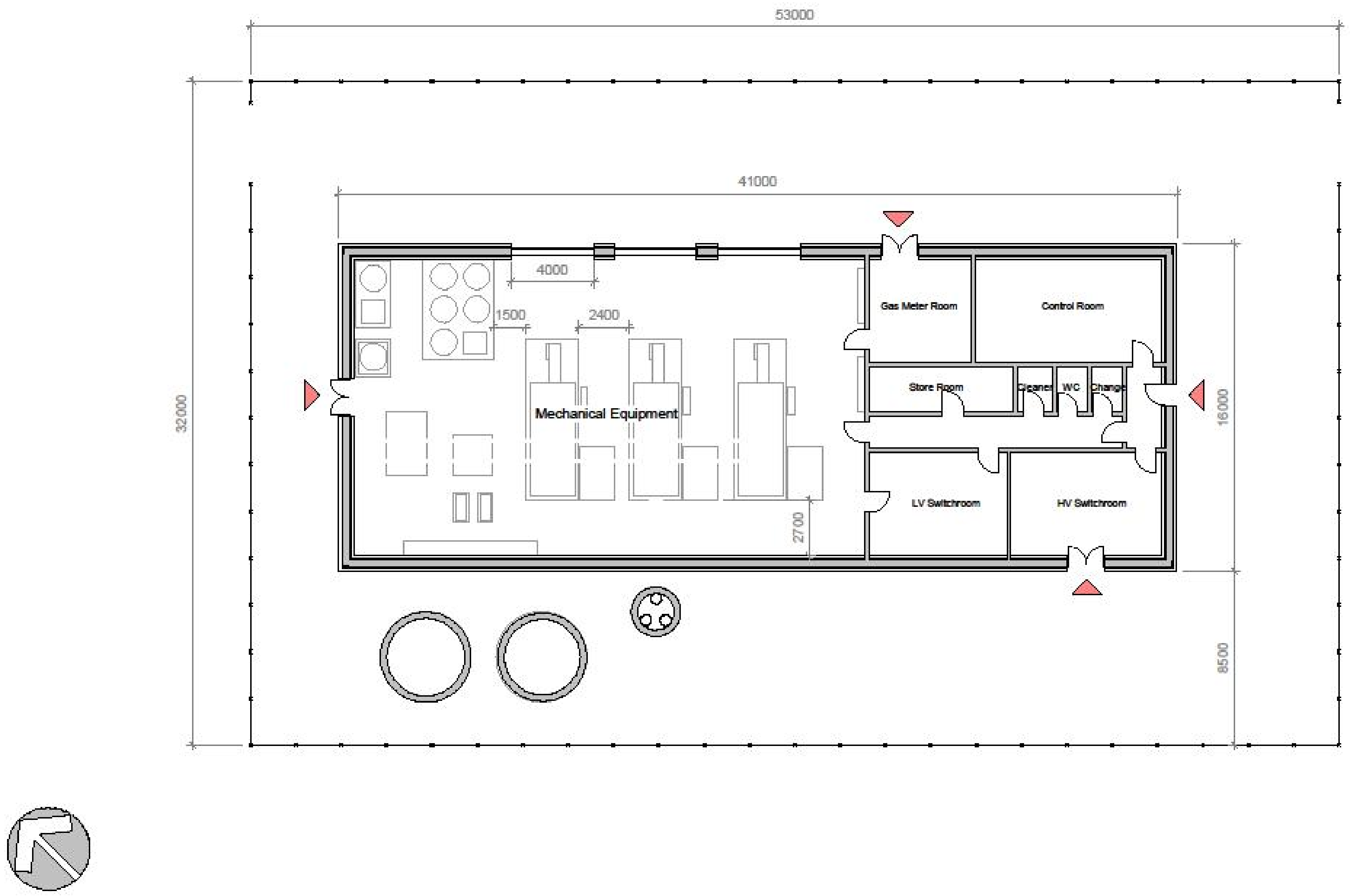
Site Location Plan

DR : DC
CH : MS
AP : Approver
(A3) 1 : 2000
09/10/14

287618A-BEL

A101

NOTE: DO NOT SCALE - REFER TO FIGURED DIMENSIONS - ALL DIMENSIONS ARE NOMINAL & MUST BE CHECKED ON SITE - THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECT'S & ENGINEER'S INFORMATION - ANY DISCREPANCIES SHOULD BE BROUGHT TO THE ATTENTION OF THE AUTHOR



