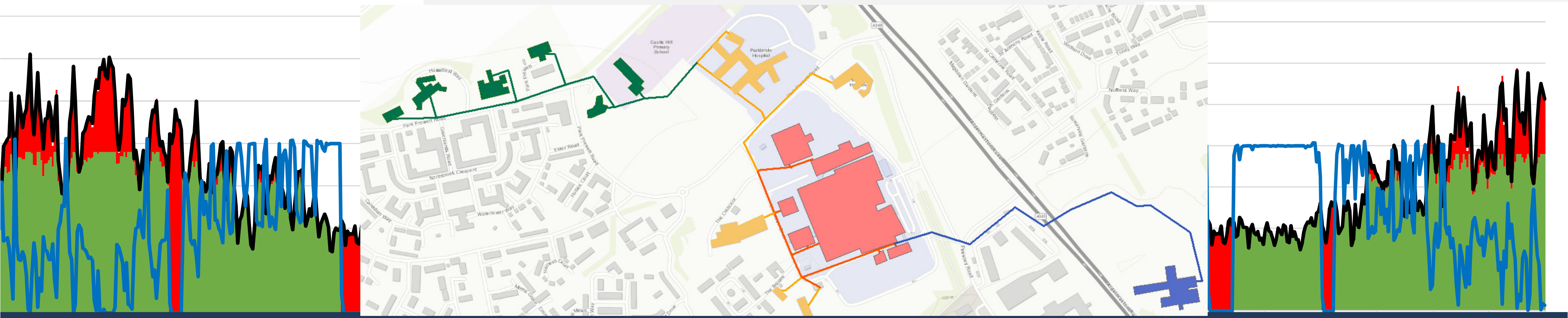

NHH Basingstoke heat network
Heat network feasibility study

Final report

February 2019

ARUP

Document Verification

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Revision	Date		Prepared By	Checked By	Approved By
Draft Feasibility Report Issue	**21/12/2018**	Name	Ewan Frost-Pennington, Kirsty Smyth	Helen Charlick	Thomas Briault
		Signature			Issued in draft under concession
Feasibility Report Issue	**07/02/2019**	Name	Ewan Frost-Pennington, Kirsty Smyth	Helen Charlick	Thomas Briault
		Signature	Kirsty Smyth	HCharlick	Thomas Briault

This report has been prepared specifically for and under the instructions of Basingstoke and Deane Borough Council under an appointment dated October 2018.

This report may be provided to third parties solely to inform any such person that our report has been prepared and to make them aware of its substance but not for the purposes of reliance. No third party is entitled to rely on this report unless and until they and we sign a reliance letter in the form attached to our appointment. We do not in any circumstances accept any responsibility or liability to retail investors whether via bond issue or otherwise and no such party is entitled to relay on this report.

In preparing this report we have relied on information provided by others and we do not accept responsibility for the accuracy of such information.

We emphasise that the forward-looking projections, forecasts, or estimates are based upon interpretations or assessments of available information at the time of writing. The realisation of the prospective financial information is dependent upon the continued validity of the assumptions on which it is based. Actual events frequently do not occur as expected, and the differences may be material. For this reason, we accept no responsibility for the realisation of any projection, forecast, opinion or estimate.

Findings are time-sensitive and relevant only to current conditions at the time of writing. We will not be under any obligation to update the report to address changes in facts or circumstances that occur after the date of our report that might materially affect the contents of the report or any of the conclusions set forth therein.

In preparing this report we have relied on information supplied by others. We have relied in particular on the accuracy and completeness of such information and accept no liability for any error or omission in this report to extent the same results from errors or omissions in the information supplied by others.

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Contents

Glossary of terms

Abbreviation	Full name	Abbreviation	Full name
ASHP	Air Source Heat Pump	HHFT	Hampshire Hospitals Foundation Trust
BAU	Business As Usual	HNDU	Heat Networks Delivery Unit
BDBC	Basingstoke and Deane Borough Council	HNIP	Heat Networks Investment Programme
BEIS	Department for Business, Energy & Industrial Strategy	IRR	Internal Rate of Return
CAPEX	Capital Expenditure	JV	Joint Venture
CHP	Combined Heat and Power	LTHW	Low Temperature Hot Water
CIBSE	Chartered Institute of Building Services Engineers	MCPD	Medium Combustion Plant Directive
CP1	Code of Practice 1 (for heat networks)	MW, kW	Megawatt, kilowatt (units of electrical or thermal power)
DBOM	Design, Build, Operate and Maintain	MWh, kWh	Megawatt-hour, kilowatt-hour (units of electrical or thermal energy)
DPD	Detailed Project Development	NHH	North Hampshire Hospital
EC	Energy Centre	NPV	Net Present Value
EfW	Energy from Waste	OPEX	Operational Expenditure
EGS	Engineered Geothermal System	PW	Private Wire
ESCo	Energy Services Company	REPEX	Replacement Expenditure
GIFA	Gross Internal Floor Area	RHI	Renewable Heat Incentive
GIS	Geographic Information Systems	RFI	Request for Information
GPR	Ground Penetration Radar	SPV	Special Purpose Vehicles
GSHP	Ground Source Heat Pump		

Table 1: Glossary of abbreviations used throughout this report

Executive summary

Arup was appointed by Basingstoke and Deane Borough Council to undertake a feasibility study for the development of a District Heating (DH) network around North Hampshire Hospital (NHH) in Basingstoke. This study was partly funded by the Heat Networks Delivery Unit (HNDU) and Hampshire Hospitals Foundation Trust.

This report provides a detailed analysis of the route, options and economic performance of an optimised scheme. It follows the heat networks code of practice 1 (CP1).

A heat network presents significant opportunities to save carbon emissions, now and in the future, and provides financial savings for the hospital under a number of the scenarios.

Encraft report

A heat network mapping and masterplanning report was prepared for Basingstoke and Deane Borough Council by Encraft in 2017. This report concluded that the area surrounding NHH represented one of the most interesting opportunities for heat network development in Basingstoke. The report recommended that the hospital cluster would be suitable for gas-fired combined heat and power (CHP) or for biomass boilers.

Report aims

We have evaluated the following key considerations:

1. Which heat source is most suitable for the network?
2. Which buildings are favourable to connect to the network?
3. Where is the optimal location for the energy centre for a heat network?
4. How can the scheme be delivered?

Scenarios were developed and modelled to establish a scheme for the site that addresses these considerations.

Figure 1 below displays the network route and buildings considered for connection in each scenario.

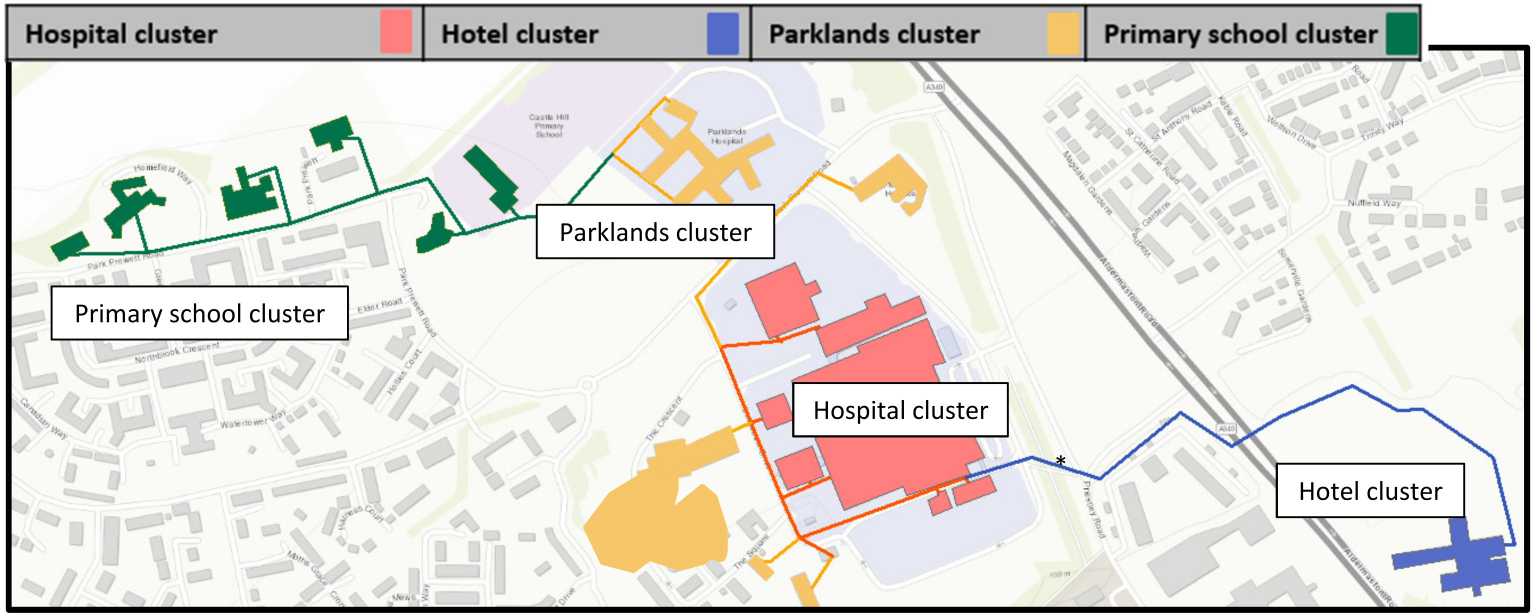


Figure 1: The core scenarios and their proposed routing

Executive summary

Demand

- The hospital is the main heat and electrical load of the network, using 60% of the heat demand just within the main building. The hospital is currently heated by three oversized boilers, they previously had a gas CHP. They also have two steam boilers which have been excluded from this study at the hospital's request.
- Cooling was also excluded from the study because it was considered insignificant in comparison to the heating loads.

Heat source

- We recommend gas CHP, for this network in the short term. Biomass is more expensive and takes up more space. Biomass has therefore been ruled out as an option for this network, although the associated carbon savings are higher (see figure 3).
- In terms of low carbon options, we recommend a transition to heat pumps in 15-20 years when the hospital has retrofitted insulation and larger radiators.

Network size

- The most economically viable network size is the hospital cluster alone. As is often the case, adding further pipework reduces the viability of the network, however the hospital is the only viable anchor load for this network and without it Basingstoke is unlikely to have a significant heat network at this time.
- Adding the Hotel and Parklands clusters is an economically viable wider network option (IRR = 6.4%) depending on the appetite of the stakeholders to connect.

Energy centre location

- The main hospital plantroom is very hot and crowded, there is limited space to install a gas CHP and thermal stores.
- A new dedicated Energy Centre (EC) in ECA – by the water tanks would allow flexibility to change technology in the future, and is closer to connections with Manydown and the Basingstoke Leisure Park developments (see figure 1.2.1).

Economic performance

- A heat network here could represent approximately 27,000tCO_2e reduction over 40 years and cost savings for the hospital and the wider community.
- Any wider network, is reliant on the hospital as the key anchor heat load.

Commercial delivery

- There are three basic models with the potential to deliver the scheme which all have their pros and cons. The most attractive to the council was concluded to be either council led or joint venture (JV) with the hospital.

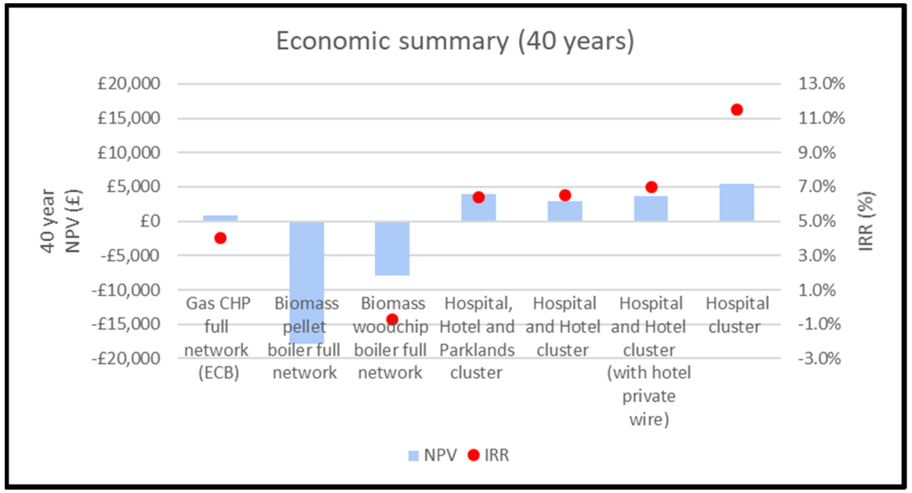


Figure 2: Economic summary of the scenarios tested in the report

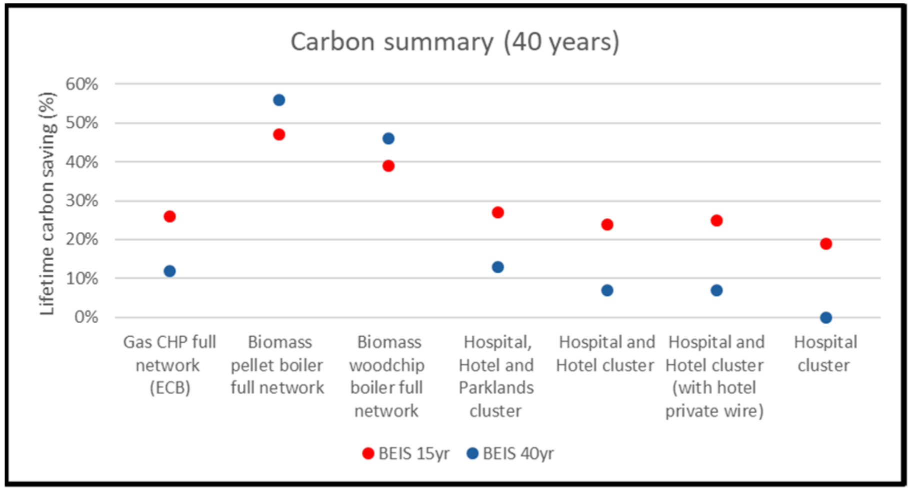


Figure 3: Carbon summary of the scenarios tested in the report

Executive summary

Future decarbonisation

The key options for future decarbonisation are ground source heat pumps (GSHPs) to the west of the Parklands Hospital, or connection to the energy from waste (EfW) from Chineham.

Recommendations

Figure 4 shows the extent of the route recommended in this study for heat network and PW sale of electricity around NHH.

The cost of the scheme is £11.4million, which includes:

- Network capex of £4.2m
- Plant capex of £1.3m
- Connection capex of £261k
- EC capex of £831k
- Project costs and optimism bias of £4.2m

It is recommended that the hospital embark on a programme of temperature reduction wherever possible, particularly with regards to return temperatures. Not only will this open up other opportunities to the hospital, but it will improve efficiency of the heating system with immediate effect.

Other considerations

All presented figures (in figures 2 and 3) are compared to a counterfactual that consists of the hospital and other buildings continuing to operate gas boilers rather than replacing their existing CHP and operating the scheme with the existing network.

Although scenario 8 is profitable it would be significantly more so if the existing heat network could be utilised which would reduce the capital expenditure (capex) by £2.9million and result in a higher IRR (Internal Rate of Return).

There are a number of funding options that could allow the hospital to fund this scheme to realise significant savings. However the hospital would have to work with their legacy asbestos pipework issues and this has not been fully costed in this study.

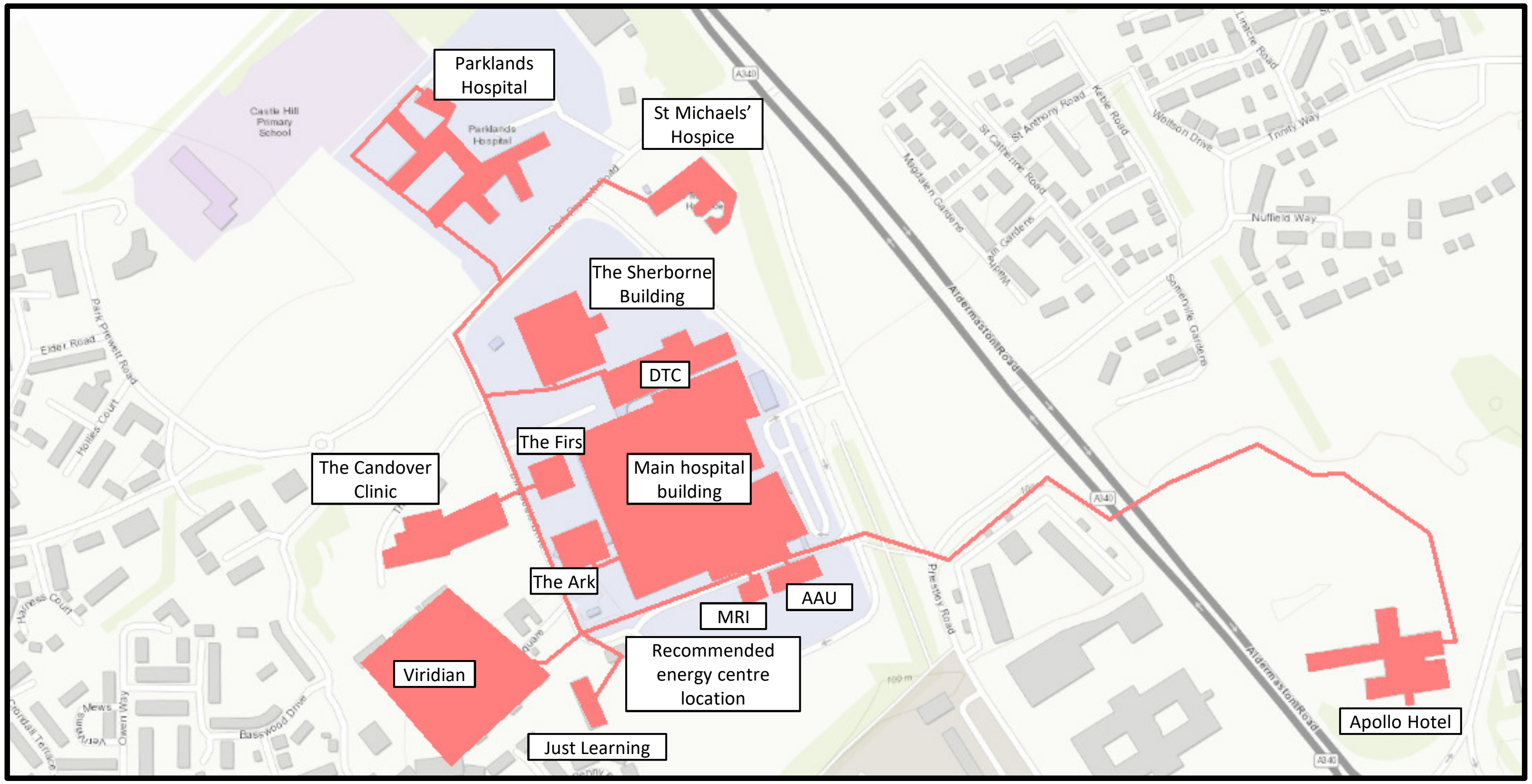


Figure 4: Recommended extent of heat network

ARUP

Executive summary

Sensitivity testing

The economic case remains relatively resilient to the other sensitivities tested including CAPEX 20% increase, operational expenditure (OPEX) 10% increase and 20% reduced heat demand. The main vulnerability is large heat losses.

Next steps

There are a number of key decisions to be made before the scheme can be progressed to final feasibility and business case.

We recommend that the council work closely with the hospital to review the findings and recommendations of this report to inform their course of action before taking forward the development of a potential heat network.

Should they wish to proceed, the critical actions and decision points are:

1. Costing of replacing the asbestos pipework, to assess whether this is lower than the £2.9million capex requirements of a heat network scheme.
2. Further stakeholder engagement with the Apollo Hotel, Parklands and St Michael’s Hospice to gauge their appetite.
3. Apply for HNDU funding and procure advice to develop the delivery model and outline business case (including financial and legal). This could include procurement support so that there does not need to be a further set of funding applications. The next HNDU round opens April 2019 – to support the delivery of the Detailed Project Development (DPD).
4. Further workshop on commercial structuring

It is recommended that the Department for Business, Energy and Industrial Strategy (BEIS) HNDU DPD Guidance is consulted for these stages. It contains advice and example contracts for the supply of heat and power. A copy can be requested from BEIS.

Project risks

A number of project risks are identified throughout the report, summarised in the conclusion slide of each chapter.

The top risks that will need to be managed are identified in the adjacent table 3.

Risk ref	Key risks	Mitigation
D4	Hospital relocation	As the hospital accounts for the most significant heat load in the area, future relocation of the hospital would significantly alter the heat and electricity demand of the network.
S4	Gas and electrical grid carbon factors changing in the imminent future	It is important to consider the impact of the carbon factors changing, because CHP may not be an attractive carbon saving technology once SAP 10 comes into effect, however a low carbon transition has been considered in this report (see section 2.5)
F2	Capex is too high or too low	This can be mitigated by undertaken more detailed design to fully assess the concept.
F8	Fuel price risks – prices of fuel ever increasing.	Heat tariff linked to gas or biomass price as appropriate to mitigate this
C4	Lower carbon solutions in the future may not come forward	Long term planning for transition from CHP in the future is important for the whole of Basingstoke, this requires an energy strategy for Basingstoke.

Table 3: Top project risks identified during study (full risk tables throughout the report)

1) Annex M – Growth and price assumptions https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017.

Chapter 1 – Demand assessment

Chapter 1 – Demand assessment

1.1 Introduction

Introduction

This chapter covers the demand assessment undertaken for the North Hampshire Hospital Heat Network.

The 2017 Encraft report sets out the various buildings within the hospital area to be included for assessment within a hospital heat network. Heat and electricity data was collated for each of these buildings to assess whether it would be financially viable to connect each of these to a heat network.

The Encraft report concluded that the most financially viable option for a hospital heat network would be one including the main hospital building (A in figure 1.1.1), the Firs (B), the Sherborne Building (G) and the Candover Clinic (S). Due to an expected change in ownership, the Eli Lily and Co. building included in the Encraft report has been omitted from this assessment. The new ownership may provide an opportunity for the heat network to expand in the future. Figure 1.1.1 and table 1.1.1 show the full extent of the buildings included in the heat network analysis and their respective owners.

Our analysis considered areas around the proposed heat network which could provide opportunities for the heat network to grow. An analysis of future expansion and changes in demand in the area are annotated on figure 1.2.1 overleaf. Risks associated with these changes have been captured in the risk register.