REV	DATE	DESCRIPTION	BY	CHK	APR

PARSONS BRINCKERHOFF
QUEEN VICTORIA HOUSE, REDLAND HILL
BRISTOL, BS6 6US
t: 44 - 117 988 9800
t: 44 - 117 988 9250

Exeter Power

Exeter Energy Centre

Ground Floor Level

DR: DC | CH: MS | AP: Approver | (A3) 1 : 200 | 09/10/14

287618A-BEL

A102

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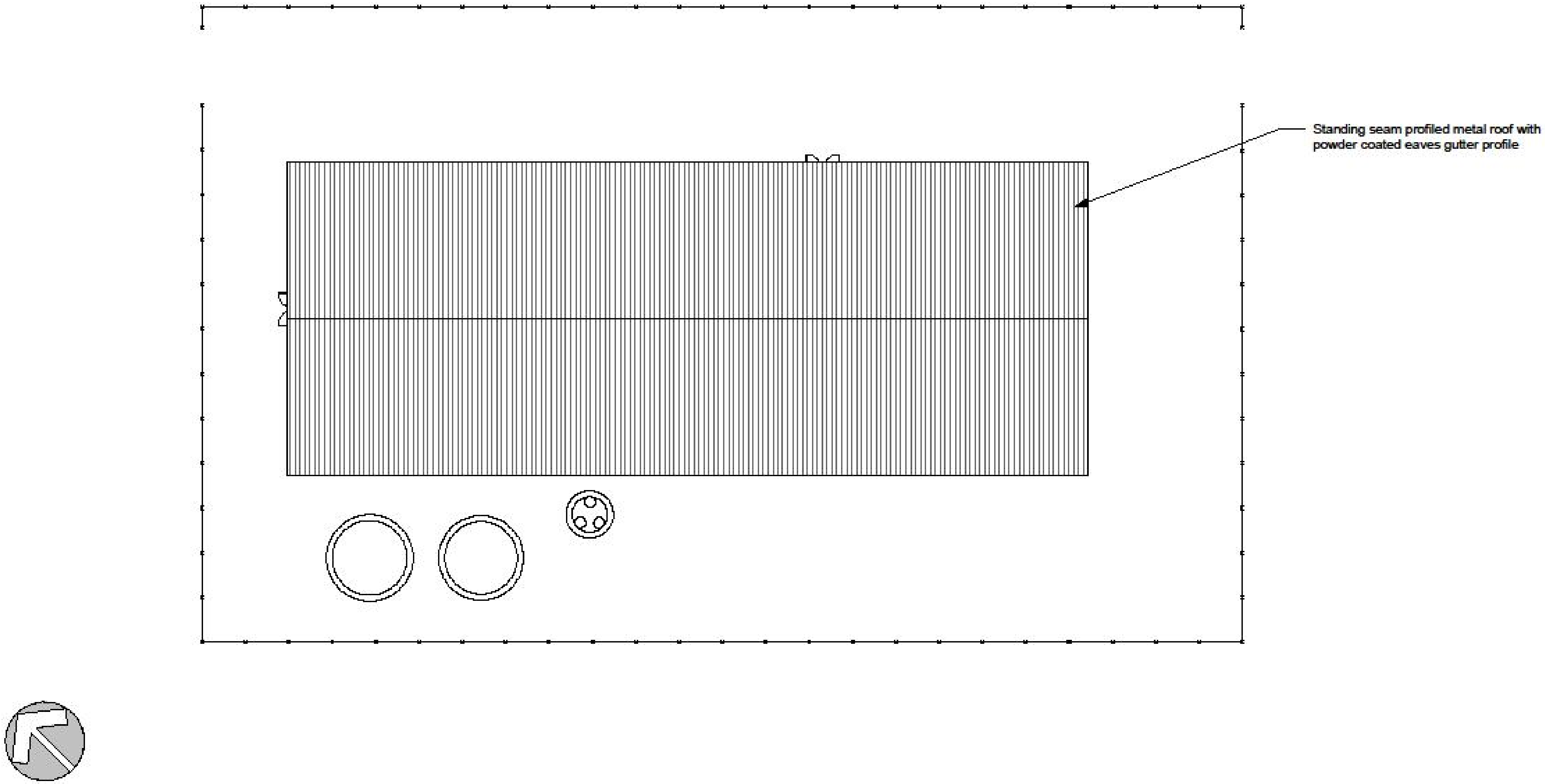