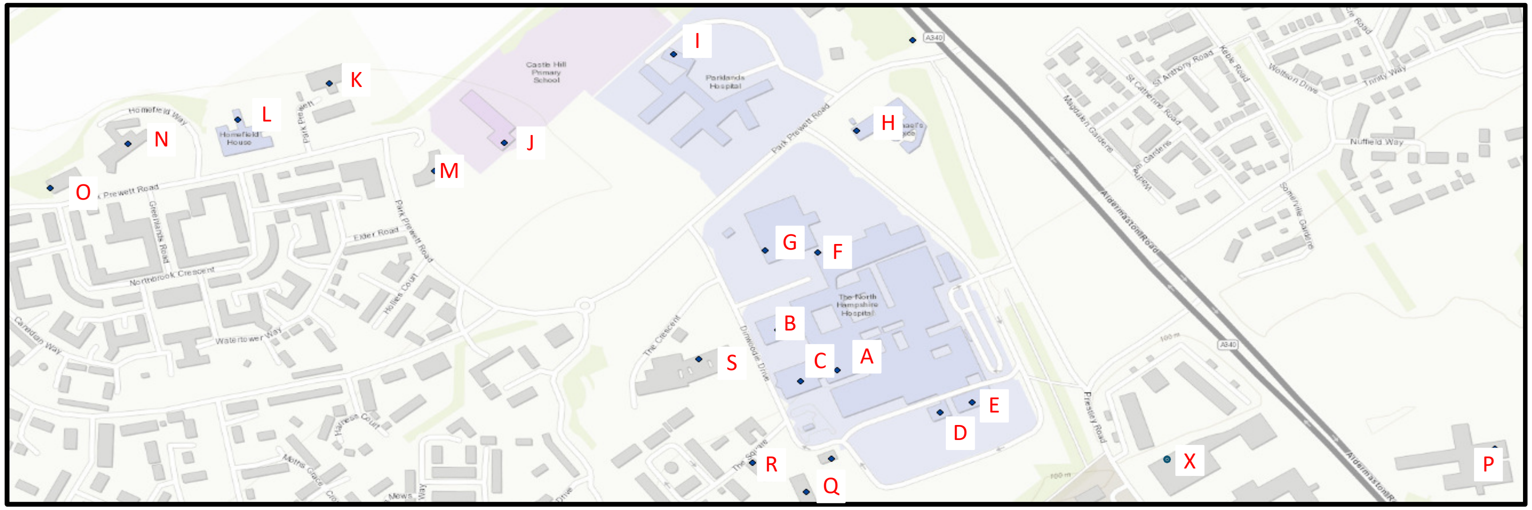


Figure 1.1.1 Map of all the heat loads considered in this report

Ref	Building	Owner	Ref	Building	Owner
A	Main hospital building	HHFT (Hampshire Hospitals Foundation Trust)	K	Firvale	HHFT
B	The Firs	HHFT	L	Homefield House	Shaw healthcare
C	The Ark	HHFT	M	Rooksdown Community Centre	Rooksdown Community Association
D	MRI	HHFT	N	Fairway House	Southern Health NHS Foundation Trust
E	AAU	HHFT	O	Headway Place	Headway Basingstoke
F	DTC	HHFT	P	Apollo Hotel	Private
G	The Sherborne Building	HHFT	Q	Just Learning	Busy Bees
H	St. Michael's Hospice	St Michael's Hospice Basingstoke (charity)	R	Viridian	Optivo Keyworker Housing
I	Parklands Hospital	Southern Health NHS Foundation Trust	S	Candover Clinic	HHFT
J	Castle Hill Primary School	Hampshire Education Authority	X	Eli Lily and Co. (not included in assessment)	

Table 1.1.1 Table of all the heat loads considered in this report

Chapter 1 – Demand assessment

1.2 Future-proofing demand assessment

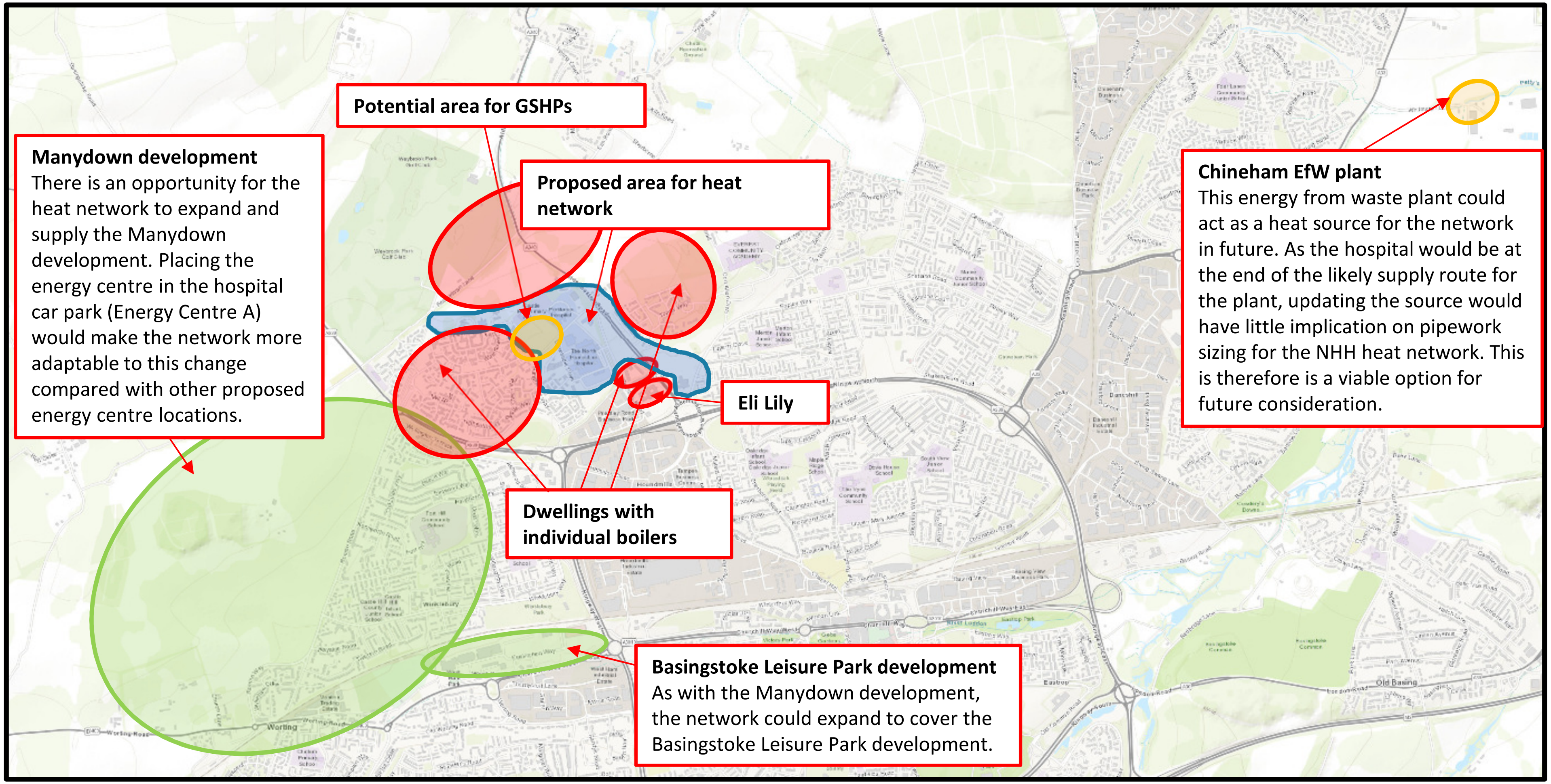


Figure 1.2.1: Showing extent of area considered, with areas that are unlikely to connect in red, proposed network in blue, new developments in green and EfW and GSHP areas in orange

Chapter 1 – Demand assessment

1.3 Demand mapping methodology and summary of results

Methodology

Following identification of the most viable area for the heat network, detailed heat mapping was conducted. The methodology for the assessment of energy demand included the following steps:

- Stakeholders and key contacts were identified and an RFI questionnaire sent to them requesting information on their energy demands.
- In parallel, site visits and plantroom inspections of the proposed heat network buildings were undertaken by Doug Walter, Helen Charlick and Ewan Frost-Pennington on the 30th October 2018.
- Information collected through site visits and RFI responses was used to build demand profiles for each building and inform subsequent connection feasibility assessments. Full notes from the site visit are provided in Appendix A.
- Where gas and electricity data could not be provided from meter readings, Gross Internal Floor Areas (GIFA) were approximated for the buildings concerned and CIBSE TM46 guidance was used to build profiles for each building.

Summary of results

Figures 1.3.1 and 1.3.2 give a visual overview of the heat demands for each building. Table 1.3.1 is the legend for figure 1.3.1.

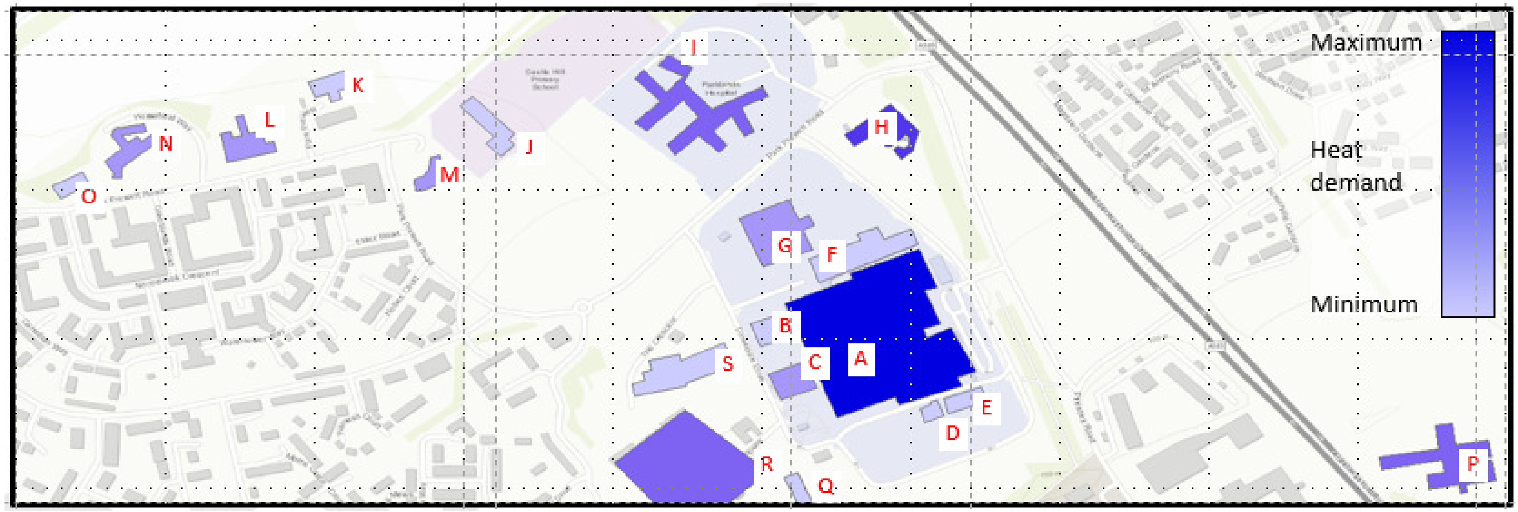


Figure 1.3.1 Visual representation of heat load by building

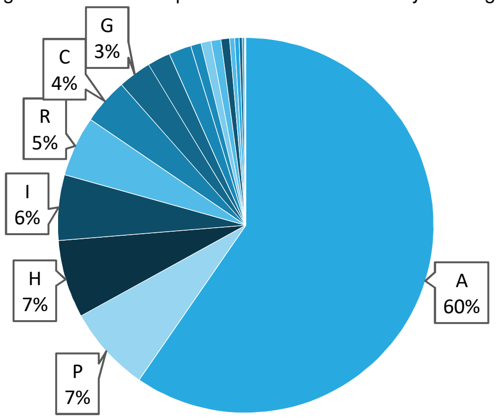


Figure 1.3.2 Visual representation of heat load by building

Ref	Building	Ref	Building
A	Main hospital building	K	Firvale
B	The Firs	L	Homefield House
C	The Ark	M	Rooksdown Community Centre
D	MRI	N	Fairway House
E	AAU	O	Headway Place
F	DTC	P	Apollo Hotel
G	The Sherborne Building	Q	Just Learning
H	St. Michael's Hospice	R	Viridian
I	Parklands Hospital	S	Candover Clinic
J	Castle Hill Primary School		

Table 1.3.1 Heat loads considered in this report

Chapter 1 – Demand assessment

1.4 Hospital heat demand

North Hampshire Hospital

The hospital is fed from three low temperature hot water (LTHW) boiler each of a 5MW capacity shown in figure 1.4.1 in the main building's plantroom. Each of these boilers is 20 years old, but appear to be in good working order. Figure 1.4.2 shows the hospital's current flue. The Sherborne Building plantroom houses a 1MW CHP. This is 20 years old and is no longer operational.

The hospital also has two steam boilers, however the hospital requested that steam was excluded from the study. There will still be small requirements for steam onsite, but these costs are not covered in this study.

2017-18 monthly gas meter data, received from NHH, was used to calculate the total heat demand for each building assuming a current boiler efficiency of 80% for each building. Arup produced hospital heat demand profiles were then used to build profiles for how the heat consumption was distributed hourly over the course of a year (and day) as shown in figures 1.4.3 and 1.4.4 respectively.

As recommended in the CIBSE heat network code of practice to verify that the 2017-18 heat data is representative of an average year, 15.5ºC degree days for the local area were calculated[1] and compared with 20-year degree day averages[2]. These deviated by less than 1% and so it was assumed that this data provides a fair representation of the heat demands overall.

Figure 1.4.1 Hospital LTHW boilers

Figure 1.4.2 Current hospital flue (google images)

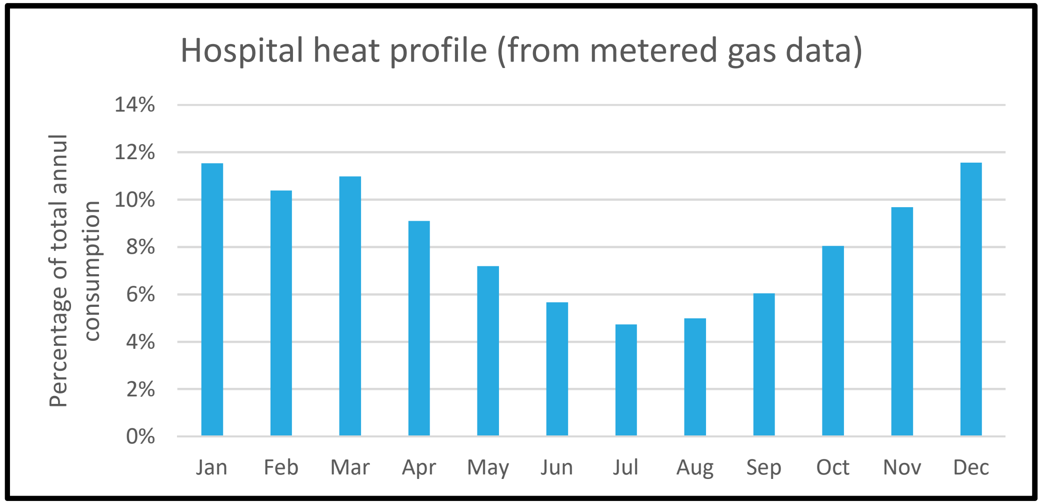


Figure 1.4.3 Hospital monthly heat profile from monthly gas metered data

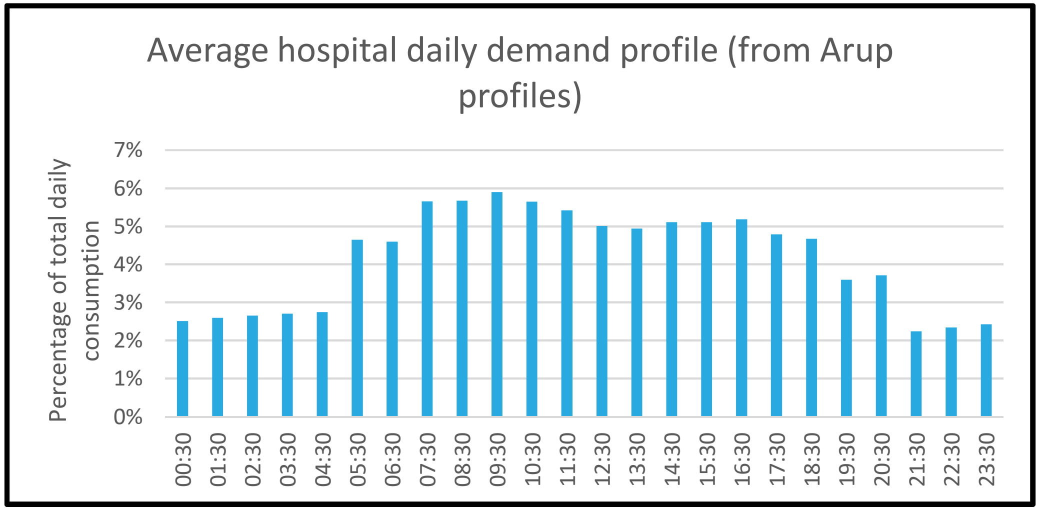


Figure 1.4.4 Hospital daily heat profile using Arup profiles

[1]Degree day data for 2017-18 for Sherborne St John, Basingstoke taken from www.degreedays.net
[2]20 year degree day averages from http://vesma.com/ddd/20year07.htm

Chapter 1 – Demand assessment

1.5 Hospital electricity demand

North Hampshire Hospital

The buildings and facilities shown in figure 1.5.1 are currently fed from the hospital's electrical ring main which is connected to multiple HV substations. This ring main was previously supplemented by the CHP in the Sherborne building which is no longer operating.

The buildings included in the private wiring for the hospital ring main are highlighted in figure 1.3.1. Where these buildings are not owned by the hospital, the hospital bills them for electricity, so there are no costs in terms of wiring or additional billing costs.

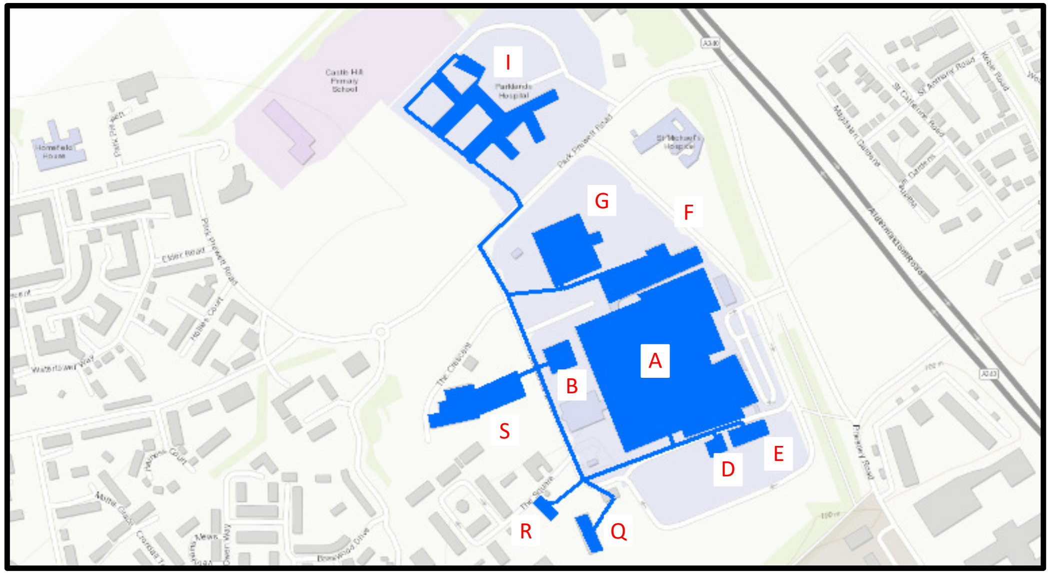


Figure 1.5.1 Buildings currently included in hospital ring main

Ref	Building
A	Main hospital building
B	The Firs
D	MRI
E	AAU
F	DTC
G	The Sherborne Building
I	Parklands Hospital
Q	Just learning
R	Viridian
S	Candover Clinic

Figure 1.5.1 Buildings included in hospital ring main

Chapter 1 – Demand assessment

1.5 Hospital electricity demand

North Hampshire Hospital

Monthly electricity consumption values from 2017-18 were summed and used to apportion a percentage of the main site import to each of these buildings. Applying these percentages to half hourly electricity meter readings received from the hospital for 2017 allowed electricity consumption profiles to be assumed for each of the buildings on the ring main. These profiles are shown in figures 1.5.3 and 1.5.4.

A full methodology for calculating electricity demand for hospital buildings is shown in Appendix B. Assumptions were verified through continued dialogue with the hospital's estates team.

Electricity meter readings for January 2017 were significantly lower than anticipated for that time of year. This was because the hospital CHP went offline at the end of January 2017. Therefore, this month has been replaced with meter reading data from February 2018. Using half hourly meter data where available aligns our data collection method with recommended best practice from CIBSE heat network code of practice.

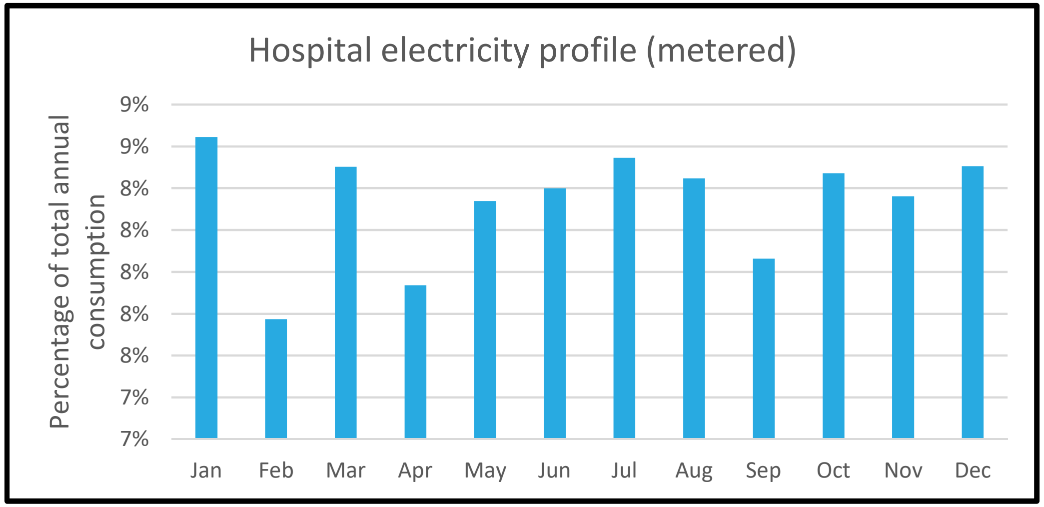


Figure 1.5.3 Hospital monthly electricity profile

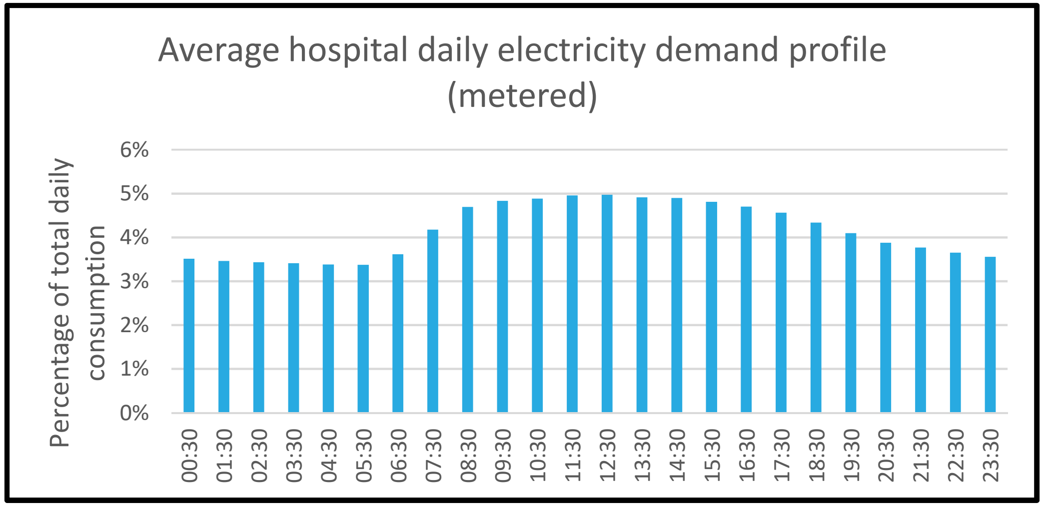


Figure 1.5.4 Hospital daily electricity profile

Chapter 1 – Demand assessment

1.6 Primary school heat and electricity demand

Heat demand

Castle Hill Primary School was built in 2015, with new gas boilers installed at that time. Hourly heat demand profiles were created from half hourly gas meter data received from the school for 2017-18. These profiles are shown in figures 1.6.1 and 1.6.2. The gas values were divided by the efficiency of the boilers installed to convert the gas to heat.