REV	DATE	DESCRIPTION	BY	CHK	APR

PARSONS BRINCKERHOFF

QUEEN VICTORIA HOUSE, REDLAND HILL
BRISTOL, BS6 6US

t: 44 - 117 933 9300
t: 44 - 117 933 9250

Exeter Power

Exeter Energy Centre

Roof Plan

DR: DC
CH: MS
AP: Approver
(A3) 1 : 200
09/10/14

287618A-BEL
A103

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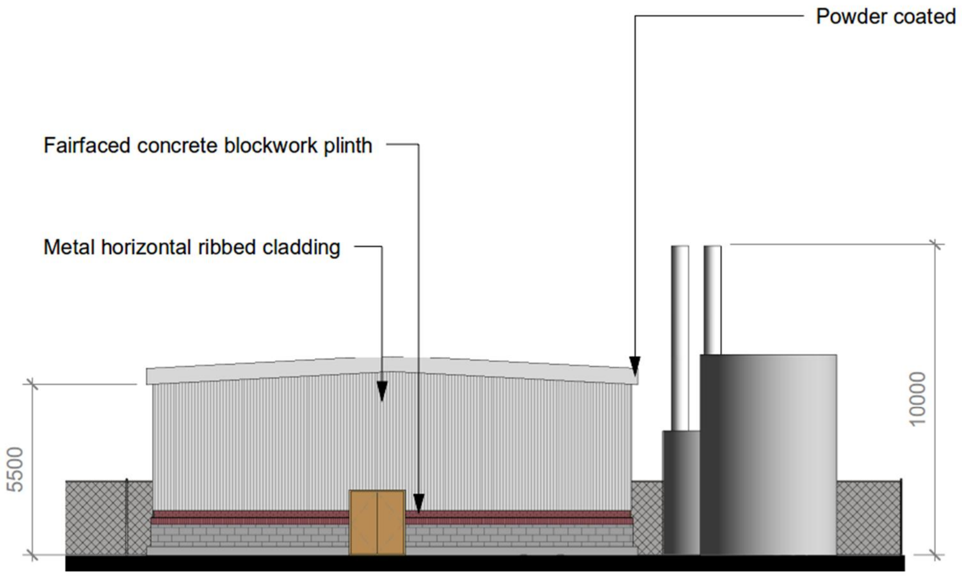