It is not required for the boilers to be replaced for a number of years and this has been accounted for in the assumed connection dates.

The average school daily demand profile shows a high base load energy consumption for the school. This is likely to be due to the heating system being left on overnight.

Electrical demand

Castle Hill Primary School has provided half hourly electricity data for 2017/18. This data was used to the create hourly electricity profiles used in our analysis and shown in figures 1.6.3 and 1.6.4.

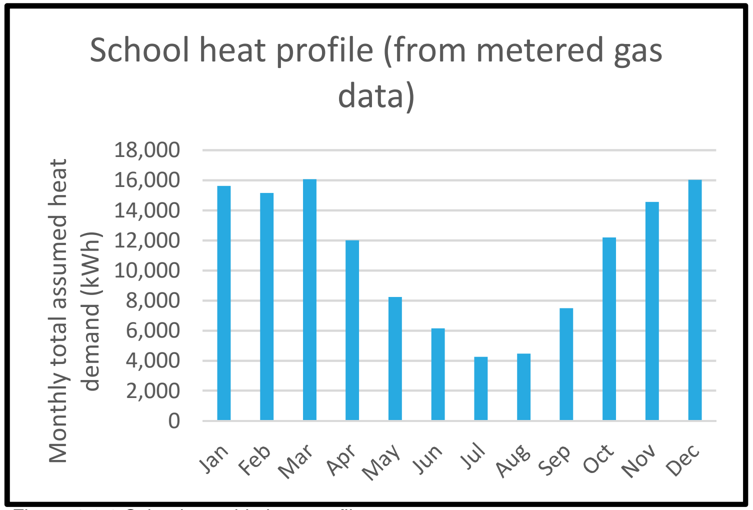


Figure 1.6.1 School monthly heat profile

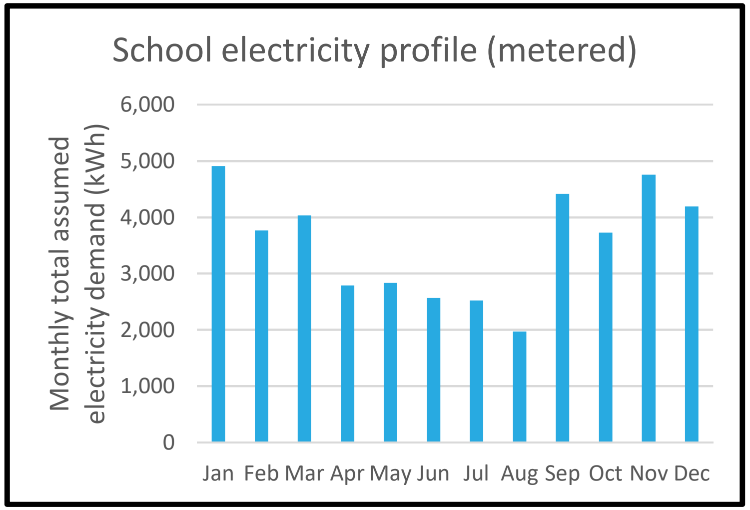


Figure 1.6.3 School monthly electricity profile

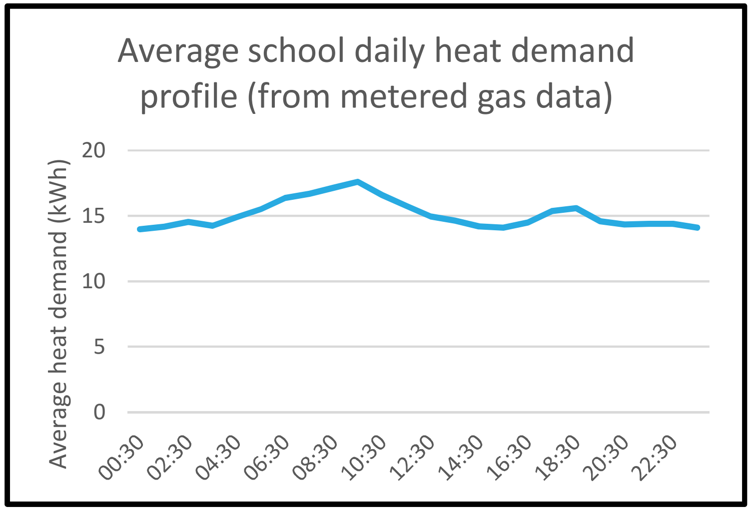


Figure 1.6.2 School daily heat profile

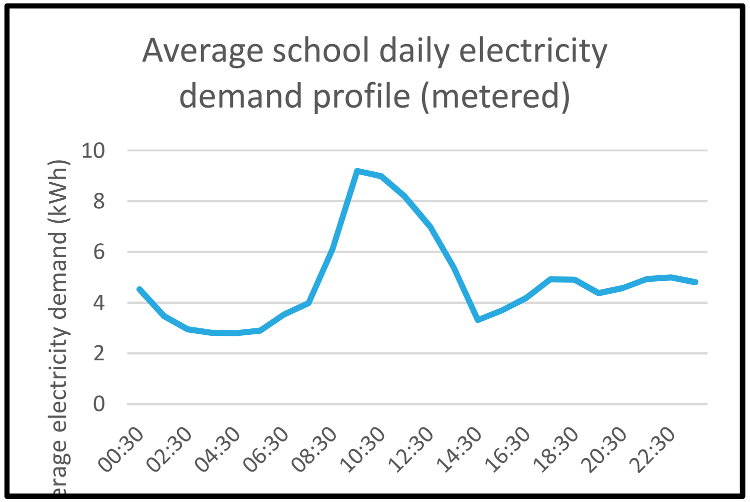


Figure 1.6.4 School daily electricity profile

Chapter 1 – Demand assessment

1.7 Hotel heat and electricity demand

Apollo Hotel

The Apollo Hotel is currently heated by boilers which are nearing the end of their operational lifetime. Including Apollo Hotel in a heat network therefore very much appeals to the hotel manager. The hotel has 132 bedrooms and a swimming pool so makes a good anchor load for the heat network.

Monthly data was received from the hotel for electricity and gas. Arup produced profiles for heat and electricity consumption were used to approximate hourly electricity and gas readings. These are shown in figures 1.7.2 to 1.7.5.

Figure 1.7.1 shows the hotel building fabric and route to be crossed.

Figure 1.7.1 Hotel building fabric and carpark that will need to be crossed

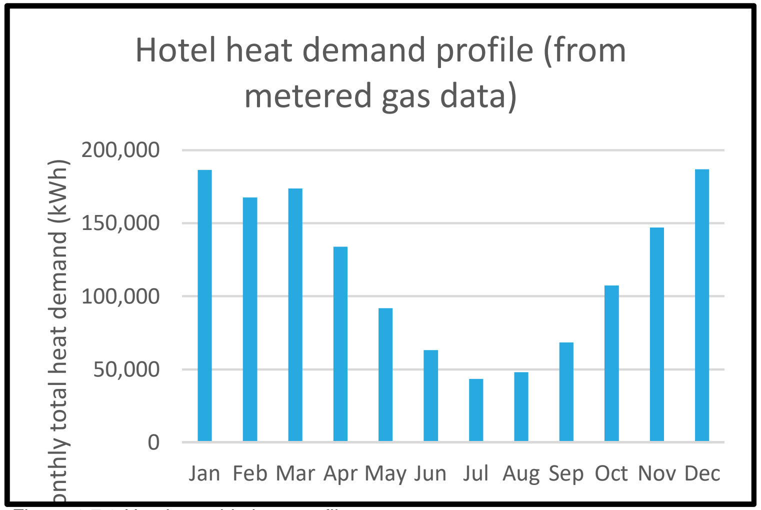


Figure 1.7.2 Hotel monthly heat profile

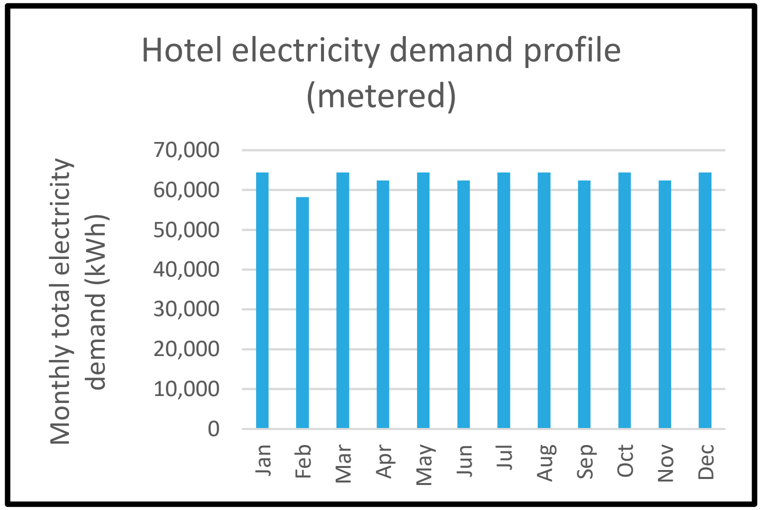


Figure 1.7.4 Hotel monthly electricity profile

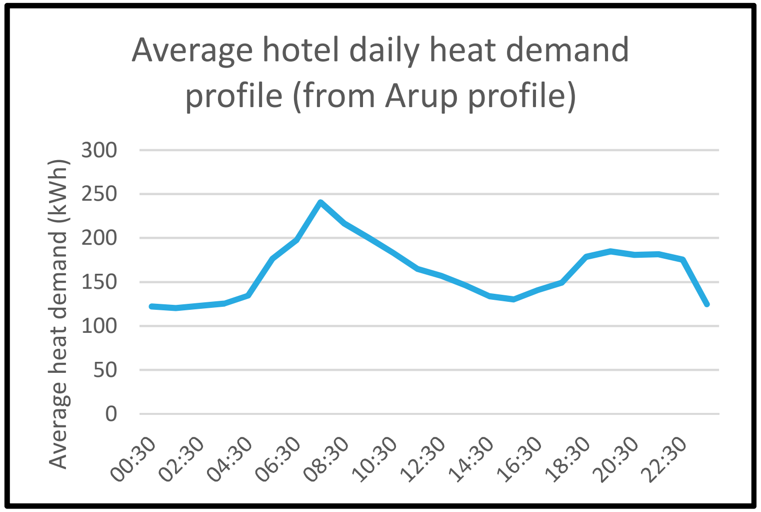


Figure 1.7.3 Hotel daily heat profile

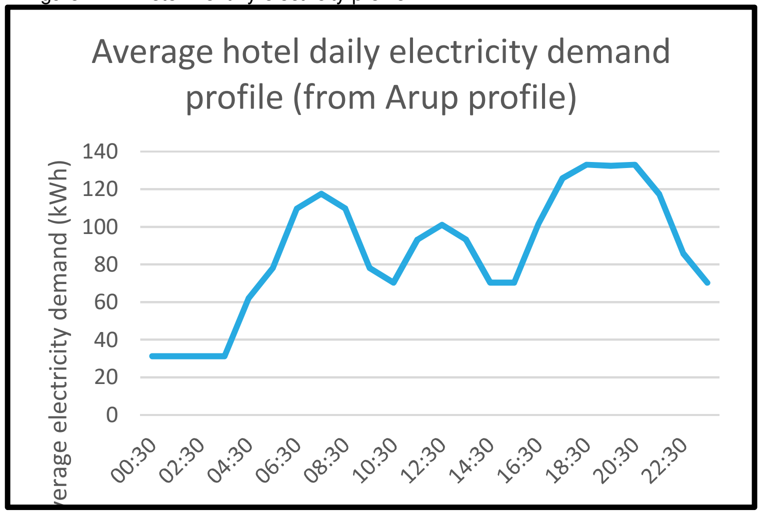


Figure 1.7.5 Hotel daily electricity profile

Chapter 1 – Demand assessment

1.8 Benchmarked heat and electricity demands

For the remaining loads considered, very little or no data was received and we were unable to obtain access for site visits. As a result the following has been assumed or gathered from public data.

For these buildings, CIBSE guide TM46 was used to calculate an assumed annual gas and electricity demand based on a demand value given per unit floor area depending on primary building use. Arup has observed that TM46 can overestimate heat and electricity demands and therefore 10% improvements were assumed for each of these values. For gas demands an 80% efficiency was assumed for converting to heat. The benchmarked assumptions are shown in table 1.8.1.

Appropriate Arup produced profiles were selected for heat and electricity demand and applied to each of the total annual assumed values to create the profiles shown overleaf in figures 1.8.1 to 1.8.4.

		Gas demand					Electricity demand				
Building	GIFA (m²)	Assumed consumption (kWh/m²/year)	Source	Assumed annual consumption (kWh)	After 10% improvements (kWh)	Assumed profile	Assumed consumption (kWh/m²/year)	Source	Assumed annual consumption (kWh)	After 10% improvements (kWh)	Assumed profile
St Michael's Hospice	4,260	420	TM46 – Hospital	1,790,000	1,610,000	Hospital heat profile	90	TM46 - Hospital	383,000	345,000	Hospital electricity profile
Homefield House (heat only)	5,270	Monthly meter readings used with profile created from hospital half hourly data					90	TM46 – Hospital	474,000	427,000	Hospital electricity profile
Rooksdown Community Centre	1,500	150	TM46 – Schools and seasonal public buildings	225,000	203,000	Public building heat profile	40	TM46 -Schools and seasonal public buildings	60,000	54,000	Non-residential electricity profile
The Ark (electricity only)	670	Monthly meter readings used with profile created from hospital half hourly data					95	TM46 – General office	64,000	57,600	Non-residential electricity profile

Table 1.8.1 Benchmarked data

Chapter 1 – Demand assessment

1.8 Benchmarked heat and electricity demands

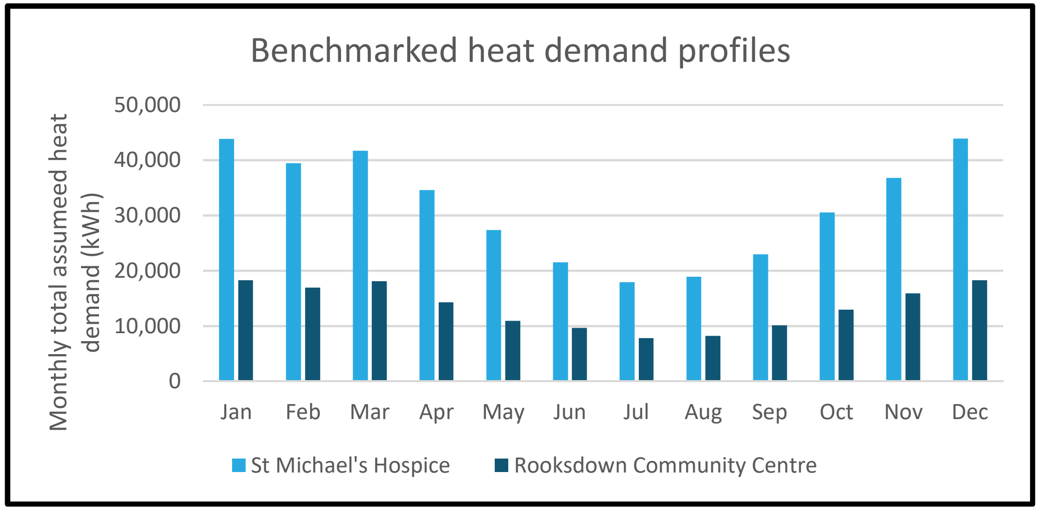


Figure 1.8.1 Benchmarked monthly heat profiles

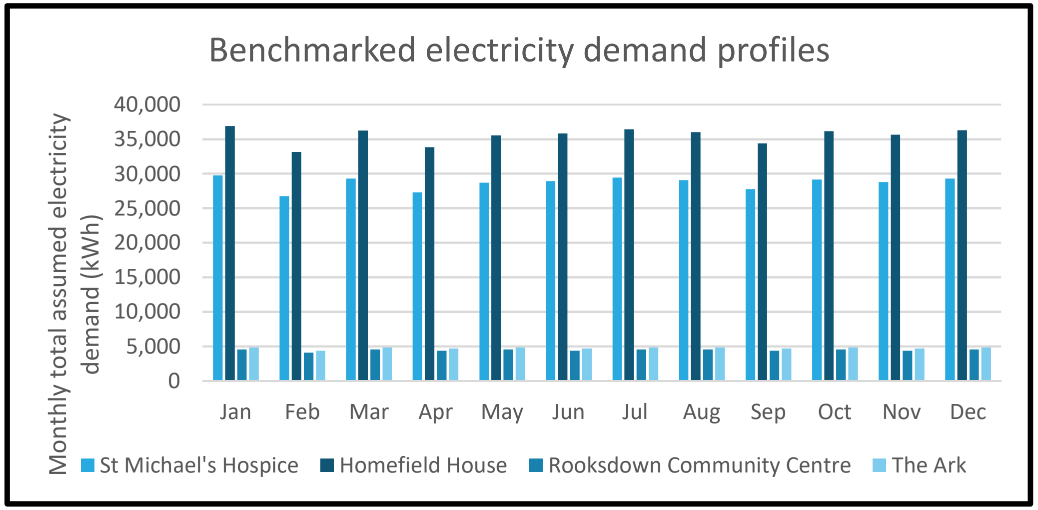


Figure 1.8.3 Benchmarked monthly electricity profiles

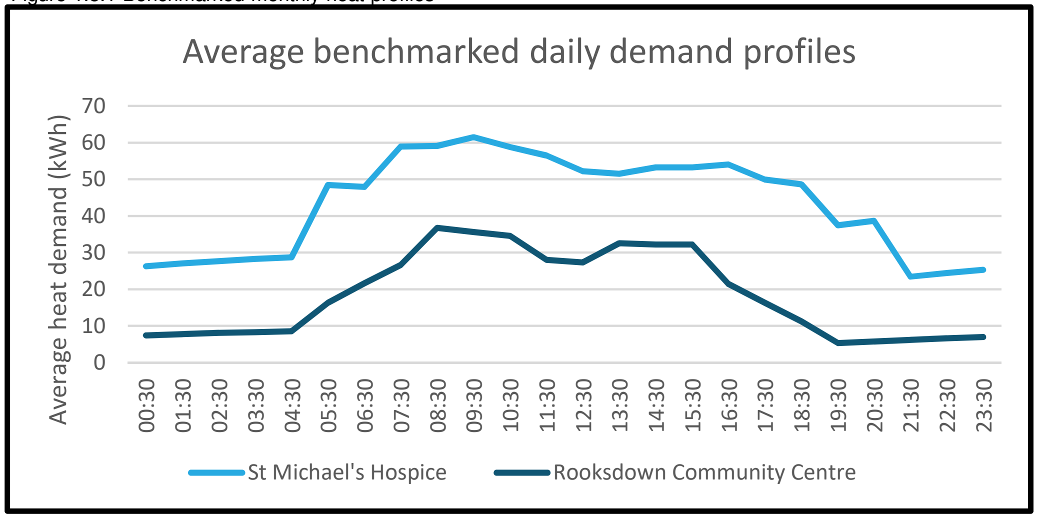


Figure 1.8.2 Benchmarked daily heat profiles

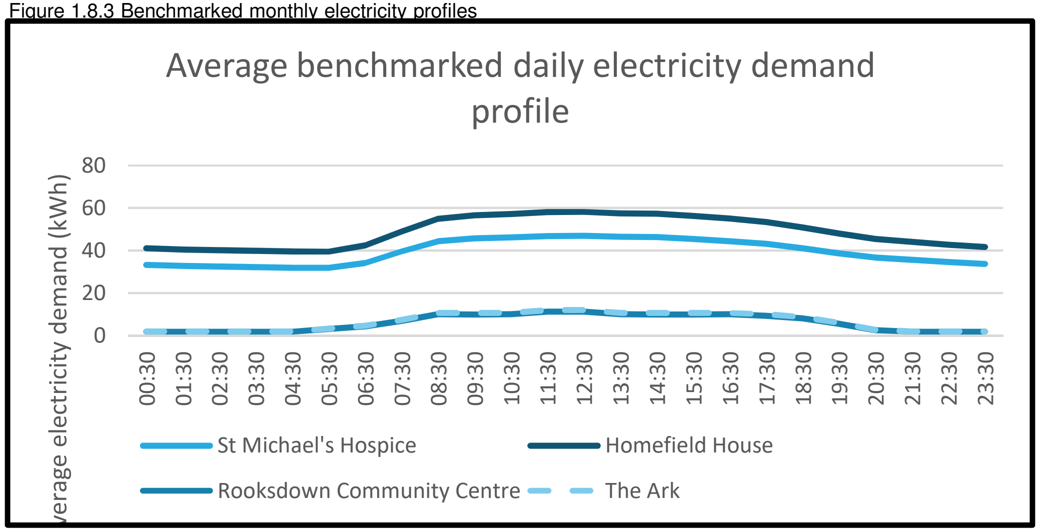


Figure 1.8.4 Benchmarked daily electricity profiles

Chapter 1 – Demand assessment

1.9 Total heat loads

The total assumed annual heat consumption and peak heat requirement for each building is summarised in table 1.9.1. The hospital noted that some of the heat demand peaks are lower than would be expected. This is because the assumed hospital profile was used with the annual meter read. However, the analysis in this study sized the combustion plant based on the maximum peak loads coinciding, thus it is not necessary for the peak load of each individual building to be representative as the overall peak load should be sufficient for the site.

The assumed connection dates for each of these loads were based on information received from the hospital highlighting the life expectancy for each of the boilers. As Apollo Hotel is in imminent need of a new heat supply, it was assumed that this would be connected to the heat network instantly. Due to limited response from St Michael's Hospice and Parklands Hospital, it was assumed that these buildings would take slightly longer to connect to the network. As Castle Hill Primary School has recently been built (2015) and has new boilers, it is anticipated that this would be the last building to connect to the network.

Building reference	Building name	Assumed annual heat consumption (kWh)	Assumed peak heat demand (kW)	Data source	Assumed connection date
A	Hospital main building	11,400,000	3,000	Hospital monthly gas meter readings	01 Jan 2020
B	The Firs	140,000	37	Hospital monthly gas meter readings	01 Jan 2030
C	The Ark	761,000	200	Hospital monthly gas meter readings	01 Jan 2020
D	MRI	167,000	44	Hospital monthly gas meter readings	01 Jan 2020
E	AAU	11,500	3	Hospital monthly gas meter readings	01 Jan 2020
F	DTC	11,400	3	Hospital monthly gas meter readings	01 Jan 2020
G	The Sherborne Building	551,000	145	Hospital monthly gas meter readings	01 Jan 2020
H	St Michael's Hospice	1,290,000	339	Benchmarked	01 Jan 2025
I	Parklands Hospital	1,090,000	286	Hospital monthly gas meter readings	01 Jan 2025
J	Castle Hill Primary	31,700	70	School gas half hourly data	01 Jan 2035
K	Firvale	52,800	14	Hospital monthly gas meter readings	01 Jan 2025
L	Homefield House	380,000	100	Hospital monthly gas meter readings	01 Jan 2025
M	Rooksdown Community Centre	162,000	59	Benchmarked	01 Jan 2030
N	Fairway House	371,000	98	Hospital monthly gas meter readings	01 Jan 2030
O	Headway Place	73,600	19	Hospital monthly gas meter readings	01 Jan 2030
P	Apollo Hotel	1,420,000	482	Hotel monthly gas meter readings	01 Jan 2020
Q	Just Learning	85,000	54	Hospital monthly gas meter readings	01 Jan 2030
R	Viridian	997,000	789	Hospital monthly gas meter readings	01 Jan 2030
S	Candover Clinic	171,000	45	Hospital monthly gas meter readings	01 Jan 2020

Table 1.9.1 Summary of total heat loads

ARUP

Chapter 1 – Demand assessment

1.10 Total electrical loads

The total assumed annual electricity demand and peak electricity consumption for each building is summarised in table 1.10.1. Some of the peak electrical demands are lower than would be expected given the size of building used. Again, this is because of the way that a percentage of the half hourly data was attributed to each building. However, as the analysis in this study sized plant based on the maximum peak loads coinciding, it is not necessary for the peak load of each individual building to be representative as the overall peak load is sufficient for the site.

Building reference	Building name	Assumed annual electricity consumption (kWh)	Assumed peak electricity demand (kW)	Data source
A	Hospital main building	7,730,000	1,290	Hospital half hourly meter readings
B	The Firs	92,100	15	Hospital monthly meter readings
C	The Ark	57,400	12	Benchmarked
D	MRI	326,000	54	Hospital monthly meter readings
E	AAU	135,000	22	Hospital monthly meter readings
F	DTC	687,000	114	Hospital monthly meter readings
G	The Sherborne Building	934,000	155	Hospital monthly meter readings
H	St Michael’s Hospice	345,000	57	Benchmarked
I	Parklands Hospital	828,000	138	Hospital monthly meter readings
J	Castle Hill Primary	12,700	26	School half hourly meter readings
K	Firvale	86,600	14	Hospital monthly meter readings
L	Homefield House	427,000	71	Benchmarked
M	Rooksdown Community Centre	53,900	11	Benchmarked
N	Fairway House	4,070	1	Hospital monthly meter readings
O	Headway Place	17,200	3	Hospital monthly meter readings
P	Apollo Hotel	759,000	133	Hotel monthly meter readings
Q	Just Learning	31,800	5	Hospital monthly meter readings
R	Viridian	394,000	65	Hospital monthly meter readings
S	Candover Clinic	833,000	139	Hospital monthly meter readings

Table 1.10.1 Summary of total electricity loads

Chapter 1 – Demand assessment

1.11 Demand assessment conclusions

Energy data

- Metered heating and electrical demand data was used where provided. Half hourly meter readings were provided by North Hampshire Hospital (for electricity to the main incomer) and by Castle Hill Primary School for electricity and gas. For other hospital building electricity demands, monthly meter readings were used and a demand profile built from the main building electricity supply applied. For hospital heat assumptions, monthly gas meter readings were used.
- Apollo Hotel provided monthly meter readings. A standard hotel profile was assumed using Arup experience of heating and electrical demands.
- Other demands and profiles were assumed using CIBSE benchmarks and guidelines.

Existing buildings

- All existing buildings included in the scope were assessed to be technically feasible for connection to the DH. The Eli Lily and Co. building has not been included in this analysis due to an expected change in ownership.

Soft market testing

- The stakeholders for the North Hampshire Trust buildings, Castle Hill Primary School and the Apollo Hotel were all engaged in the process to gather data and expressed initial interested in finding out more about connecting to the scheme as it develops.
- The stakeholders for the remainder of buildings that represent 17% of the heat load did not respond to our requests or engage with the study.

New developments

- Manydown, see figure 1.2.1, is not progressed enough to be considered with this scheme. If in the future a heat network is considered to be the right strategy for Manydown, we would recommend that connection between the two sites was considered. The same applies to Basingstoke Leisure Park. Advice for these other local developments in given in Appendix C.

Energy mapping

- Heating and electrical load maps were created in GIS for subsequent use in developing the heat network concept route and design and completing the techno-economic analysis.

Risk register

- Table 1.11.1 shows the risks associated with the energy demand assumptions underpinning the analysis. A full risk register is available in Appendix E.

Risk ref	Risk title	Description	Mitigation
D1	Risk of connections not materialising	Lack of engagement from potential building operators	Designing model to only consider options that will financially incentivise building connections Secure key stakeholders through continuous engagement
D2	Risk of lower heat demand than expected	Incorrect assumptions related to the heat demand. Renovations to buildings reducing their energy demand.	We have used actual data wherever possible and informed benchmarks in situations when this is not the case. Understanding the future plans of stakeholders for their buildings
D3	Hospital extending (or relocating) into Eli Lilly building	There is a risk of the hospital demand being significantly higher than expected if the hospital extends into the current Eli Lilly building.	Establishing and maintaining good communication with key stakeholders in the local area. Performing sensitivity analysis on the model results so that the resulting design is flexible to changes in the needs of end users
D4	Hospital relocation	As the hospital accounts for the most significant heat load in the area, future relocation of the hospital would significantly alter the heat and electricity demand of the network.	Establishing and maintaining good communication with key stakeholders in the local area. Performing sensitivity analysis on the model results so that the resulting design is flexible to changes in the needs of end users
D5	Phasing/ timing of connections	As majority of buildings are already existing and operational, their renovations or unexpected changes in layouts could cause disruption.	Understanding the future plans of stakeholders for their buildings. If existing energy centres are replaced, ensure replacement is timed such that it doesn't coincide with winter months
D6	Contractual risk	If existing boilers are to stay in the buildings, there is a risk that the infrastructure is installed then the building operator decides not to use the scheme and instead use the boilers.	Careful contract writing to ensure that the ESCo is not exposed to large risk, or the boilers are controlled by the ESCo.
D7	Early replacement of hotel boiler	The Apollo Hotel boilers are currently nearing the end of their lifetime. There is therefore a risk that these may need to be replaced before the heat network is installed.	Establishing and maintaining good communication with Apollo Hotel. Ensuring that Apollo Hotel is included in the first phase of the heat network.

Table 1.11.1 Summary of risks associated with demand

Chapter 2 – Supply and routing options

Chapter 2 – Supply and routing appraisal

2.1 Introduction and methodology

Supply options

This chapter presents the options to supply heat and a routing appraisal for a network at NHH.

There are two potential sites for new energy centres to be built in the vicinity of the proposed heat network. Existing plantrooms in the main hospital building and the Sherborne Building could also be adapted to accommodate new plant. However, this would not be appropriate if the preferred option is for biomass to be used. This is due to the regular deliveries of wood chip or pellet that would be required. It is also not the preferred option of the hospital, who have overheating problems in the room above the main hospital plantroom.

Supply options methodology

On the basis of the energy demands identified in Chapter 1, the appraisal of the supply options was conducted as follows:

- The existing energy centre sites and their capacity for heat provision were assessed during the site visit conducted on 30th October 2018.
- Discussions were held with stakeholders to establish their future plans and willingness to connect to a DH scheme.
- The two potential energy centre locations were also assessed during this site visit.
- A high level appraisal of each energy centre location and technology type was conducted as shown on page 24.
- The plant size required for each technology was calculated using an Arup spacing tool. The required areas were compared with the land available in each of the considered energy centre locations.

The energy centre options, shown in figure 2.1.1, are:

- Energy centre option A – dead space located within hospital car park
- Energy centre option B – ex-laundry site to the north of St Michael's Hospice
- Energy centre option C – use existing plant space in main hospital building and Sherborne Building

Evaluation of the potential route

The feasibility of the scheme is reliant on the connections between the heat supply and heat demands. We have explored different options for a route for the network to take in the area. The most direct route that takes advantage of opportunities to make pipe installation easier (e.g. soft dig at the side of roads) was identified. The results of this informed the pipe lengths and costs in the techno-economic modelling.

This section will discuss the approach of the routing study and introduce the barriers and potential risks that remain on this proposed route.

Routing methodology

The most direct route for the heat network was identified using GIS. The route was chosen because the hospital stated that the left hand side of the drive (as you enter from the rear) currently has no pipework in it, and recommended it for consideration. They also suggested that using the old steam pipework as ducting might be possible, but would need further investigation and survey (especially for asbestos). During the site visit, key points in the route were examined. Utilities drawings provided by the hospital and school were used to identify underground services which might obstruct the proposed route. These are discussed in more detail throughout this section.

Current hospital heat supply route

The current pipework between the main hospital building and the Sherborne building is asbestos coated and not in good condition. The hospital wishes to stop using this pipework, hence their wish to split their current heating circuit into three hydraulically separate circuits. The cost for the removal of this pipework or changes to internal pipework has not been included, although the costs for the three heat exchangers has been considered and included in the study. The heat exchangers for the Sherborne and main hospital building would fit in the current plantrooms, although the hospital may have to remove the old CHP. The position of the heat exchanger for the DTC building would need further consideration, the hospital has suggest placing it above the asbestos pipework, but more consideration needs to be given to the safety and risk around this.

Chapter 2 – Supply and routing appraisal

2.2 Energy centre options appraisal

The energy centre options, shown in Figure 2.1.1, are:

- Energy centre option A (ECA) – dead space located within hospital car park shown in Figure 2.1.2
- Energy centre option B (ECB) – ex-laundry site to the north of St Michael's Hospice shown in Figure 2.1.3
- Energy centre option C (ECC) – use existing plant space in main hospital building, shown in figure 2.1.4.
- We recommend that the CHP is removed from the Sherborne plantroom and this space is utilised for the heat exchanger for the heat network.

Figure 2.1.2 ECA – dead space behind water tank

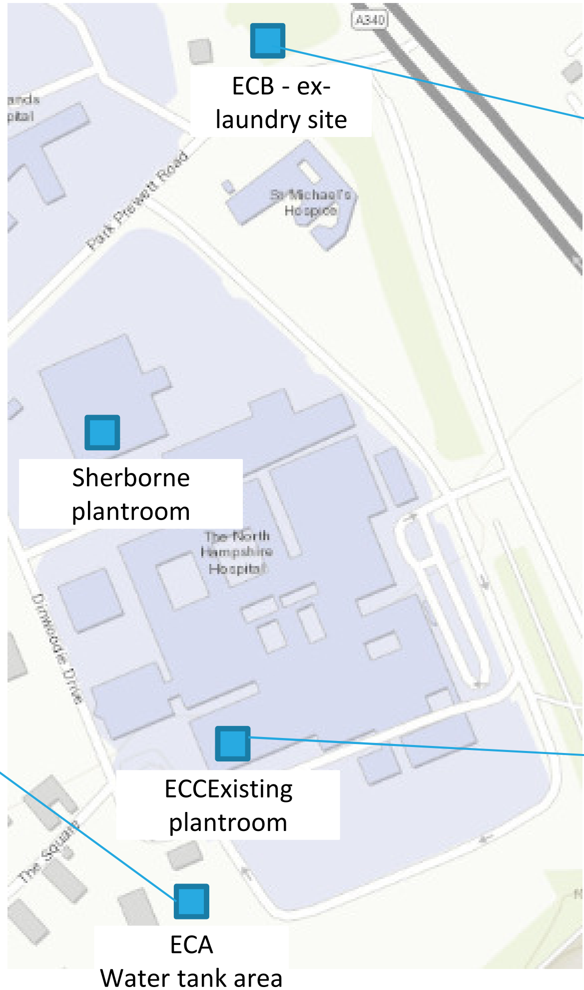


Figure 2.1.1 Site plan with the locations of the existing/proposed ECs

Figure 2.1.3 ECB – ex-laundry site

Figure 2.1.4 ECC – existing hospital plantroom (main building)

Chapter 2 – Supply and routing appraisal

2.2 Energy centre options appraisal

After the site visit, a high level feasibility study was conducted to determine which energy centre location would be suitable for each of the technologies considered. The findings from this exercise are shown in table 2.1.1. These were later developed as shown in the following slides.

	ECA – water tank area	ECB – ex-laundry site	ECC – existing plantroom
CHP	✓	✓	✓
Biomass	✓	✓	X
Benefits	• Shorter pipework routes compared to option B – lower CAPEX • Closer to Manydown development and Basingstoke Leisure Park development (shown in figure 1.2.1) allowing more opportunity for expansion. • Closer to the anchor load than option B.	• Situated away from hospital, so biomass unlikely to impact on hospital air quality • Good road access • 30 meters closer to area for heat pumps shown in figure 1.2.1.	• Makes use of existing plantrooms – lower CAPEX • Closest to the anchor load
Risks	• Poor road access for CHP or biomass delivery, via hospital car park • Space is more expensive to convert than anticipated given the different levels of the current site – the trees need to be removed and some ground works would be required. • Requires new building and flue, which both have significant CAPEX and planning challenges	• Longer pipework lengths will be required (approximately 100m more hard dig length) • Gas connection at site has been decommissioned so would need to be reinstated • Hospital may have other plans for this site given it has better accessibility for a third party user • Requires new building and flue, which both have significant CAPEX and planning challenges.	• Space is likely to be an issue • Boilers will have to be removed – seasonal considerations required for works • Temporary plant would be required, location not certain • Thermal stores would need to be located outside, and there is no available space • CHP would need to come out every 10 years so it would need the same space in front of it as the space for it which is not possible in the current plantroom. • Hospital not keen on hosting within current plantroom • Inflexible for future technologies.

Table 2.1.1 High level energy centre options appraisal

Chapter 2 – Supply and routing appraisal

2.3 Energy centre detailed appraisal

Using results from our modelling, the sizes required for energy centres for the explored technology and phasing scenarios were calculated. The purpose of this exercise was to allow locations that did not have sufficient space to house the required plant to be eliminated from the analysis.

Manufacturers' data and industry guidance was used to collate sizes for the pieces of plant. Access requirements for each piece of equipment were also taken into consideration. The equipment was then arranged in the most space-efficient layout allowing additional space for pumps, pressurisation units, pipework and pipework ancillaries. A 2m walkway was included in each layout.

Layouts were produced for the three primary technologies as summarised in table 2.3.1, taking the full network sizing into account.

Plant has also been sized to consider the lower ceiling heights that will be required if CHP is to be installed in ECC - existing hospital plantrooms. As CHP plant is noisier than gas boilers, we have assumed an acoustic container will be required, and acoustic attenuation may also be required on the exhaust flue to minimise disturbances to office spaces above the plantroom. The gas supply to the current energy centre will need to be brought up to current safety standard, and a plate heat exchanger is required as well to separate the existing hospital secondary circuit from the heat network.

Figures 2.3.1 and 2.3.2 show the space available in each of the two proposed new energy centre locations. Figures 2.3.3 to 2.3.8 (overleaf) show the dimensions required for ECs for each option. For the new EC options (figures 2.3.6 to 2.3.8), the size available in each of the considered areas is highlighted on the layouts to provide a visual overview of the space available.

It can be concluded that CHP, woodchip biomass and pellet biomass would all fit within the size constraints of both ECA water tank area and ECB ex-laundry site. However, installing a woodchip biomass boiler in ECA may require trees to be cut down to accommodate the large woodchip storage facilities and access required. It should also be taken into consideration that ECA would require frequent deliveries through the hospital carpark.

Fitting a 2MW CHP into ECC - existing plantroom would be very complex, and is unlikely to be a suitable option, because:

- The thermal stores would need to be located outside (and there is no space that does not block access ways).
- Access is required to remove the CHP every 10 years, and there is not space to allow for this.
- All the existing plant would need to be removed and the hospital would require a temporary solution for which the position is unclear.

	EC 1 – CHP	EC 2 – woodchip biomass	EC 3 – pellet biomass
Gas boiler	5,400kWth For n+1 resilience	5,400kWth For n+1 resilience	5,400kWth For n+1 resilience
Thermal store	2,500kWh	2,500kWh	2,500kWh
CHP	2,000kWe	N/A	N/A
Biomass	N/A	2,000kWth	2,000kWth
Biomass storage	N/A	100 hours storage CIBSE B	100 hours storage CIBSE B
Other plant	A minimum of 26m^2 has been allowed in each plantroom to accommodate pressurisation units, pumps, mcc, pipework and pipework ancillaries		

Table 2.3.1 Energy centre size plant considerations for full network

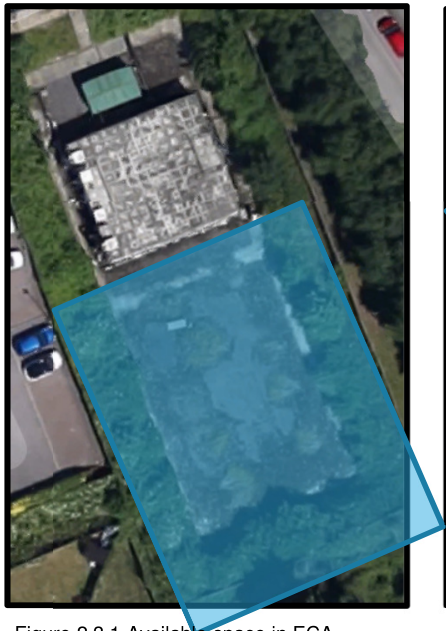


Figure 2.3.1 Available space in ECA – water tank area

Figure 2.3.2 Available space in ECB – ex-laundry site

Chapter 2 – Supply and routing appraisal

2.3 Energy centre detailed appraisal

A detailed analysis was conducted to determine whether the CHP and associated required plant could be accommodated within the existing hospital plantroom.

As shown in figure 2.3.3, the access requirements for the CHP, blue hatched box, when placed over a layout of the existing energy centre show access to be extremely limited, and there is limited space for the thermal stores or ancillary equipment. Due to the dimensions of the CHP required, there is not enough space for the equipment to be moved into the plantroom through the existing door or to be removed for maintenance. A new sliding door would therefore be required as shown in figure 2.3.3.

To determine whether the space available would allow the CHP plant to be removed from the plantroom using this new sliding door, hospital site plans and plantroom drawings were overlaid and the CHP movements required for removal were mapped. This analysis, shown in figure 2.3.4, suggests that there is space for the CHP to be installed and removed. However, figure 2.5.5 shows plant that, if unable to be moved, would stop the CHP from being removed.

Using the existing plantroom would require thermal stores to be placed outside the main plantroom. There are two options for the thermal stores to be placed outside, shown in figure 2.3.3. However, option A would block access to the hospital. Option B would require the area to be cleared. Both of these options mean that for one thermal store to be removed or replaced, the other would also have to be removed.

Using the existing plantroom would also require a temporary energy centre to be installed to supply heat and hot water to the hospital while the current plantroom is stripped out and new plant installed. For these reasons, using the existing plantroom is not recommended.

Figure 2.3.3 CHP in ECC – existing hospital plantroom

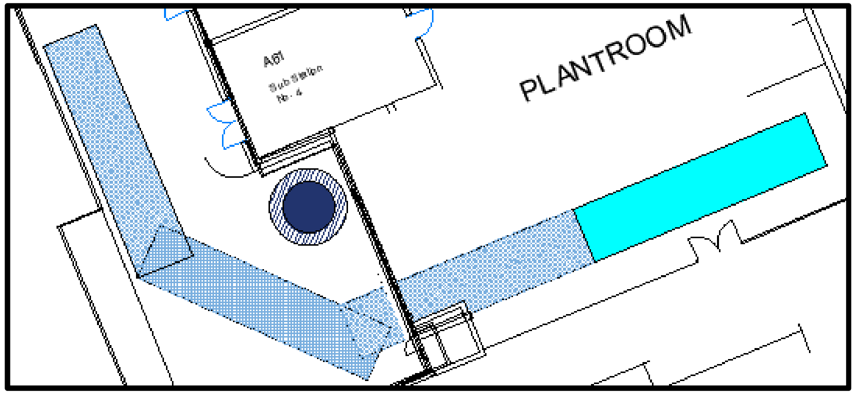


Figure 2.3.4 CHP access to existing plantroom

Figure 2.3.5 Potential restriction to existing plantroom

Chapter 2 – Supply and routing appraisal

2.3 Energy centre detailed appraisal

Figure 2.3.6 shows that there is sufficient space within both the ECA site (the water tank area in the hospital car park shown in orange) and the ECB site (the ex-laundry site shown in green) to accommodate a new CHP EC. As there is sufficient space in both sites, ECA is considered to be preferable for CHP as techno-economic modelling shows this to be a cheaper option due to the significant reduction in hard-dig pipe work required compared to ECB. ECA is also closer to proposed future developments and so provides more flexibility for future expansion of the heat network.