SE Elevation
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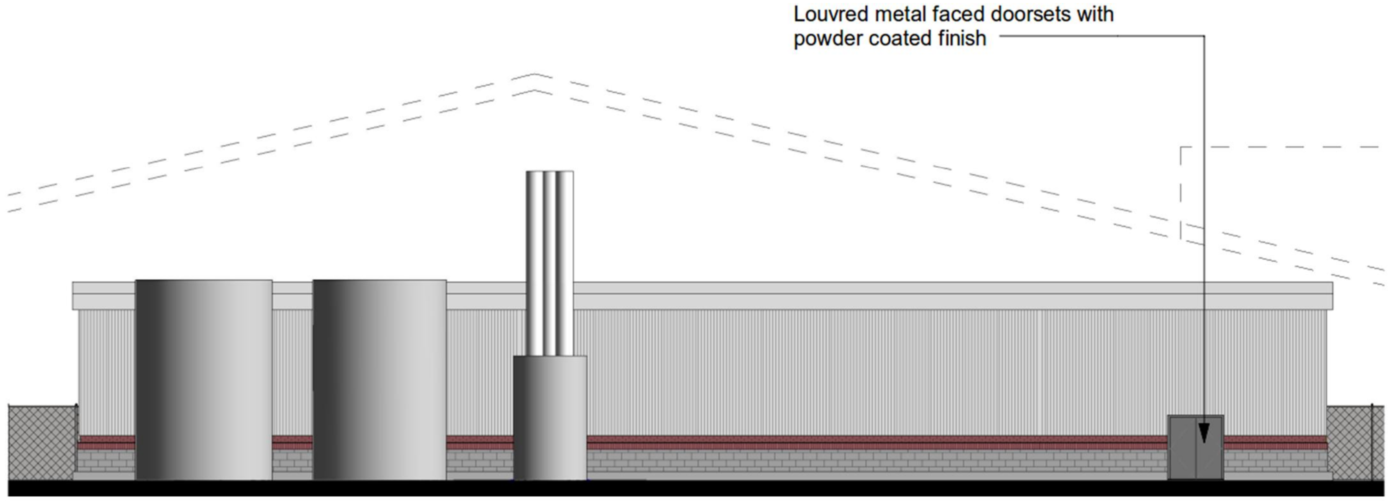

NE Elevation
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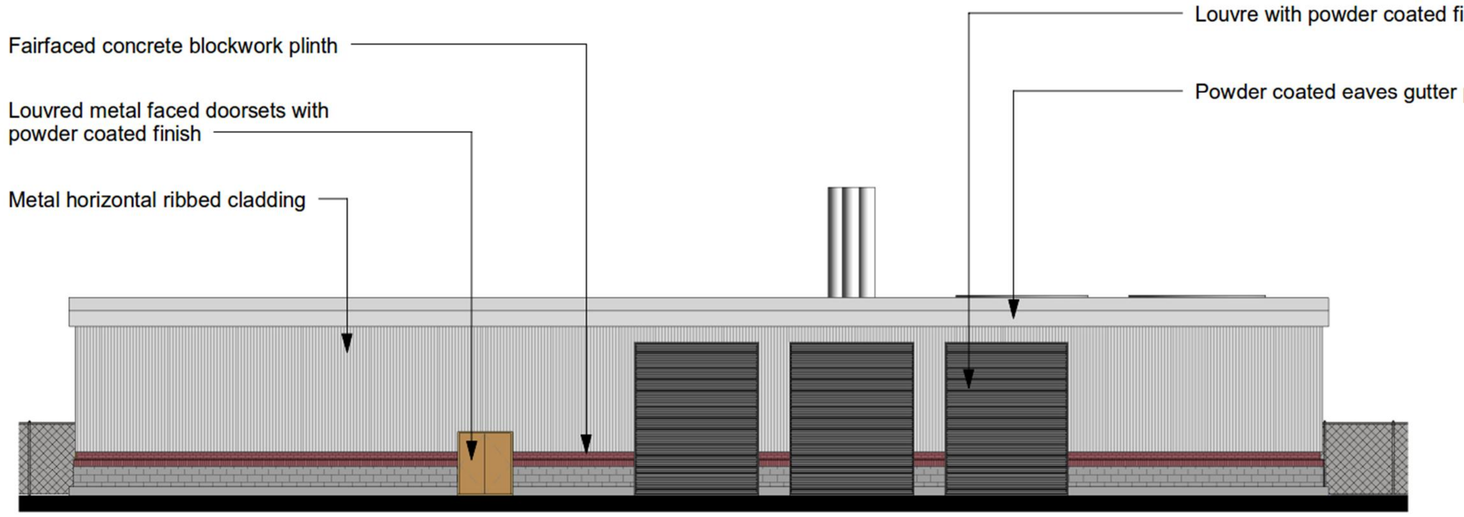

SW Elevation
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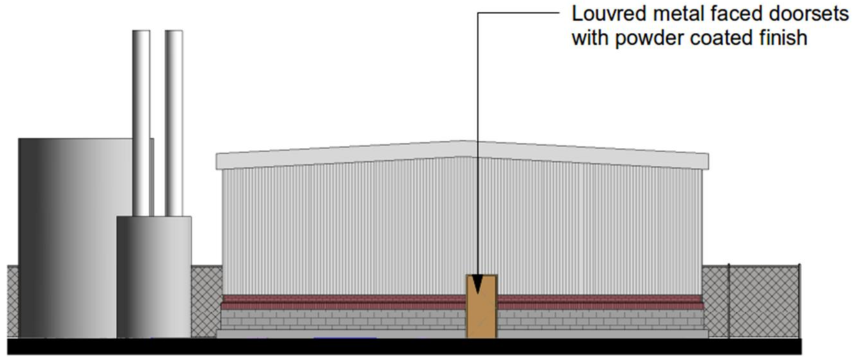

NW Elevation
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REV	DATE	DESCRIPTION	BY	CHK	APR
A	11.12.14	Flue heights updated. Dimensions added	DC		

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BRISTOL, BS6 6US
t: 44 - 117 933 9300
f: 44 - 117 933 9250

Exeter Power

Exeter Energy Centre

Elevations

DR : DC
CH : MS
AP : Approver
(A3) 1 : 200
09/10/14

287618A-BEL
A104
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REV	DATE	DESCRIPTION	BY	CHK	APR