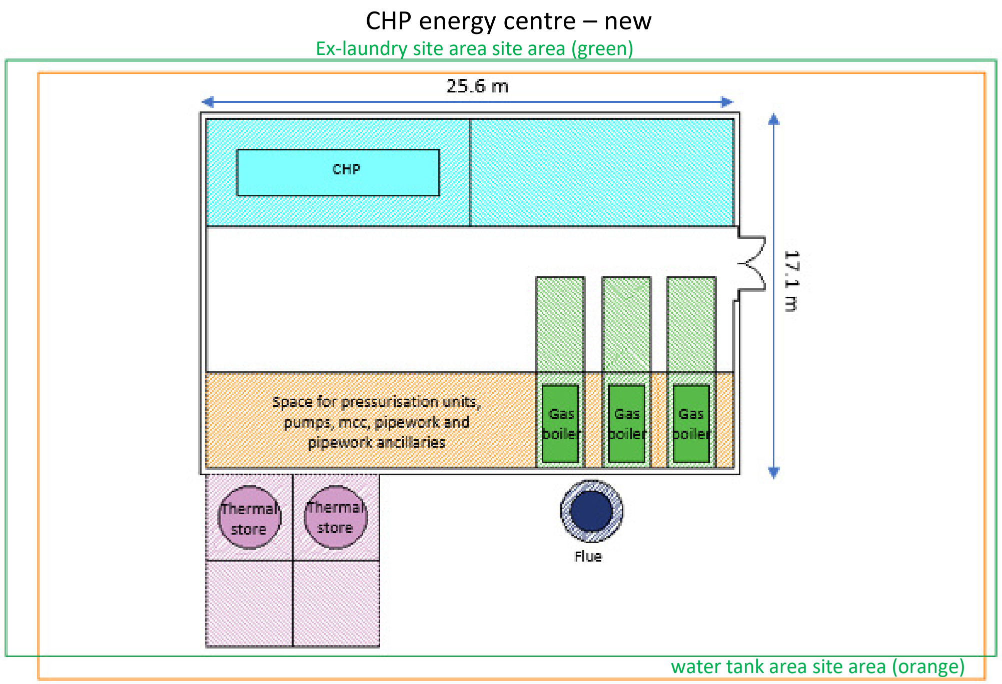


Figure 2.3.6 CHP in ECA - water tank area (orange) and ECB – ex-laundry site (green)

Total footprint = 436 m^2
Area for pressurisation units, pumps, mcc, pipework and pipework ancillaries = 131 m^2
Hatched lines shown space required for access to plant represented in the same colour

Chapter 2 – Supply and routing appraisal
2.3 Energy centre detailed appraisal

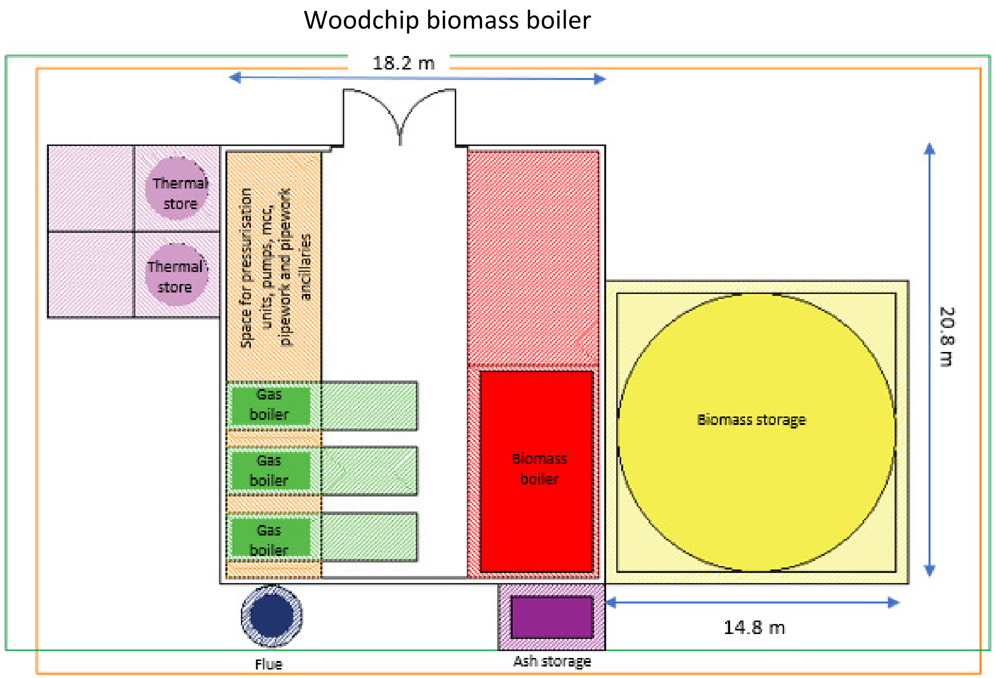


Figure 2.3.7 Woodchip biomass in ECA – water tank area (orange) and ECB – ex-laundry site (green)

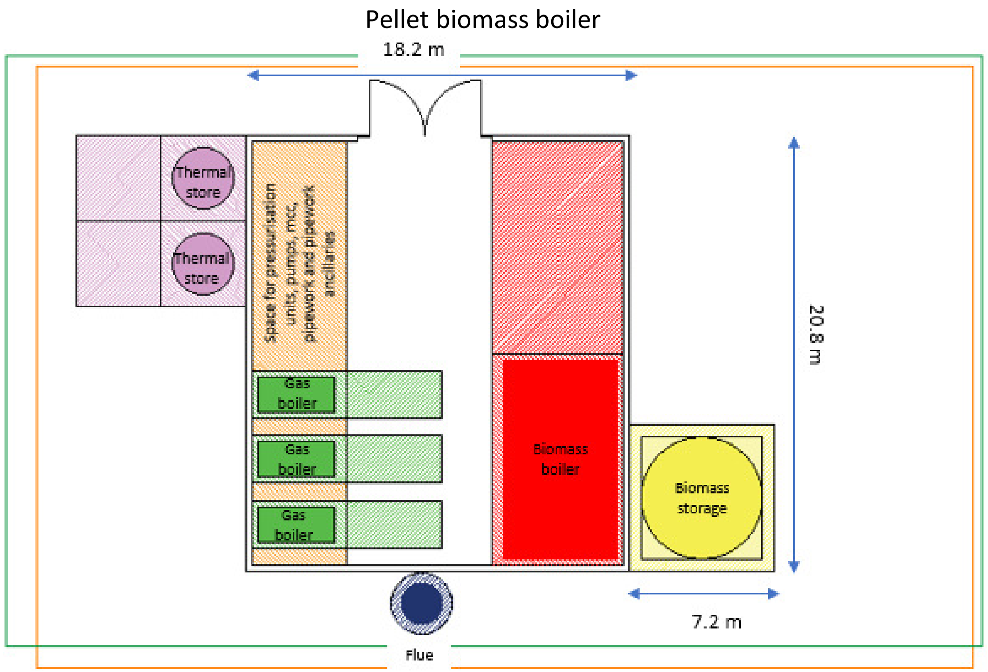


Figure 2.3.8 Pellet biomass in ECA - water tank area (orange) and ECB – ex-laundry site (green)

Figure 2.3.7 shows that there is sufficient space within both the ECA site (the water tank area in the hospital car park shown in orange) and the ECB site (the ex-laundry site shown in green) to accommodate a biomass woodchip EC. Due to the high costs associated with biomass identified through the techno-economic modelling, biomass is not recommended for NHH. However, due to the large area required for biomass storage, if this option were to be taken forward, a detailed traffic study should be performed to ensure that there is sufficient space available for delivery access and ash removal.

> Total footprint = 378 m^2
> Area for pressurisation units, pumps, mcc, pipework and pipework ancillaries = 58 m^2
> Hatched lines shown space required for access to plant represented in the same colour

Figure 2.3.8 shows that there is sufficient space within both the ECA site (the water tank area in the hospital car park shown in orange) and the ECB site (the ex-laundry site shown in green) to accommodate a biomass pellet EC. Again, this option is not recommended due to its poor performance in the techno-economic analysis however, using a pellet biomass boiler, rather than woodchip, significantly reduces the space requirements for the energy centre area.

> Total footprint = 378 m^2
> Area for pressurisation units, pumps, mcc, pipework and pipework ancillaries = 58 m^2
> Hatched lines shown space required for access to plant represented in the same colour

Chapter 2 – Supply and routing appraisal

2.4 Supply options appraisal

	CHP	Woodchip biomass boiler	Pellet biomass boiler
Total energy centre footprint	436m^2	378m^2 (energy centre excluding chip handling)	378m^2 (energy centre excluding chip handling)
Planning permission	Not needed if contained within existing plantrooms, however if new EC is required planning permission would be required	Required	Required
Access	Space constraints in the existing plantrooms, even with the removal of the steam boilers in the current plantroom, there is not likely to be space in the main hospital building plantroom, and the access will be constrained. There would be no access issues for a new EC.	Good access required for regular deliveries Frequency of delivery is depended on the extent of the network and the delivery method employed. Guidance from Carbon Trust suggests that the full extent of the network would require wood chip deliveries more than an average of twice per day if using a tipper trailer.	Good access required for regular deliveries Frequency of delivery is depended on the extent of the network and the delivery method employed. Guidance from Carbon Trust suggests that the full extent of the network would require pellet deliveries once per day.
Visual impact	If ECA – water tank area or ECB – ex-laundry site was selected, a new flue would be required and the energy centre building or external thermal stores could be 7.9m tall due to the thermal store dimensions.	A flue is required and the energy centre building or external thermal stores could be 7.9m tall due to the thermal store dimensions.	A flue is required and the energy centre building or external thermal stores could be 7.9m tall due to the thermal store dimensions.
Ground works	If ECC – existing hospital plantroom is selected, the plantroom floor will need to be tested to make sure it's suitable for the loading required by the plant. If ECA or ECB see the biomass options.	Concrete plinth will need to be tested to make sure it's suitable for the loading required by the plant.	Concrete plinth will need to be tested to make sure it's suitable for the loading required by the plant.
Flue	If ECA or ECB was selected, a flue may be required. In terms of air quality, there are no Air Quality Management Areas in Basingstoke, but the plant would need to conform with relevant regulations such as MCPD (Medium Combustion Plant Directive)	New flue required, in terms of air quality, there are no Air Quality Management Areas in Basingstoke, but the plant would need to conform with relevant regulations such as MCPD (Medium Combustion Plant Directive)	New flue required, in terms of air quality, there are no Air Quality Management Areas in Basingstoke, but the plant would need to conform with relevant regulations such as MCPD (Medium Combustion Plant Directive)
Key risks	If ECC, removal of all boilers and installation of the new CHP and boilers would be required. See biomass options for ECA or ECB.	Construction, planning & disruption caused by regular deliveries	Construction, planning & disruption caused by regular deliveries

Table 2.4.1 Supply options detailed study

1) https://www.basingstoke.gov.uk/air-quality .

Chapter 2 – Supply and routing appraisal
2.5 Zero carbon transition

We have focused the study on the use of gas CHP and biomass for this study as this is what was proposed in the previous study by the Encraft report. These are the two options that are the most applicable to the heating systems of the existing buildings as explained further below.

However neither option is zero carbon. This is especially true for gas CHP, which does not save carbon over the counterfactual of gas boilers. The alternative technologies that could allow this transition to zero carbon are outlined here.

It is important to consider the future when designing the network to facilitate this transition. For each known technology described, the main adaptations to the network and/or buildings that would be needed are outlined.

Heat pumps

The main constraint to the use of heat pumps is that the existing buildings have been designed to operate at high temperatures (80ºC), which makes heat pumps inefficient. This has been done on schemes such as London Southbank University scheme but should be avoided in order to maximise efficiency. It is likely that in 15 years time when the CHP/biomass comes to the end of its life, the site will need to be refurbished allowing the heating temperature to be reduced to around 40ºC in order to make the heat pump more efficient. Although DHW will still need to be produced at 60ºC.

There is scope to incorporate these technologies into the heat network system in the future using them to complement the biomass boiler or CHP. If the insulation is improved in the hospital in the long term and radiator sizes are increased, heat pumps could become the main heat source. Funding for improvements to building fabric is available through RE:FIT local partnerships; a procurement initiative for public bodies wishing to implement energy efficiency and local energy generation measures to their buildings.

There are two types of heat pump applicable to this site:

Ground source heat pumps (GSHPs)

The large fields near the hospital shown in figure 1.2.1 could be utilised for ground source heat pumps (GSHPs). The large field to the west of Parklands Hospital (as shown in figure 1.2.1) could be utilised for GSHPs, this is ~30,000m^2. This land is publicly owned and is open park land. This land could be used for either vertical (boreholes) or horizontal (trench network) heat pumps with vertical preferred due to the scale of the heat demand.

Air Source Heat Pumps (ASHPs)

There is also space in the area to add air source heat pumps (ASHPs) which would extract heat from the ambient surroundings. It is important to note that centralising these can have negative effects as they can adversely effect each others operating performance. There are complications related to how to connect these to an existing network if they are not centrally located.

Geothermal

Geothermal heat could also be considered, geothermal heat sources include drilling over 500m into the ground. Further study would need to be undertaken to assess the suitability of this heat source compared to the heating load. Geothermal heat may not be at a high enough temperature for the existing hospital system (typically in the UK extraction temperatures are 60°C to 100°C[1]) this could be overcome by use of a top up boiler. Uncertainty of well yield at depth is a serious risk. A dry bore may not be sustainable. If little water is available at deep depth then engineered geothermal systems (EGS) can be considered by drilling 2 boreholes, one injection and one abstraction.

- Mean ground temperature of 10ºC[2]
- Mean temperature at depth of 1km in this area of the UK at 34-38ºC[3]
- Indicates that a 2km well could produce circa 50-60ºC output temperatures.

The site sits above the Wessex Basin aquifer, so there is potential for good ground flow. If 2l/s can be sustained with a deep borehole of 2km, the heating output could be 200~400kW. If 50l/s can be sustained for example through access to an aquifer, the heating output could be ~6,000kW per borehole.

To construct a well a minimum space of around 50m by 50m is required during construction. The installation itself is a small proportion of this (i.e. manhole sized to cover the well, and a small interface unit).

1) 'Developing Geothermal District Heating in Europe', European Geothermal Energy Council, pp.29, 2011
2) Microgeneration Installation Standard: MIS 3005, Issue 1.0. DECC 2011. Accessed via: https://www.icax.co.uk/pdf/MIS_3005_Ground_loop_sizing_tables.pdf
3) The measured shallow temperature field in Britain. J. Busby, A. Kingdon, J. Williams. British Geological Survey. qjegh.lyellcollection.org/ Downloaded: March 2017

Chapter 2 – Supply and routing appraisal
2.5 Zero carbon transition

EfW plant

As identified in the Encraft report there is an EfW plant in Basingstoke, this is situated 3.7 miles from the hospital as shown in figure 1.2.1. In the long term, this could be connected to the hospital network and allow the CHP/biomass boiler to be superseded. This would cost between £10-18m in pipework costs, though it is important to note that this cost would be shared by others in the area connecting to it.

If the network went ahead with CHP, it only has a lifetime of about 15 years, so this gives time for the renewable options to be considered, and for changes to happen.

This fits with the government agenda and is plausible especially with the EfW plant likely to be obliged to assess the viability of heat offtake on a regular basis. This could be a long term carbon strategy for the hospital if the Council was to considered this in a long term plan for Basingstoke.

Previous work by Arup (for another client) optimised heat use from this EfW plant, and showed connection to the hospital. For the scheme we proposed, we predicted an overall cost of £21million for the scheme and an IRR of 5%.

Hydrogen

The other option would be to continue with a gas solution (gas CHP or boilers) and wait and see if hydrogen becomes viable in the 15 to 20 years. This may be an easier conversion if a gas CHP is in situ, but is highly dependent on technological progress. Projects such as Leeds H21 are leading the way in this area and the government is investing money into hydrogen networks.

The obvious advantage of this heat network compared to other options is that the energy technology supplying the network could easily be replaced with a zero carbon hydrogen technology.

Conclusion

There are two main options:

- heat pumps now or
- heat pumps in 15 years.

The reason we would not propose heat pumps now is that the hospital requires high temperatures of 80°C, and changes would be required which would take too long to achieve, whereas it is more likely that lowering the flow temperatures could be achieved if the hospital has 15 years to work towards this goal.

It is recommended that the hospital embark on a programme of temperature reduction wherever possible, particularly with regards return temperatures. Not only will this open up other opportunities to the hospital, but it will improve efficiency of the heating system with immediate effect.

Either ECA – water tank area or ECB – ex-laundry site would be suitable sites. ECB is slightly closer to the field with potential for heat pumps, however for connection to the EfW ECA would be in a better location.

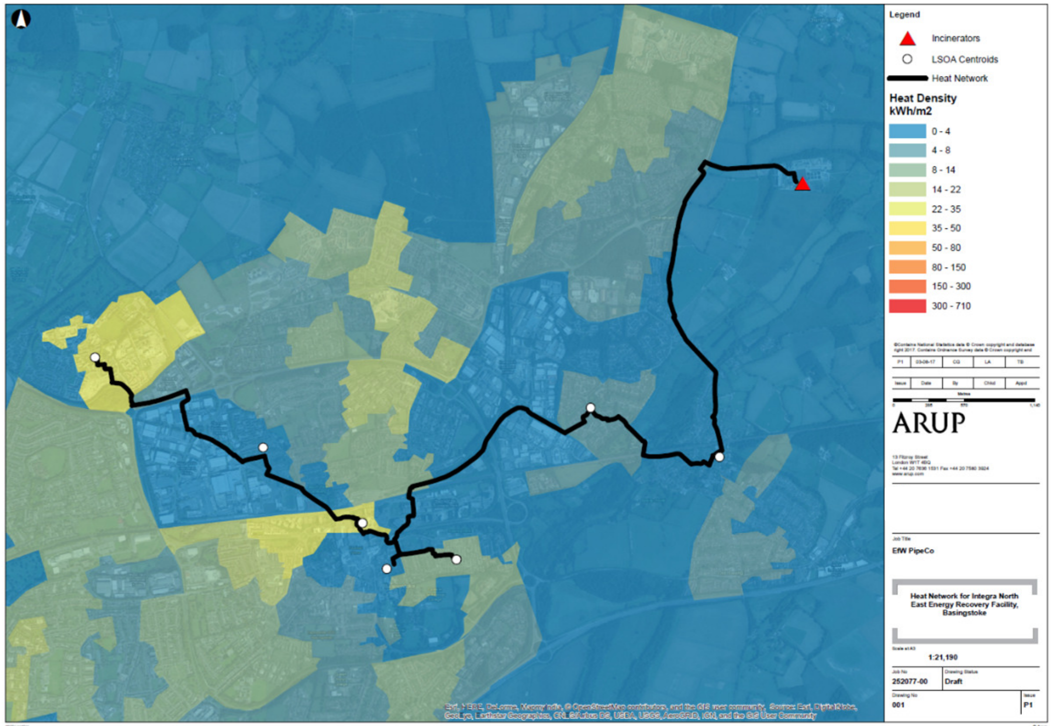


Figure 2.5.1: Previous Arup work showing connection to the hospital as part of a wider Basingstoke heat network scheme

Chapter 2 – Supply and routing appraisal

2.6 Routing

The proposed route for the site was selected for the following reasons:

- It minimised the number of locations where the heat network pipework was in close proximity to existing utilities, particularly a SGN medium pressure main which runs close to the north-east of the hospital.
- It minimised the pipework length required in order to minimise overall costs as required by CIBSE heat network code of practice.
- It made use of opportunities for pipework to go in soft dig ground to minimise overall costs. It was in the verge on the other side of the road compared to most of the hospital's pipework.

Four different extents were examined for the pipework and were analysed in the techno-economic modelling. These phasing options are shown in figure 2.6.1 and table 2.6.1.

The various energy centre locations are highlighted in figure 2.6.1. As discussed in section 3, the energy centre location was decided after the optimal route is identified.

Costs were calculated for each EC configuration for each scenario tested.

The current hospital heating system joins buildings A, F and G, through pipework within the ceilings and across a pipeway corridor between buildings A and G. This network has been stated by the hospital to be at the end

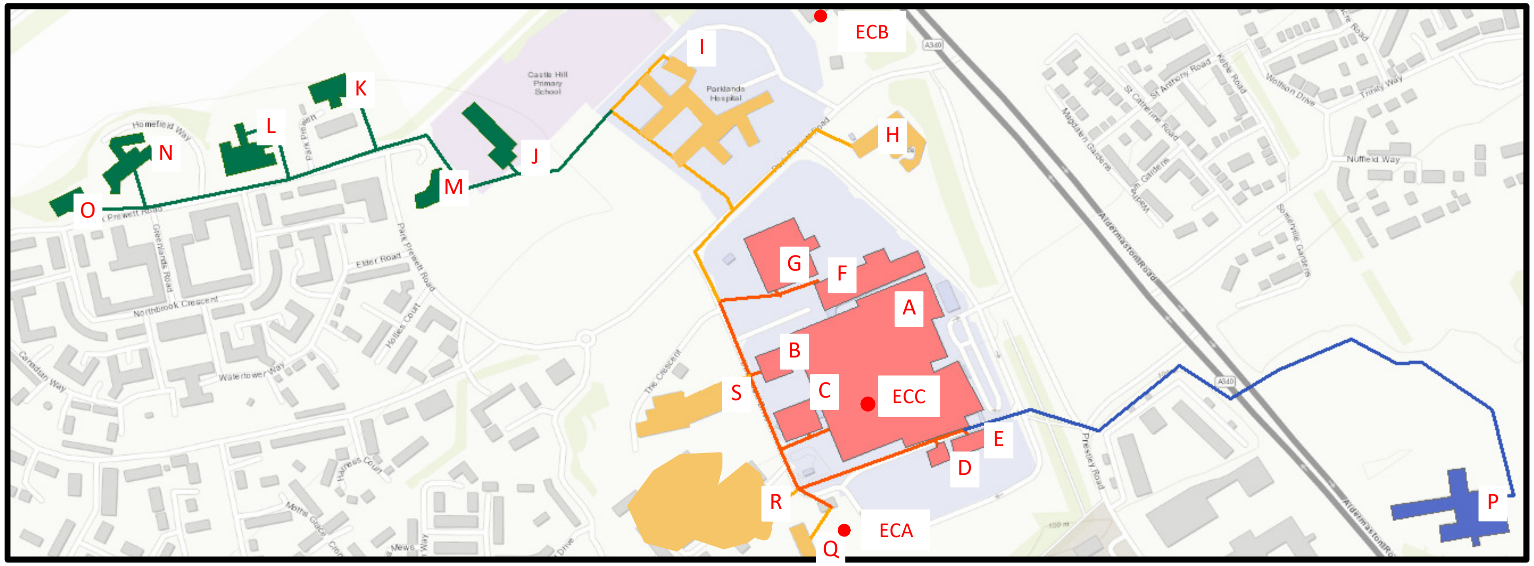


Figure 2.6.1 Proposed routes and phasing

Hospital cluster		Hotel cluster	Parklands cluster	Primary school cluster
A. Main hospital building B. The Firs C. The Ark D. MRI E. AAU F. DTC	G. The Sherborne Building	P. Apollo Hotel	H. St. Michael's Hospice I. Parklands Hospital Q. Just Learning R. Viridian S. Candover Clinic	J. Castle Hill Primary School K. Firvale L. Homefield House M. Rooksdown Community Centre N. Fairway House O. Headway Place

Table 2.6.1 Proposed routes and phasing key

Chapter 2 – Supply and routing appraisal

2.6 Routing

of it's lifetime and they would not consider it fit to be used. They consider the cost of replacement to be high due to the amount of asbestos in the building. This is tested in section 3.7.

Private wire is only considered to the hotel and hospice as an extension to the current ring main. This routing is the same as the heat network route.

Chapter 2 – Supply and routing appraisal

2.7 Utilities

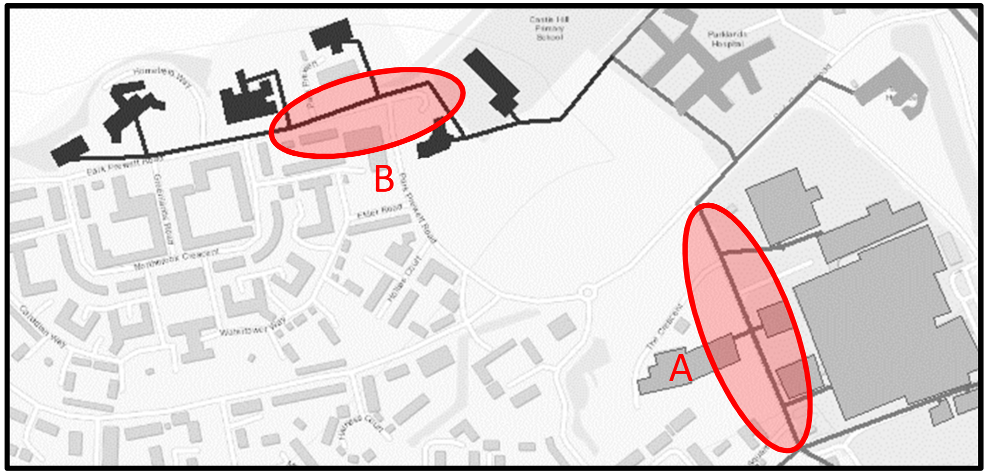
Using GIS, examination and mapping of existing utility services within the area of the proposed heat network was performed. Using existing utility drawings to assess pipework routing is recommended as best practice in CIBSE heat network code of practice. The route was designed to minimise disturbances to existing utilities. Never-the-less, there were two instances where the heat network runs in particularly congested areas. This could pose a risk to the project if adequate precautions are not taken to ensure that these utilities are taken in to full consideration within detailed design stages.

The areas concerned are Dinwoodie Drive to the west of the hospital and Park Prewett Road in the primary school cluster. These areas are shown in figure 2.7.1. The risk associated with installing a heat network in these constrained areas can be mitigated by undertaking sufficient ground penetration radar (GPR), installing pipework in soft dig areas and by not extending the network into the primary school cluster.

A detailed levels analysis will need to be undertaken.

A pipe schedule has been completed with hydraulic analysis and optimisation of pipe sizes. We have oversized routes to enable future carbon transition – for instance along Dinwoodie Drive for potential connection to heat pumps.

Utilities have not been contacted with regard to capacity because the loads are all existing and the hospital has previously had capacity and a gas meter at ECB – ex-laundry site and there is a gas meter and entry point to the north of the water tanks for ECA.



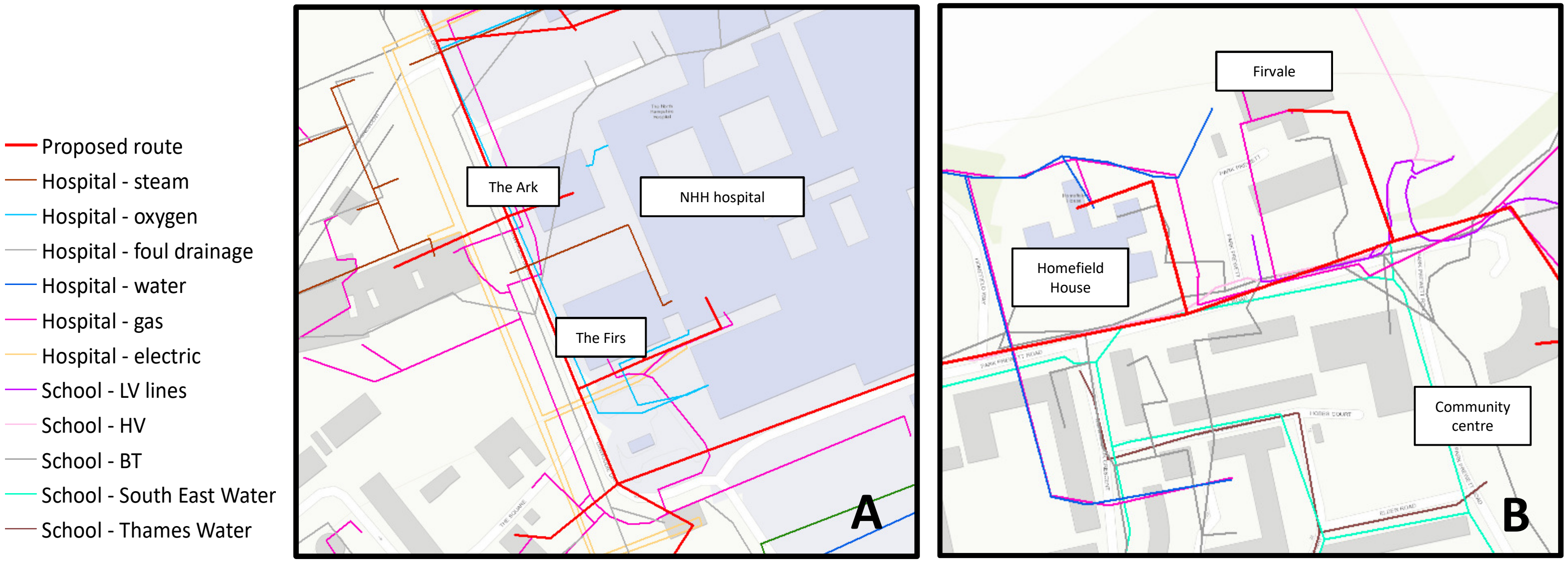


Figure 2.7.1 Utility areas of concern

Chapter 1 – Supply and routing appraisal
2.8 Supply and routing appraisal conclusions

Energy centre conclusions

The space to fit a new 2MW gas CHP in the existing plantroom, is very limited and we could not prove it would definitively fit. Certainly it would require the removal of all plant in that energy centre and reconfiguration, which may end up costing more than a new energy centre.

The number of biomass deliveries means that ECB – ex-laundry site would be the preferred option for a biomass energy centre.

ECA – water tank area would be the preferred option for the gas CHP, due to the length of network but also because of proximity for future connections to the EfW and other nearby developments such as Manydown. In terms of connection to heat pumps, while this site is closer to ECB, connecting to ECB is a further 300m of hard dig, while only pipework in Dinwoodie Drive would need to be oversized if ECA was used.

Routing appraisal conclusions

A proposed route for the network has been developed based on GIS mapping, the existing utility routing and a site visit. This has been refined to cause minimum disruption to the operation of the hospital and businesses in the area while minimising costs.

Table 2.8.1 shows the supply and network routing risks. In this table, risks referenced S relate to supply associated risks and N relate to network associated risks. A full risk register is presented in Appendix E.

Risk ref	Risk title	Description	Mitigation
S1	Spacing assumptions	Risk that there is insufficient space within existing plantrooms to accommodate new biomass or gas CHP equipment.	High level assessment of the space available for plant installation.
S2	Low carbon options	The network is installed with gas CHP, and no transition plan comes forward.	Allow for space in energy centre so future biomass boiler could replace gas boiler.
S4	Future of electric grid and carbon factors	The electric grid becomes overburdens and has lots of blackouts	CHP helps NHH have a more stable electric grid.
S5	Future of gas grid and carbon factors	The gas grid becomes defunct and doesn't transition to hydrogen or a lower carbon gas.	If use CHP and there is no gas, there would be no network, likelihood of this happening in the next 15 years is low, so transition to future technology requires further thought in 10 years.
S6	AQMA	The area could become an AQMA and more stringent requirements could impact gas CHP or biomass boilers	Leave space for additional abatement measures to be installed around the technology.
S7	Availability of sustainable biomass	There is no available sustainable biomass suitable for use with the biomass boilers.	Sign up for a long term contract with a reliable supplier.
S8	Energy from waste becoming available	If energy from waste becomes available in the future as an energy source for the heat network, this would mean that plant equipment is oversized	Establishing and maintaining good communication with key stakeholders in the local area.
N1	Gas utility crossing	Crossing of SGN medium pressure mains increases cost of network installation.	Crossing of gas mains kept to a minimum
N2	More hard dig than anticipated due to misc. pipes/cables in the verges	More hard dig than anticipated due to misc. pipes/cables in the verges	Early trial pits and GPR to be undertaken
N3	Road crossing	Heat networks in the road may cause disruption to hospital access and may risk a cable stike if there are other utilities already in the road.	Heat network to use underpass under main road to minimise disruption Partial road closures may be required.
N4	Land ownership permission	The land owners do not allow the crossing of their land.	Early engagement. Seen as low risk as the majority of the land is owned by the hospital, council or properties that are proposed to join the scheme.
N5	Crossing the road to Apollo hotel	It is difficult to tunnel under the road, and an option could be to contain the heat pipes in a false cavity in the tunnel.	Route feasibility on the road/tunnel crossing
N6	Future proofing the scheme	Other buildings wishing to connect to the network without sufficient capacity.	Thorough analysis of local area has been undertaken Understanding the future plans of stakeholders for their buildings

Table 2.8.1 Summary of risks associated with supply and routing

Chapter 3 – Techno-economic analysis

Chapter 3 – Techno-economic analysis
3.1 Scenario testing

Introduction

This chapter covers the techno-economic modelling undertaken for the heat network based on the information presented in previous chapters and assumptions informed by Arup's technical experience. For a detailed list of assumptions see Appendix A. The key assumptions are discussed in this section.

The key questions this chapter answers are:

(i) Which heat source is most suitable for the network?

(ii) Which buildings are favourable to connect to the network?

(iii) Where is the optimal location for the energy centre for the heat network?

Table 3.1.1 displays the scenarios modelled to answer these questions and the following slides discuss the answers to each of these. Appraising various options in this way aligns with the CIBSE heat network code of practice objective of conducting consistent economic analysis and options appraisal.

For each scenario, the heating technologies were sized and optimised by a linear optimisation process. This has been developed by Arup based on academic research. This functions by converting the problem into a mathematical one, where the various parameters (e.g. sizing of different plant type and which buildings to connect to the network) are varied by a solver to find the solution with lowest overall cost or carbon performance.

Which heat source?				
Scenario	**Technology**	**Buildings included**	**Private wire**	**Energy centre location**
1	Gas boilers (baseline)	Full network	Hospital ring main	C
2	CHP			B
3	Biomass pellet			B
4	Biomass woodchip			B
Size of heat network				
Scenario	**Technology**	**Buildings included**	**Private wire**	**Energy centre location**
9	CHP	Full network	Hospital ring main	A
5	CHP	Hospital, Parklands and Hotel		A
6	CHP	Hospital and Hotel clusters		A
8	CHP	Hospital cluster		A
Extension of the private wire network				
Scenario	**Technology**	**Buildings included**	**Private wire**	**Energy centre location**
6	CHP	Hospital and Hotel clusters	Hospital ring main	A
7	CHP		Hospital ring main and Hotel	A
Optimal location of energy centre				
Scenario	**Technology**	**Buildings included**	**Private wire**	**Energy centre location**
9	CHP	Full network	Hospital ring main	A
2	CHP			B
10	CHP			C

Table 3.1.1 Scenario testing with the green boxes indicating what was varied in that scenario

Chapter 3 – Techno-economic analysis
3.1 Scenario testing

Carbon savings calculations

To compare the predicted carbon emissions from the scheme with a counterfactual for the existing scheme, gas electricity and biomass carbon intensity factors were taken from BEIS, from SAP 10 and from SAP 2012. These values are summarised in Table 1.1.1. For each of the scenarios tested, guidance from HNDU Appendix D was used to calculate carbon savings for 15-year and 40-year durations using each of three sources.

Gas and electricity prices

The gas and electricity prices used for this assessment took into account the future projections[1] up to 2035 as shown in figure 3.1.1, using the industrial prices starting at 2.4p/kWh for gas. This is different from the price the hospital currently pay for gas given that we anticipate gas being purchased by a third party where a new heat network is installed. The prices were then assumed to stay at the same level until the end of the project's lifetime.

Our assumptions for modelling are included in Appendix B.

	BEIS	SAP 10	SAP 2012
Gas factor (gCO_2e/kWh)	184	210	216
Electricity factor (gCO_2e/kWh)	Marginal factors used	233	519
Biomass factor (gCO_2e/kWh)	21 – pellet 50 – woodchip	23	16

Table 3.1.1: Carbon emission factors

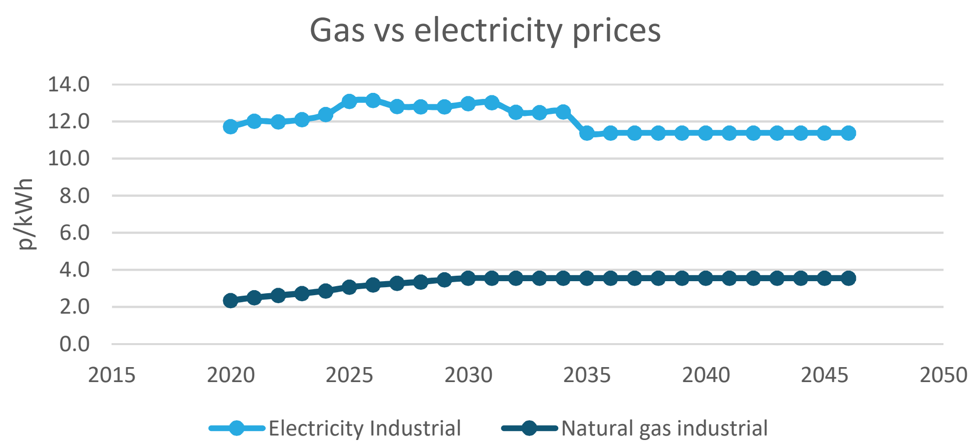


Figure 3.1.1: Price projections from BEIS

1) BEIS. 2017. BEIS 2017 Updated Energy & Emissions Projections – Annex M Growth assumptions and prices. [Online]. [Accessed: 14 November 2018]. Available from: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017

Chapter 3 – Techno-economic analysis
3.2 The counterfactual

Hospital BAU

To compare the different options, all the scenarios are compared to a counterfactual. This represents what would be the most probable solution in the absence of additional investment or this study. The values are then used to determine the heat tariff and connection charges used in the techno-economic modelling.

There are multiple options that could be considered the counterfactual for the hospital which are shown in table 3.2.1. These options include the hospital deferring back to their previous arrangement with Scottish Power, gas boilers (current set up) or installing their own CHP.

After engagement with the council and hospital, it was determined that the counterfactual should be gas boilers for all of the buildings.

Heat tariff prices were calculated based on the gas prices the hospital are currently paying (2.9p/kWh), this is higher than what would typically be paid by a district heating operator (for this we have assumed BEIS prices, see figure 3.1.1). The heat price will be the cost to the customer, and a revenue to the heat network project.

In addition, the heat tariffs have been derived from:

- **Variable rate** based on the counterfactual variable heat price that it is estimated that each consumer would be subject to, and estimated boiler efficiencies.
- **Fixed charge** based on counterfactual costs for maintenance and replacement of gas-fired boilers.

Input	Unit	CHP + boilers	Boiler only (counterfactual)	Scottish Power PFI (based on December 2017 bill)
Total hospital CAPEX	£/year	-£1,090,000	-£451,824	£0
Annual costs				
Hospital average cost of heat (including elec. revenues)	£/kWh	-£0.03	-£0.03	-£0.02
Annual cost of heat	£/year	-£450,632	-£457,182	-£325,769
Hospital average cost of electricity	£/kWh	-£0.07	-£0.11	-£0.14
Annual cost of electricity	£/year	-£665,079	-£1,065,864	-£1,332,329
Total annual REPEX CAPEX	£/year	-£73,000	-£73,000	£0
Total annual hospital counterfactual cost	£/year	-£1,188,710	-£1,596,045	-£1,658,099

Table 3.2.1: Counterfactual assumptions

Chapter 3 – Techno-economic analysis

3.2 The counterfactual

Modelling approach

The hospital and surrounding buildings will incur a cost for heat under any scenario, with or without a heat network. To effectively communicate the carbon or economic merits of each scenario they are compared to a counterfactual which would be considered as the business as usual (BAU) scenario.

This BAU determines the maximum cost of heat, electricity and capital costs that the buildings are willing to pay for the services. If the economic metrics are positive then that indicates that the proposed scenario will result in an overall saving.

How that saving is apportioned between the different parties is a commercial decision, for that reason at this stage of modelling no heat or electrical tariff discounts have been applied, as this is a refinement of the scheme and only worthwhile once it is known that it is economically viable.

In this study a discount rate of 3.5% was used which is aligned with the Green Book.[1]

Counterfactual scenario selected

Prior to modelling, the counterfactual scenario to which the options are compared against was agreed with the Hospital and Council.

This counterfactual was for the continued operation of the gas boilers in the hospital and all other buildings, this is the current situation and most likely to remain so if no further investment is made as it is the cheapest in terms of capital cost. It is also what the hospital has currently budgeted for.

Table 3.2.1 summarises the resultant assumed variables used with a description of what each of these represent with reference to the counterfactual scenarios. The variation between the different buildings for connection charge and standing charge is due to the different sizes of heating systems. If there is a large heating system then there is a lower cost per kW due to economies of scale.

The heat prices are all the same due to the assumption that all the commercial buildings get the same price of gas as the hospital (2.9p/kWh).

Price forecasts

The gas and electrical prices are increased in the model in line with the BEIS 2017 updated emissions and energy projections reference case. The heat price is assumed to be directly linked to the gas price and increased at the same rate until 2035 after which it remains the same, as this is the counterfactual heating cost for all the buildings.

	Standing charge (REPEX)	Connection charge (CAPEX)	Price of heat (O&M and fuel)	Customers
Unit	£/kW/year	£/kW	£/kWh	N/A
Description	Calculated annualised replacement cost of the boilers	Based on avoided capital cost of boilers and ancillary equipment	Based on the hospital cost of gas, boiler efficiency and respective boiler operation and maintenance costs	Who is purchasing the heat?
Hospital	£6.2	£92.4	£0.0365	HHFT
The Firs	£6.4	£96.7	£0.0365	HHFT
The Ark	£6.4	£95.8	£0.0365	HHFT
MRI	£6.4	£96.7	£0.0365	HHFT
AAU	£15.7	£235.1	£0.0365	HHFT
DTC	£15.8	£236.8	£0.0365	HHFT
Sherborne Building	£6.2	£93.1	£0.0365	HHFT
St Michael's Hospice	£6.2	£92.4	£0.0365	St Michael's Hospice Basingstoke (charity)
Parklands Hospital	£6.3	£94.5	£0.0365	Southern Health NHS Foundation Trust
Castle Hill Primary	£6.8	£101.9	£0.0365	Hampshire Education Authority
Firvale	£6.8	£102.2	£0.0365	HHFT
Homefield House	£6.6	£99.4	£0.0365	Shaw healthcare
Rooksdown Community	£6.3	£93.8	£0.0365	Rooksdown Community Association
Fairway House	£6.3	£94.5	£0.0365	Southern Health NHS Foundation Trust
Headway Place	£7.3	£110.0	£0.0365	Headway Basingstoke
Apollo Hotel	£6.2	£92.8	£0.0365	Private
Just learning	£7.0	£104.6	£0.0365	Busy Bees
Viridian	£6.2	£92.8	£0.0365	Optivo Keyworker Housing
Candover Clinic	£6.3	£94.4	£0.0365	HHFT

Table 3.2.1: Counterfactual assumptions and the resulting heat tariffs used in the techno-economic modelling

1) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

Chapter 3 – Techno-economic analysis
3.3 Heat source

Which heat source is most suitable for the network?

Figure 3.3.1 shows the Net Present Value (NPV at 3.5% discount rate) and IRR over 40 years for the different heat sources. Figure 3.3.2 shows the % lifetime carbon savings for the different heat sources, using BEIS and SAP 10 figures, for 15 and 40 years.

Of the three options the CHP is more favourable returning a positive NPV and IRR, due to the direct sale of electricity to the hospital ring main, and the gap between the heat price and gas price because of the hospital's current gas price.

The biomass options return a negative IRR and NPV at the full network scale over 40 years (also applies to 15 and 25 years). The woodchip biomass boiler is more favourable in terms of IRR, because of the cheap feedstock that can be provided locally (1.5p/kWh) and the RHI which is confirmed until 2021 (although this could degress).

The pellet boiler is the least favourable because of the expensive feedstock (4p/kWh) outweighing the benefits of the improved efficiency and operational flexibility compared to the woodchip boiler.

In terms of carbon, the biomass boilers are more favourable in SAP 10 and BEIS's calculations. The lifetime of a CHP is 15-20 years, so the transition to heat pumps as discussed in section 2.5 is an opportunity to lower the long term carbon.

Which heat source?				
Scenario	**Technology**	**Buildings included**	**Private wire**	**Energy centre location**
2	CHP	Full network	Hospital ring main	B
3	Biomass pellet			B
4	Biomass woodchip			B

Table 3.3.1: Heat source analysis

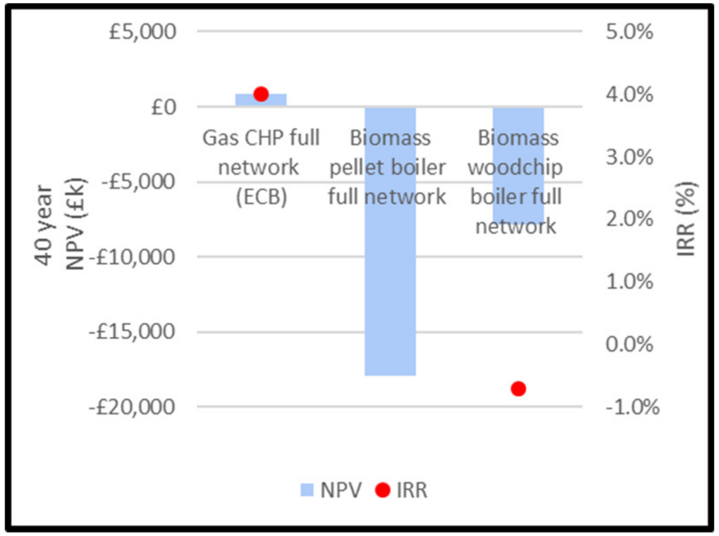


Figure 3.3.1: NPV for 3.5% discount rate and IRR for different heat sources

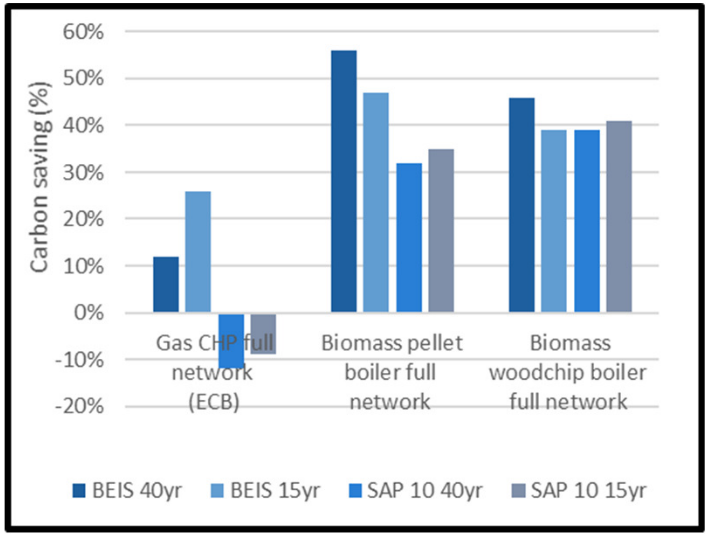


Figure 3.3.2: Carbon saving for different heat sources

Chapter 3 – Techno-economic analysis
3.4 Extent of heat network

Which buildings are favourable to connect to the network?

Figure 3.4.1 shows the NPV (for the 3.5% discount rate) and IRR over 40 years for the different sizes of heat network, while figure 3.4.2 shows the lifetime carbon savings using the BEIS Appendix D method and the SAP 10 figures, for 40 years and 15 years.

The results of this modelling indicate that it is economically viable to extend the network to the Hotel and Parklands clusters. With three schemes (apart from the full network) having IRRs above 6%, and all having positive NPVs. The higher carbon savings come from the larger schemes.

It is not economically viable to include the School cluster because the extra pipework costs are too high compared to the revenues that can be achieved from connection of these additional buildings. This is due to the heat load not being sufficiently large to recuperate the high costs of this.

Size of heat network				
Scenario	**Technology**	**Buildings included**	**Private wire**	**Energy centre location**
9	CHP	Full network	Hospital ring main	A
5	CHP	Hospital, Hotel and Parklands clusters		A
6	CHP	Hospital and Hotel clusters		A
8	CHP	Hospital cluster		A

Table 3.4.1: Network extent analysis

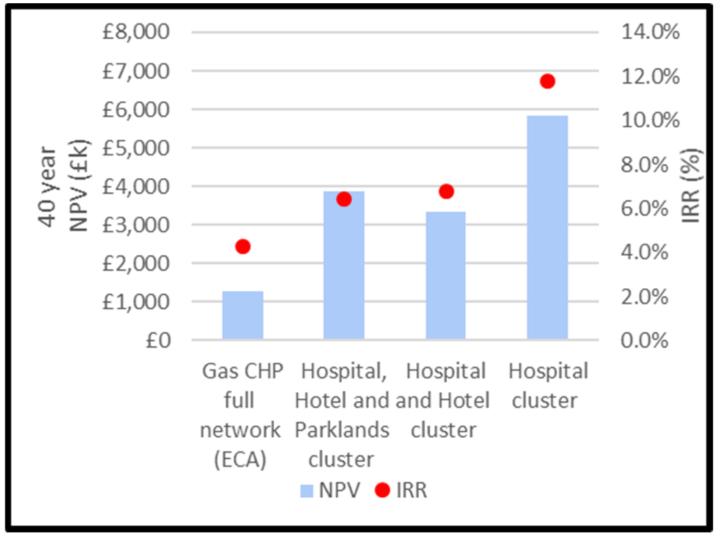


Figure 3.4.1: NPV for 3.5% discount rate and IRR for different network extents

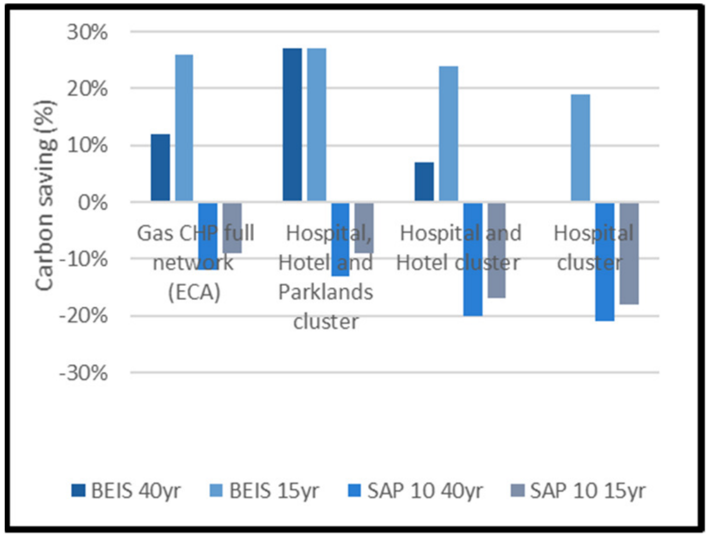


Figure 3.4.2: Carbon saving for different network extents

Chapter 3 – Techno-economic analysis

3.5 Private wire network extension

What would be the effect of extending the hospital PW network?