PARSONS
BRINCKERHOFF

QUEEN VICTORIA HOUSE, REDLAND HILL
BRISTOL, BS6 6US

t: 44 - 117 933 9300
t: 44 - 117 933 9250

Exeter Power

Exeter Energy Centre

3D Perspective View

DR: DC | CH: MS | AP: Approver | (A3) | 01/23/07

287618A-BEL | **A105**

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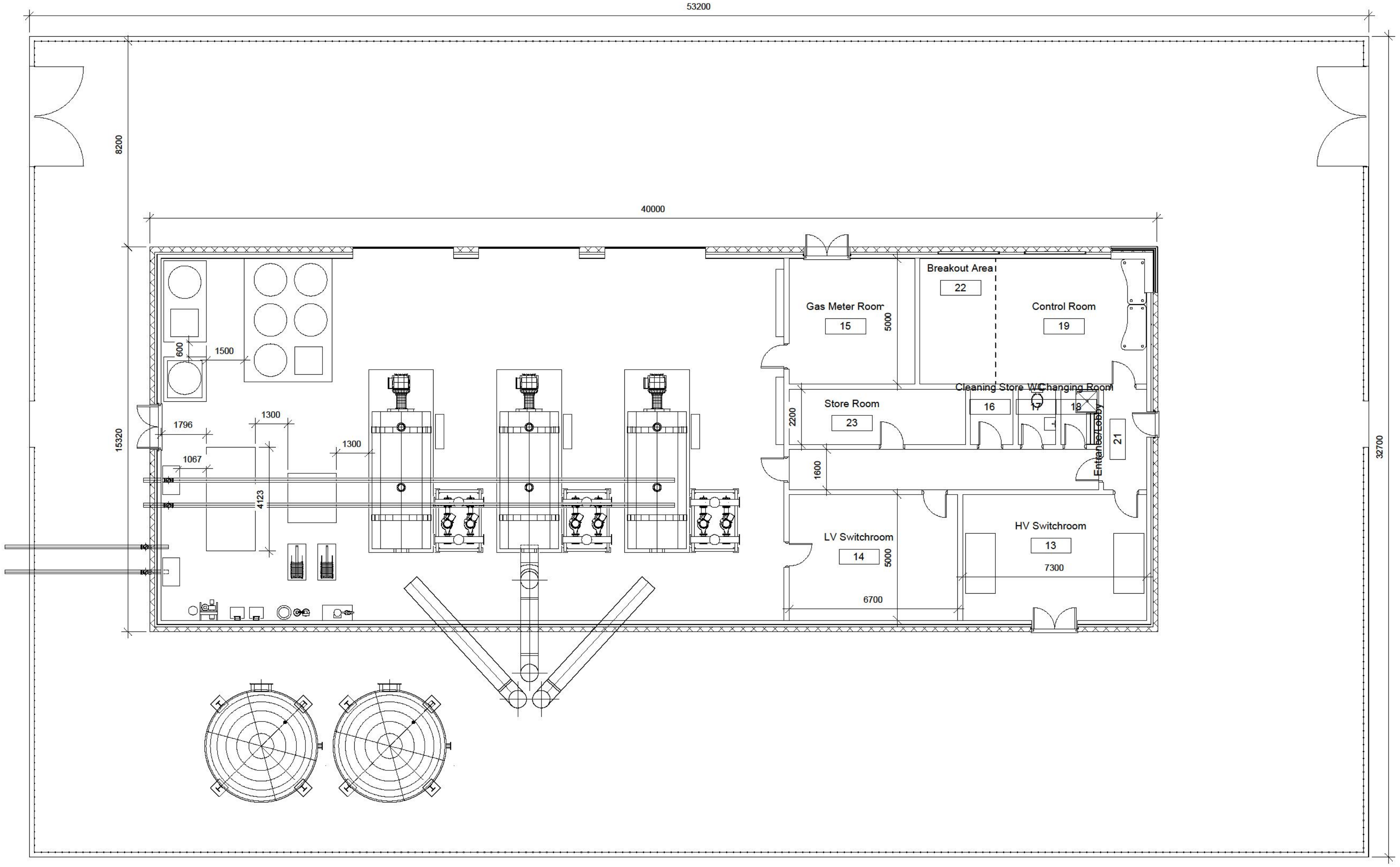
11.4 Appendix D – DHEC layout and schematic