Figure 3.5.1 shows the NPV (for the 3.5% discount rate) and IRR over 40 years for extending the private wire to the Hotel, while figure 3.5.2 shows the lifetime carbon savings using the BEIS Appendix D method and the SAP 10 figures, for 40 years and 15 years.

The results of this modelling indicate that there is a economic benefit to extending the private wire network to include the Apollo Hotel. This increases the direct sale proportion of the CHP electrical output from 64% on average to 68%.

Selling the electricity directly avoids the transmission fees of the grid meaning that electricity that would have been exported to the grid at around 4.6p/kWh can be sold to the hotel at approximately 11.7p/kWh.

This makes the scheme more economically viable if a private wire connection to the hotel is also included with the heat network.

The carbon implications of this are insignificant, with the direct sale of electricity being slightly more favourable because there are avoided transmissions losses on the grid.

The additional CHP heat generation that is facilitated by additional electrical demand of the private wire scheme is not sufficient to have a tangible carbon impact.

Extension of the private wire network				
Scenario	Technology	Buildings included	Private wire	Energy centre location
6	CHP	Hospital and Hotel clusters	Hospital ring main	A
7	CHP		Hospital ring main & Hotel	A

Table 3.5.1: Extension of the private network analysis

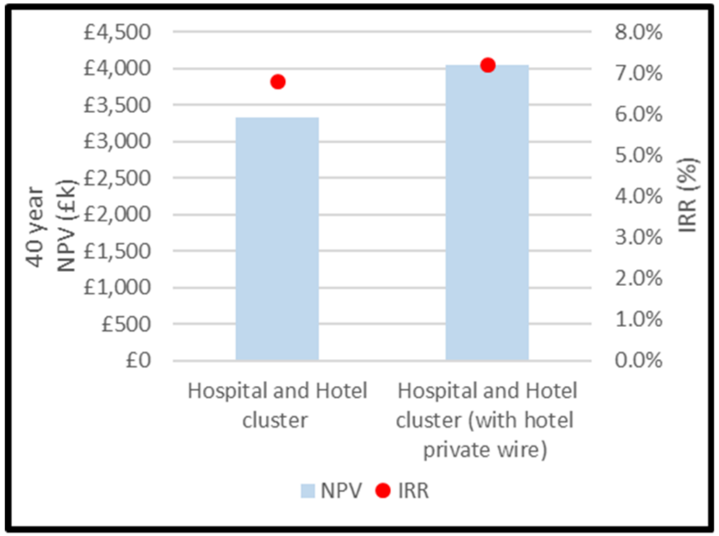


Figure 3.5.1: NPV for 3.5% discount rate and IRR for different PW networks

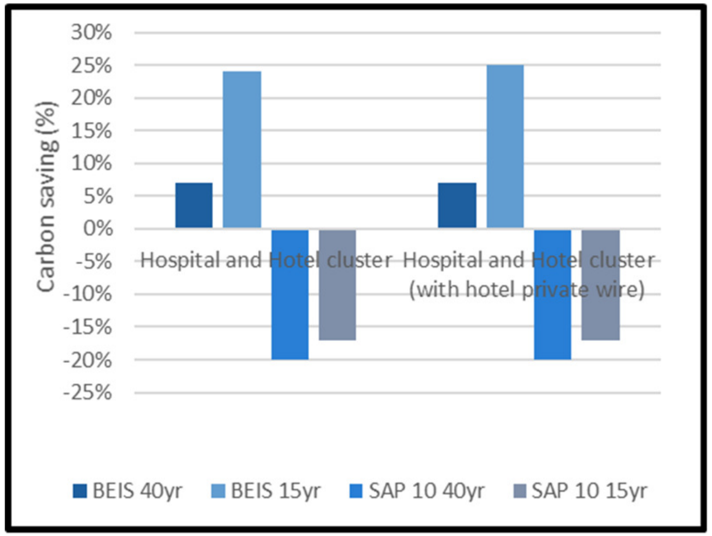


Figure 3.5.2: Carbon saving for different private wire networks

Chapter 3 – Techno-economic analysis

3.5 Private wire network extension to Parklands cluster

What would be the effect of extending the hospital PW network?

Figure 3.5.1 shows the NPV (for the 3.5% discount rate) and IRR over 40 years for extending the private wire to the Hospice, while figure 3.5.2 shows the lifetime carbon savings using the BEIS Appendix D method and the SAP 10 figures, for 40 years and 15 years.

The results of this modelling indicate that there is no benefit to extending the private wire network to include the Apollo Hotel and St Michael's Hospice, when the heat network including the Hospital, Hotel and Parklands clusters. This increases the direct sale proportion of the CHP electrical output from 64% on average to 75%. The IRR increases from 6.4% to 6.6%, and the NPV increases with the additional PW sales.

Extension of the private wire network				
Scenario	**Technology**	**Buildings included**	**Private wire**	**Energy centre location**
5	CHP	Hospital, Hotel and Parklands clusters	Hospital ring main	A
11	CHP		Hospital ring main & Hotel & St Michael's Hospice	A

Table 3.5.2: Extension of the private network analysis

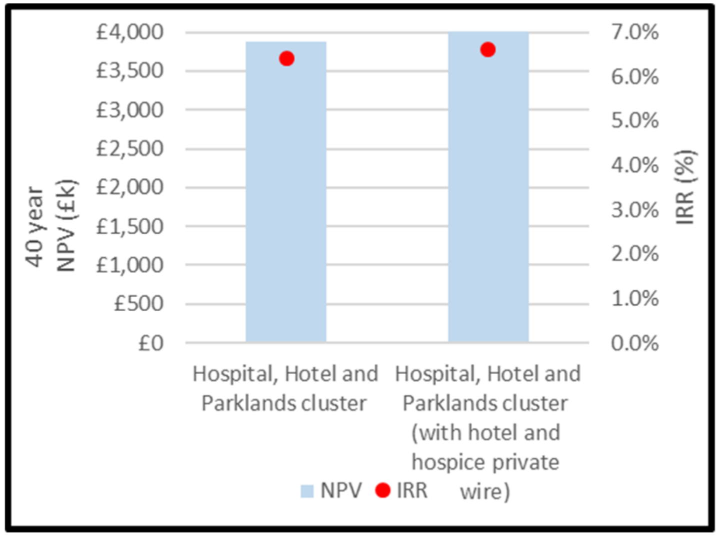


Figure 3.5.3: NPV for 3.5% discount rate and IRR for different PW networks

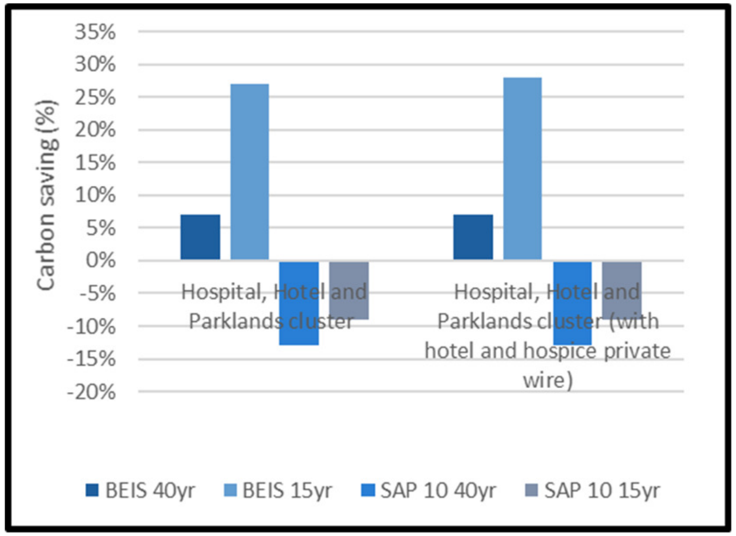


Figure 3.5.4: Carbon saving for different PW networks

Chapter 3 – Techno-economic analysis

3.6 Energy centre location

Energy centre location?

Figure 3.6.1 shows the NPV (for the 3.5% discount rate) and IRR over 40 years for the different energy centre locations, while figure 3.6.2 shows the lifetime carbon savings using the BEIS Appendix D method and the SAP 10 figures, for 40 years and 15 years.

The main location of the energy centre will not impact the operation of the plant or revenues, other than to account for a small marginal increase in losses if it requires more piping.

However the length of piping and potential requirement for a new building, gas connection or electrical connection will add to the CAPEX. For this reason the use of the existing hospital plantrooms returns a slightly better NPV. It is also centrally located so no additional piping would be required.

There is no difference in the carbon savings of the different EC locations.

Having a new EC would offer more flexibility to the scheme, in terms of long term carbon transition and ability to have larger heating plant. The modelling shows that ECA – water tank area is the more economical of the two EC locations.

Which energy centre location				
Scenario	**Technology**	**Buildings included**	**Private wire**	**Energy centre location**
9	CHP	Full network	Hospital ring main	A
2	CHP	Full network	Hospital ring main	B
10	CHP	Full network	Hospital ring main	C

Table 3.6.1: Energy centre location analysis

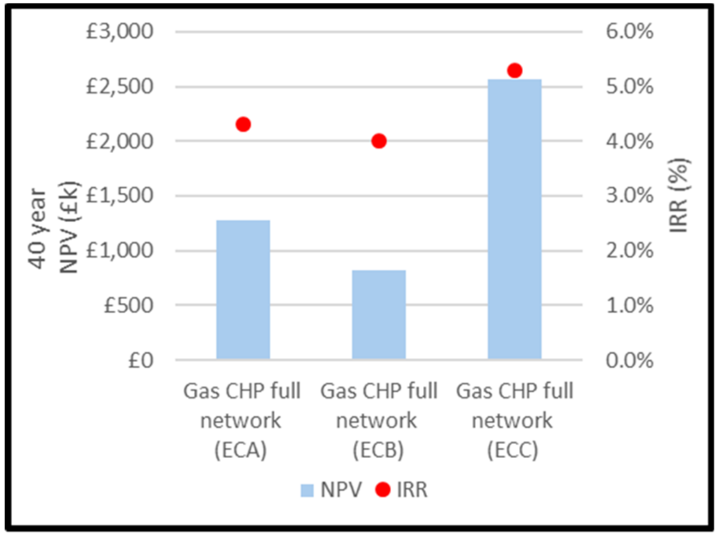


Figure 3.6.1: NPV for 3.5% discount rate and IRR for different energy centre locations

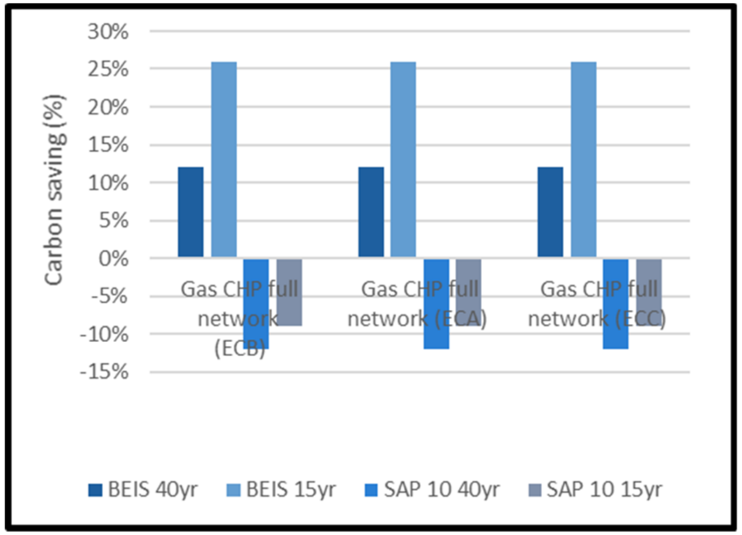


Figure 3.6.2: Carbon saving for different energy centre locations

Chapter 3 – Techno-economic analysis

3.7 Analysis of new network construction

New network?

Figure 3.7.1 shows the NPV (for the 3.5% discount rate) and IRR over 40 years if the old network was utilised.

A large proportion of the costs for this project are due to the network construction cost. To illustrate the cost implications of this and the potential savings of not upgrading the network a scenario with no new network has been modelled. It is likely that some of the network upgrades reqauired in the current system are part of the hospital's backlog maintenance, and we recommend that these are costed in detail to establish that they are higher than the costs of the £2.9million extra required to build a new EC.

On the other hand, as discussed previously there is little space in ECC for a bigger CHP, and it would be difficult to foresee how a transition to a lower carbon technology would work with the current set-up.

As can be seen the scheme is more profitable if no new network is installed. The revenues associated with the CHP installation do not need to be invested into a new network and can be utilised for other hospital functions.

Costs of constructing a new heat network				
Scenario	**Technology**	**Buildings included**	**Private wire**	**Use existing network**
8	CHP	Hospital cluster	Hospital cluster	N
11	CHP		Hospital cluster	Y

Table 3.7.1: New network construction analysis

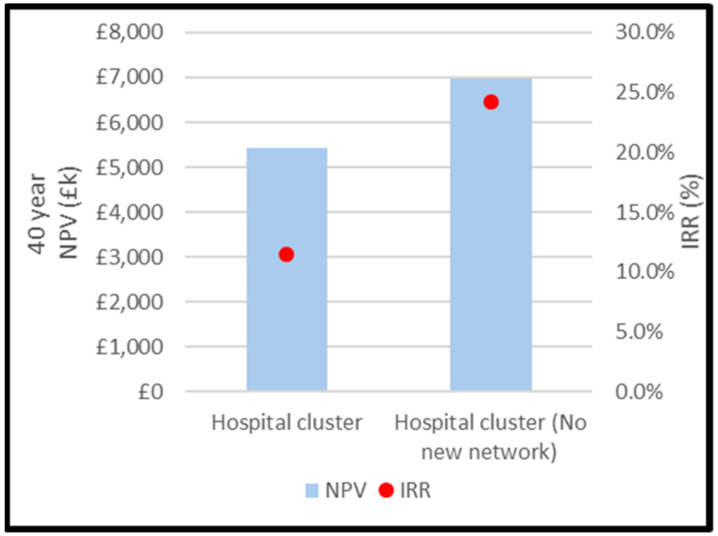


Figure 3.7.1: NPV for 3.5% discount rate and IRR

Chapter 3 – Techno-economic analysis
3.8 Sensitivity testing

In CP1, CIBSE stresses the importance of considering the risks associated with a project and of quantifying risks through performing a sensitivity analysis.

The chart in figure 3.8.1 shows the variation in NPV of the hospital cluster scenario.. The following are the main observations:

- If the gas and electricity prices do not increase as predicted by BEIS (50% in the next 10 years for gas) the economic viability of the scheme will improve.
- Change in heat demand is met by the boilers, as it is assumed that the equipment installed will be the same. For this reason additional heat demand increases boiler use which results in higher cost. Reduction in heat demand results in a higher proportion of the heat coming from CHP resulting in increased electricity revenues.
- Increased heat losses (20% as opposed to 10% in the initial scenario) results in a lower NPV because there is more heating cost without the revenues.

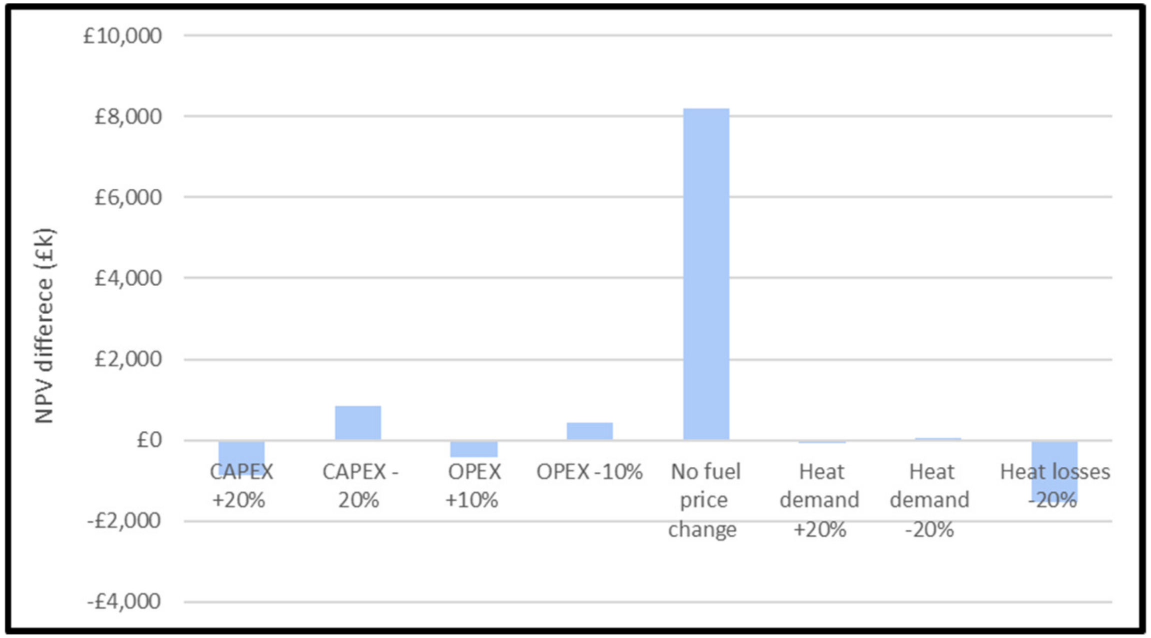


Figure 3.8.1: Sensitivity testing on the NPV for 3.5% discount rate

Chapter 3 – Techno-economic analysis
3.8 Generation split on the heat network

The chart in figure 3.8.2 shows the variation in generation split for the different scenarios.

The split has been determined by optimisation software that operates the plant input so to minimise the cost of providing heating and electricity to the buildings.

It is important to note that for the hospital cluster there is a smaller CHP than for the other scenarios, hence a greater reliance on the gas boilers. For the other CHPs operation is maximised so to capitalise on the electricity revenues. To be eligible for HNIP, the amount of heat generated by the CHP must be greater than 75%. This is met in every scenario.

For the biomass boiler, the operation is also maximised in order to capitalise on the Renewable heat incentive that makes the cost of heat provision lower than gas boilers. For HNIP eligibility, the amount generated from the biomass must be greater than 50%, this is met in both biomass scenarios.

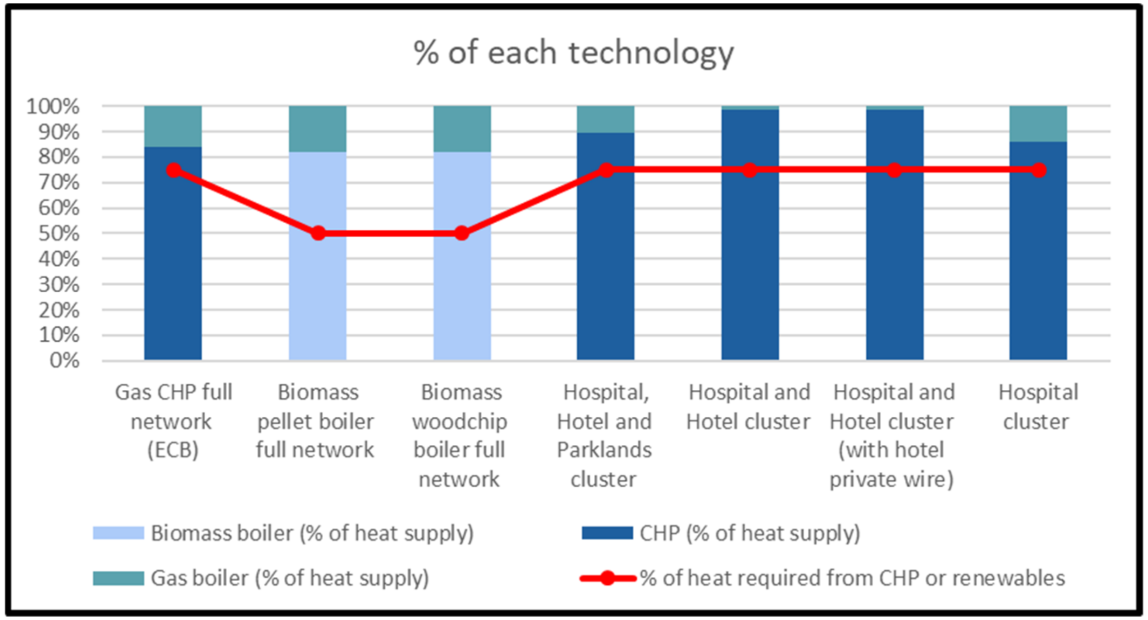


Figure 3.8.2: Generation split for different scenarios

Chapter 3 – Techno-economic analysis
3.10 Techno-economic conclusions

The feasibility modelling has revealed the following clear conclusions:

Heat source

- The preferred heat source is gas CHP. This is because gas CHP has income from the PW and a lower capex, see table 3.9.1.
- In terms of carbon saving, biomass saves more carbon over 40 years, however, over 15 years using HNDU's method gas CHP saves between 15% and 29% (see table 3.9.2 overleaf)
- Due to decarbonisation of the grid, using SAP 10 only has a carbon reduction when using biomass boilers which is a costly option.

Network size

- The most viable network size is the Hospital cluster, this is because it is a dense heat load.
- Reuse of the current hospital network should be explored and costs to replace the link pipework should be investigated to mitigate parts of the £2.9million of capex required to build a new EC and network.
- Further exploration of heating to the Hotel and Parklands cluster is required, because this returns an economically viable network. Stakeholder engagement is required particularly with St Michael's Hospice and Parklands Hospital who have not engaged in this study.

Scenario No.	Scenario	Total heat demand (kWth)	CHP (% of heat supply)	Gas boiler (% of heat supply)	Biomass boiler (% of heat supply)	CAPEX (£k)	40yr NPV (£k)	IRR (%)		
								15yr	25yr	40yr
2	Gas CHP full network (ECB)	20,599,000	84.0%	16.0%		£13,587	£815	-2.2%	1.6%	4.0%
3	Biomass pellet boiler full network	20,599,000		18.1%	81.9%	£14,317	-£17,881			
4	Biomass woodchip boiler full network	20,599,000		18.1%	81.9%	£15,371	-£7,874	-11.6%	-4.6%	-0.7%
5	Hospital, Hotel and Parklands cluster	19,363,000	89.7%	10.3%		£10,524	£3,874	1.7%	4.7%	6.4%
6	Hospital and Hotel cluster	17,372,000	98.4%	1.6%		£8,360	£3,335	2.7%	5.2%	6.8%
7	Hospital and Hotel cluster (with hotel private wire)	17,372,000	98.4%	1.6%		£8,813	£4,059	3.2%	5.7%	7.2%
8	Hospital cluster	17,287,000	86.3%	13.7%		£5,651	£5,828	9.4%	11.1%	11.8%
9	Gas CHP full network (ECA)	20,599,000	84.0%	16.0%		£13,113	£1,273	-1.7%	2.0%	4.3%
10	Gas CHP full network (ECC)	20,599,000	84.0%	16.0%		£11,812	£2,570	-0.1%	3.2%	5.3%
11	Hospital cluster (No new network)	18,353,000	81.2%	18.8%		£2,942	£7,376	23.9%	24.4%	24.4%
12	Hospital, Hotel and Parklands cluster (with hotel and hospice private wire)	19,363,000	89.7%	10.3%		£11,350	£4,543	1.8%	4.9%	6.6%

Table 3.9.1 Summary table of the different scenarios

Chapter 3 – Techno-economic analysis
3.10 Techno-economic conclusions

Energy centre location

- The current plantroom is unlikely to fit a 2MW gas CHP, so this option has been eliminated. For future flexibility a new EC is considered to be required.
- ECA – water tank area is the more economically viable option of the dedicated energy centre options, and is closer to the Manydown development and EfW connections.
- Whereas ECB – ex-laundry site is closer to the heat pumps, the capex is higher.
- ECB would be more suitable for biomass deliveries, however biomass has been eliminated.