X	XXX	XXX	XXX	XXX	XX.XX.XX
REV.	DETAILS	DRN	CHK	APPR	DATE

CLIENT
Devon County Council

PROJECT
SW Exeter Technical Study

TITLE
Energy Centre
Layout

DATE 17/09/14
SCALE 1:60 @ A0
CAD REF

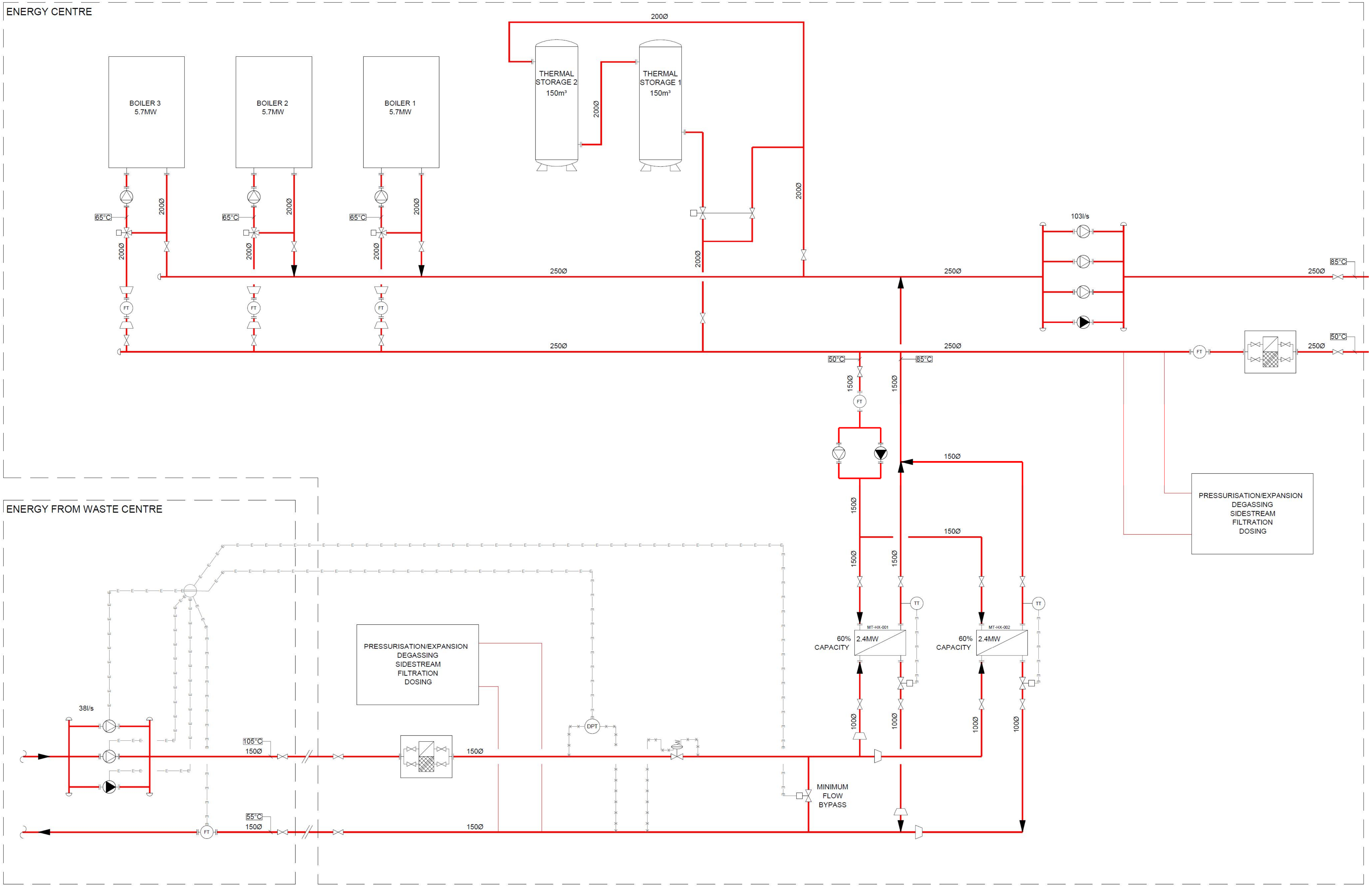
DRAWN BY CMM
PRODUCED BY AJG
CHECKED TM
APPROVED TH

PARSONS BRINCKERHOFF

Energy Solutions

6 Devonshire Square, London EC2M 4YE, UK
Tel: 44-(0)20-7337-1700 Fax: 44-(0)20-7337-1701

DRAWING NUMBER
287618A-BEL-M002 | -


ENERGY CENTRE
BOILER 3
5.7MW
BOILER 2
5.7MW
BOILER 1
5.7MW
THERMAL STORAGE 2
150m³
THERMAL STORAGE 1
150m³
200Ø
200Ø
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65°C
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FT
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85°C
50°C
FT
50°C
85°C
150Ø
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FT
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PRESSURISATION/EXPANSION
DEGASSING
SIDESTREAM
FILTRATION
DOSING
TT
TT
MT-HX-001
60%
CAPACITY
2.4MW
MT-HX-002
60%
CAPACITY
2.4MW
100Ø
100Ø
100Ø
100Ø
MINIMUM
FLOW
BYPASS
ENERGY FROM WASTE CENTRE
38l/s
105°C
150Ø
55°C
150Ø
FT
PRESSURISATION/EXPANSION
DEGASSING
SIDESTREAM
FILTRATION
DOSING
150Ø
150Ø
DPT