Scenario No.	Scenario	BEIS lifetime carbon emissions				SAP 10 lifetime carbon emissions			
		BEIS (tCO_2e) 40 year	BEIS (%) 40 year	BEIS (tCO_2e) 15 year	BEIS (%) 15 year	SAP 10 (tCO_2e) 40 year	SAP 10 (%) 40 year	SAP 10 (tCO_2e) 15 year	SAP 10 (%) 15 year
2	Gas CHP full network (ECB)	26,000	12%	25,000	26%	-40,000	-12%	-10,000	-9%
3	Biomass pellet boiler full network	126,000	56%	46,000	47%	105,000	32%	41,000	35%
4	Biomass woodchip boiler full network	102,000	46%	38,000	39%	124,000	39%	48,000	41%
5	Hospital, Hotel and Parklands cluster	27,000	13%	26,000	27%	-39,000	-13%	-10,000	-9%
6	Hospital and Hotel cluster	13,000	7%	21,000	24%	-54,000	-20%	-17,000	-17%
7	Hospital and Hotel cluster (with hotel private wire)	12,000	7%	21,000	25%	-54,000	-20%	-17,000	-17%
8	Hospital cluster	0	0%	15,000	19%	-54,000	-21%	-18,000	-18%
9	Gas CHP full network (ECA)	26,000	12%	25,000	26%	-40,000	-12%	-10,000	-9%
10	Gas CHP full network (ECC)	26,000	12%	25,000	26%	-40,000	-12%	-10,000	-9%
11	Hospital cluster (No new network)	-10,000	-6%	12,000	15%	-65,000	-25%	-22,000	-23%
12	Hospital, Hotel and Parklands cluster (with hotel and hospice private wire)	26,000	12%	26,000	28%	-39,000	-13%	-10,000	-9%

Table 3.9.2 Summary table of the different scenarios

Chapter 3 – Techno-economic analysis

3.11 Funding options

Gap funding requirements

There are currently very limited gap funding requirements for the Hospital alone since we estimate an IRR above 10% and so could be privately funded. Combining the Hospital with Parklands and Hotel cluster may require some funding depending on the commercial solution chosen. Once the detailed design and financial case has been complete, gap funding requirements should be revisited.

HNDU funding

HNDU funding has been used by BDBC to complete the energy masterplanning previously undertaken by Encraft and this study. Round 8 funding is due to open in April 2019, and the next phase of this project (DPD) could apply for this funding.

HNIP funding

The other option available is the Heat Network Investment Programme (HNIP) which is designed to support projects which are:

- Viable
    - financially (taking account of HNIP funding)
    - technically
    - commercially.
- Offer sufficient economic and social benefit.
- Contribute to the HNIP wider goals for transforming the market.
- A deliverable project.
- Will deliver genuine carbon savings relative to a counterfactual scheme option.
- Have a future-proofed design to ensure that expansion and/or carbon savings can continue to be made during their expected lifetime.

This fund also supports Detailed Project Development (DPD) and capital funding for heat networks.

Key features of the funding include:

- Grants between £0 and £5million
- Loans between £25k and £10million.
- HNIP awards must be less than 50% of the capex to be incurred for the construction of the project.

This scheme is likely to be eligible for funding, as long as the future transition to heat pumps is accepted to require upgrades to the hospital.

The grant funding has a competition element and Triple Point (the scheme managers) have Business Development Managers who can assist with the application.

Renewable Heat Incentive (RHI)

The non-domestic RHI is a government programme to provide financial incentives to increase the update of renewable heat such as biomass and heat pumps.

Eligible installations receive quarterly payments over 20 years based on the amount of heat generated.

This scheme has been confirmed until 2021, although degressions are likely on biomass in this timescale.

Other funding options

See section 4.1 for information on RE:FIT and Salix which are both potential options for loans for both the hospital and council.

Chapter 4 – Commercial considerations

Chapter 4 – Commercial considerations

4.1 Purpose and approach

Purpose

This note provides a review of potentially suitable commercial delivery models for the proposed NHH heat network.

Approach

In contrast to other utility services, the heat market is largely unregulated at the national level; it is therefore the contracts between the different parties to a heat service that establish the necessary rights and obligations of each party. Consequently, practice varies widely, and delivery models range from wholly public to wholly private, with many configurations in between.

Arup's 2016 guidance for BEIS[1] on commercial delivery of heat networks identifies thirteen different roles associated with heat networks. The particular choice of delivery models is closely related to how these roles are allocated by circumstance or by choice.

We have drawn upon this guidance and prior project experience, along with the circumstances at NHH and the workshop held with BDBC and NHH, to consider the potential allocations of roles and how these allocations could combine into particular structures of contractual relationships between the relevant parties.

Basis of review

The review takes account of:

- The workshop held on 27/11/18 with BDBC &NHH
- the current technical parameters of the proposed network; and
- our current understanding of the key stakeholders, their drivers, preferences for roles and their appetite for risk.

Structure

The chapter is structured as follows:

- Section 4.2 sets out the particular commercial context in Basingstoke which has shaped the selection of commercial delivery options
- Section 4.3 looks at the outcomes of the commercial workshop
- Section 4.4 describes the three proposed commercial delivery options
- Section 4.5 provides a summary and comparison of the three options, in relation to allocation of roles, risks and opportunities.

Appendix D provides additional context on the roles in a heat network.

Key facts on Salix

- Interest free Government funding for public sector bodies.
- Funded by BEIS, Welsh Government, Scottish Government and Department for Education.
- Moving away from funding CHP alone, but if it was combined with other energy efficiency measures they would fund it.
- https://www.salixfinance.co.uk/

Key facts on RE:FIT

- Framework of ESCos selected for track record in providing energy reduction and generation measures.
- Competitively tendered and OJEU-advertised.
- The ESCo guarantees the energy savings from the works that it is undertaking over a given period.
- Heat networks can be procured under this framework.
- http://localpartnerships.org.uk/our-expertise/refit/

[1] Arup 2016. Heat Network Detailed Project Development Resource: Guidance on Strategic and Commercial Case. Arup with Lux Nova Partners, Mazars and Willis Towers Watson for the Department for Business, Energy & Industrial Strategy. Can be found here: https://www.arup.com/-/media/arup/files/publications/h/strategic_comm_hn_guide_issue_1_22072016.pdf

Chapter 4 – Commercial considerations

4.2 Commercial context for NHH and surrounding area

Feature	Significance
The majority of the heat load is controlled by the hospital who also has the majority of landholding in the area. They are interested in a heat network because their CHP has come to the end of its life and their boilers are oversized and inefficient.	The hospital would be the main customer and also undertake the promoter role. Since the hospital has limited capital, they are looking at how the capital costs can be financed, either the Council would provide funding (potentially with Heat Network Investment Programme (HNIP) assistance) or NHH would use an Energy Performance Contract (EPC) supplier under RE:FIT or/or apply for a Salix loan. At the workshop it was jointly concluded that: • NHH and BDBC needs to take the promoter role. • A public sector body or an appointed ESCo will need to take the funding and sale of heat roles.
The Apollo Hotel has an end of life boiler and they are in urgent need to a solution in the short term. They are therefore interested in connecting a heat network.	The timescales would have to work for the hotel, given the status of their boilers and the time it would take to construct and start operation of the heat network. Solutions could include the provision of temporary boilers, or the council could purchase boilers to use as back up for the network, installing them in the plantroom at the hotel.
The economic assessment of a system serving a network beyond the hospital has a lower return on investment of 1% over 40 years depending on the scenario.	At such a rate of return, the scheme would be considered economically beneficial but not commercially attractive. Additional funding would be needed to bring the scheme up to a commercially attractive rate of return (typically 12%). Alternatively, a public sector body could choose to deliver the scheme at a lower rate of return.
The most significant site is owned by the Hospital Trust.	Therefore, agreements with the hospital for a heat connection are a necessary pre-requisite to any heat network model. In terms of land, while the open park area (see figure 1.2.1 potential area for GSHPs) which belongs to BDBC could be considered for the energy centre. There are three options for land for the energy centre on the hospital site. So the most likely party to undertake the land ownership role is the hospital.
BDBC has the necessary powers to raise finance, acquire land and to procure and own a heat network.	BDBC could choose to deliver a public-owned network, with a simple Design, Build, Operate and Maintain (DBOM)-type contract for delivery and operation of the network.
NHH could deliver a heat network on their site under an EPC contract using the RE:FIT framework.	NHH don't necessarily need to engage with BDBC

Table 4.2.1: Features of commercial significance

Chapter 4 – Commercial considerations
4.3 Workshop outcomes

Table 4.3.1 shows the outcomes from the commercial workshop held on the 27th November 2018 attended by members of BDBC, NHH and HNDU.

Sale of heat is assigned to two places because this is what was proposed in the workshop. This would depend on if there was sale of electricity, because if there was the two may be combined and outsourced, whereas if it was only heat, BDBC would be more inclined to undertake the role.

BDBC	BDBC + NHH	NHH	Third party	Unknown
Asset ownership	Promoter	Customer	Operation	Sale of heat
Funder	Land ownership	Landlordship	Installation	
Supplier of last resort	Governance	Development of property	Sale of electricity	
Sale of heat			Regulation	

Table 4.3.1 Commercial workshop outcomes

Chapter 4 – Commercial considerations
4.4 Delivery models

The figures to the right show the amount of control vs the risk/reward for the parties depending on who is taking each role. This shows the different delivery models that could be undertaken, given the roles allocated above.

Figure 4.4.1 summarises the key roles allocated to different delivery models from the council's perspective.

We have identified three main options for delivery of a heat network which appear to be consistent with the conditions described above. These are:

1. BDBC led with a DBOM contract.
2. Shared leadership between BDBC and NHH with a DBOM contract.
3. Private sector led concession model.

The hospital has discounted a hospital led district heating network.

The council has a larger appetite to own a heat network than the hospital. However, the hospital would require some governance and knowledge of other users on the network, and could take on the land ownership role. It can also access funding via Salix or RE:FIT.

Each model is described in turn in the following sections. Roles, risks and opportunities for the three options are shown in Section 4.5.

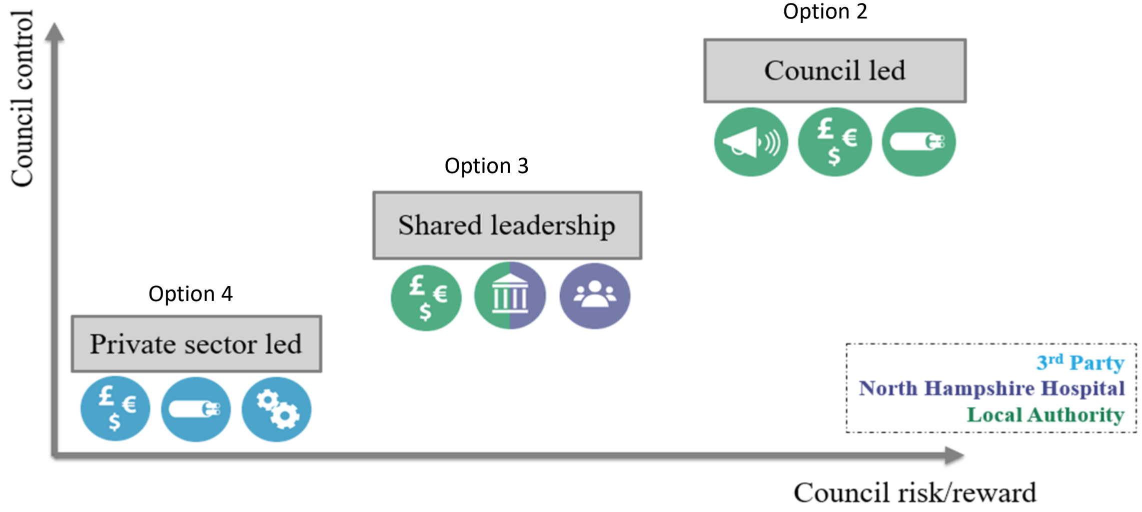


Figure 4.4.1: Delivery models for council perspective

Chapter 4 – Commercial considerations
4.4 Delivery models

Council led with DBOM contract

The simplest option for the delivery of a heat network would be for a wholly BDBC led network, with all heat sale and purchase transactions remaining with the Council or a wholly owned special purpose vehicle (SPV) established to own and operate the network.

We would expect the network itself to be delivered and operated under a conventional DBOM contract. This could be a fixed price contract, potentially with incentives for system efficiency or minimising carbon emissions. Metering and billing services could be outsourced or kept in house, depending on whether BDBC has or can acquire in-house resources for these services.

The Borough and County Councils can assist delivery of the network through a number of other actions:

- If necessary, BDBC could fund or underwrite early investment in critical path sections of the network.
- If necessary, BDBC could secure the necessary land acquisitions, easements and rights of way to enable the energy centre(s) and network to be constructed.
- Hampshire County Council as highway authority, could provide a commitment to grant the necessary licences for laying the network in the public highway.

Shared leadership between BDBC and NHH and a DBOM contract

A joint venture (JV) between BDBC and NHH, may also require the setup of an SPV to own and operate the network.

As above, we would expect the network itself to be delivered and operated under a conventional DBOM contract.

The public sector can assist delivery of the network through a number of other actions:

- NHH owns the land for the initial phase of the heat network, granting necessary leases, easements and wayleaves for a network.

Private sector led

This would be where the hospital, potentially in partnership with BDBC, lets a concession for a heat network and energy centre on the hospital site. The network could be designed to extend beyond the hospital boundary.

On such schemes a concession may be granted to a third party provider who will substantially fund, design, construct, install, operate and maintain a network across the development. A ‘concession agreement’ would grant a company or consortia exclusivity to provide heat on a given site for a period of typically 25 years or more.

The developer, or more often the appointed concession contractor, may elect to extend the network to serve customers beyond the boundaries of the original network. However the terms of the concession contract that bind parties within the original network are unlikely to be enforceable beyond it.

In seeking to reduce costs for its customers (tenants or purchasers of property for example), a private Developer of Property may decide to part fund the scheme and/or own the assets for a rate of return at a lower margin.

The private sector delivery model is attractive to Local Authorities who are risk averse and do not have the capability or appetite to undertake any of the key delivery roles associated with a heat network scheme. With Private Sector led delivery models, the only roles undertaken by a Local Authority are likely to be Promotion and potentially Development of Property and Customer.

A private sector led model passes on many of the risks to a party potentially more able to manage that risk, that private sector party does so for a return greater than what would be required from the public sector, i.e. in the long run it costs more.

Chapter 4 – Commercial considerations
4.5 Summary of commercial outcomes

Role	BDBC led	Shared leadership	Private sector led
Promotion	BDBC	NHH and BDBC	BDBC and NHH
Customer	NHH Shaws Healthcare Parklands Viridan St Michaels Hospice Apollo hotel Other outlying buildings	<-	<-
Governance	BDBC	BDBC / NHH	Private ESCo, with representation by developers and customers
Regulation	Contract / The Heat Trust (if residential)	Contract / The Heat Trust (if residential)	Contract / The Heat Trust (if residential)
Funding	BDBC HNIP	NHH: Salix BDBC HNIP	Private sector HNIP Customers (via connection agreements)
Asset ownership	BDBC (or SPV owned by BDBC)	BDBC/NHH (or jointly owned SPV)	Private ESCo
Development of property	NHH Eli Lily site	NHH Eli Lily site	NHH Eli Lily site
Land ownership	NHH mostly (paid rental from NHH)	NHH mostly	NHH mostly (paid rental from NHH)
Landlordship	NHH / Viridan	NHH / Viridan	NHH / Viridan
Installation	DBOM contractor	DBOM contractor	Private ESCo
Operation	DBOM contractor	DBOM contractor	Private ESCo
Sale of heat	BDBC or a metering/billing company employed by BDBC (or their SPV)	NHH/BDBC or a metering/billing company employed by NHH/BDBC (or their SPV)	Private ESCo
Supplier of last resort	BDBC	BDBC / NHH	NHH / BDBC

Table 4.5.1: Commercial workshop outcomes

Chapter 4 – Commercial considerations

4.5 Summary of commercial outcomes

Risk assessment

In the below table we have set out the key risks perceived for the different models. The likelihood of these risks occurring is rated low/medium/high. They are not scored here for severity.

A risks matrix for the scheme as a whole can be found in Appendix E.

Opportunities assessment

In the below table we have also outlined the key opportunities or benefits for the different parties for the various models.

A scoring has not been provided for these because such a scoring would be very subjective depending on the particular perspective from which they are viewed.

A further workshop to explore these options, including the risks and scoring of them would be beneficial in the next stage of work.

Role	BDBC led	Shared leadership	Private sector led
Risks	• Public sector takes most risks on the scheme, including demand risk (low, demand relatively well know). • BDBC does not have access to necessary skills and resources to deliver and own a heat network, so input from specialists key to avoiding poor contracts and/or poor network performance (medium). • Hospital pulls out late in the process (low).	• Agreement between NHH and BDBC needs to allocate risks appropriately to enable success of scheme (medium). • NHH has limited capital, although can get Salix loans or use RE:FIT (low). • Hospital may not wish to connect all loads (high).	• The procurement takes too long and hospital / hotel build stand-alone solutions (medium). • Future network expansion and decarbonisation may be difficult to achieve without the right specialist advice into the contract (medium).
Opportunities	• Investment returns from heat and electricity sales. • BDBC retains control to enable future network expansion and to decarbonise network.	• Investment returns (for BDBC) from heat and electricity sales. • Lower energy bills (for NHH) as a result of CHP installation and lower required IRR from BDBC. • Shared risks and benefits, lead to good collaboration between BDBC and NHH.	• A network is privately financed with little or no public sector investment or risk. • The approach becomes a model for wider cooperation in the area on infrastructure planning.

Table 4.5.2: Risks and opportunities

Chapter 5 – Conclusions and next steps

Chapter 5 – Conclusions and next steps

5.1 Conclusions

Heat network demand

- The hospital is the main heat and electrical load of the network, using 60% of the heat demand just within the main building. The hospital is currently heated by three oversized boilers, they previously had a gas CHP. They also have two steam boilers which have been excluded from this study at the hospital's request.
- Cooling was also excluded from the study because it was considered insignificant in comparison to the heating loads.

1. Which heat source is most suitable for the network?

- The most suitable heat source for the network is gas CHP. This is because it is easy to maintain, familiar technology, which gives a reasonable payback from PW income.
- Due to decarbonisation of grid supplied electricity, when using the proposed SAP 10 carbon figures (which are likely to be used on new developments from late 2019), the only carbon reduction benefit comes from the biomass boiler option. This is a more costly option and requires a higher capacity/capability of operational staff which is not favourable to either the council or hospital. In the short term (over 15 years), gas CHP has a saving of between 15 to 29% depending on the size of the heat network.
- A heat network gives the flexibility to change technology at a later date, we recommend using CHP as a transition technology for the first 15 years, followed by a low carbon technology in the future. We would expect that in the future, GSHPs could be installed in the location shown in figure 1.2.1, as long as the hospital retrofits insulation and other energy reduction methods, and large radiators.

2. Which buildings are favourable to connect to the network?

- We would recommend that the council starts with the hospital and hotel (if the hotel is interested and comes on board in the DPD stage), leaving flexibility to extend the network to the Parklands cluster as and when appropriate.
- For the Parklands cluster, further engagement with the hotel and St Michael's Hospice is required.
- It is not favourable from a carbon or financial perspective to connect the school cluster to the network. There is too little heat load to justify the additional heat network pipework. There is very limited heat load beyond the school cluster.

3. Where is the optimal location for the energy centre for a heat network?

- There is unlikely to be enough space for the gas CHP in the existing plantroom without major disruption to the hospital. Therefore we propose using a dedicated EC.
- We would recommend a stand alone energy centre to also allow flexibility to change technology in the future in location ECA – water tanks area because this option has lower capex and is closer to the Manydown development and EfW if this was to connect.

4. How can the scheme be delivered?

- There are three basic models with the potential to deliver the scheme which all have their pros and cons.
- The most attractive to the council was concluded to be either council led model or JV with the hospital.
- The hospital has little appetite to own/operate a heat network.

Other considerations

All presented figures are compared to a counterfactual that consists of the hospital and other buildings continuing to operate gas boilers rather than replacing their existing CHP and operating the scheme with the existing network.

Although scenario 8 (see table 3.9.1) is profitable it would be significantly more so if the existing heat network could be utilised which would reduce the capex by £2.9million and result in a higher IRR. There are a number of funding options that could allow the hospital to fund this scheme to realise significant savings.

Chapter 5 – Conclusions and next steps

5.2 Next steps and recommendations

Next steps

There are a number of key decisions to be made before the scheme can be progressed to final feasibility and business case.

We recommend that the Council work closely with the hospital to review the findings of this report to inform their course of action before taking forward the development of a potential heat network.

Should they wish to proceed, the critical actions and decision points are:

1. Costing of replacing the asbestos pipework, to assess whether this is lower than the £2.9million capex requirements of a heat network scheme.
2. Further stakeholder engagement with the Apollo Hotel, Parklands and St Michael's Hospice to gauge their appetite.
3. Apply for HNDU funding and procure advice to develop the delivery model and outline business case (including financial and legal). This could include procurement support so that there does not need to be a further set of funding applications. The next HNDU round opens April 2019 – to support the delivery of the Detailed Project Development (DPD).
4. Further workshop on the commercial structuring

Further recommendations

It is recommended that the hospital embark on a programme of temperature reduction wherever possible, particularly with regards return temperatures. Not only will this open up other opportunities to the hospital and network, but it will improve the efficiency of the heating system with immediate effect.

Chapter 5 – Conclusions and next steps

5.2 Next steps and recommendations

Figure 5.2.1 shows the next steps with timeline overlaid. This is superimposed on the HNDU project development timeline, which shows indicative time frames for completion of the project stages. These can be influenced by a multitude of factors, including the speed of decision making, the complexity of the project, windows of opportunity with connected loads.

It is recommended that the BEIS HNDU DPD guidance is consulted for these stages. It contains advice and example contracts for the supply of heat and power. A copy can be requested from BEIS.

The next stage in the development of this project will be to prepare an outline business case which, based on the HNDU five cases model, must articulate:

i. The project is supported by a compelling case for change that fits with the Council's strategic objectives and those of the wider public sector (the hospital) – the **Strategic Case**

ii. That the project represents best value – the **Economic Case**

iii. The proposed structure to deliver the project can be procured and is commercially viable – the **Commercial Case**

iv. The project is affordable and profitable – the **Financial Case**

v. What is required from all parties involved in delivery is achievable – the **Management Case**.

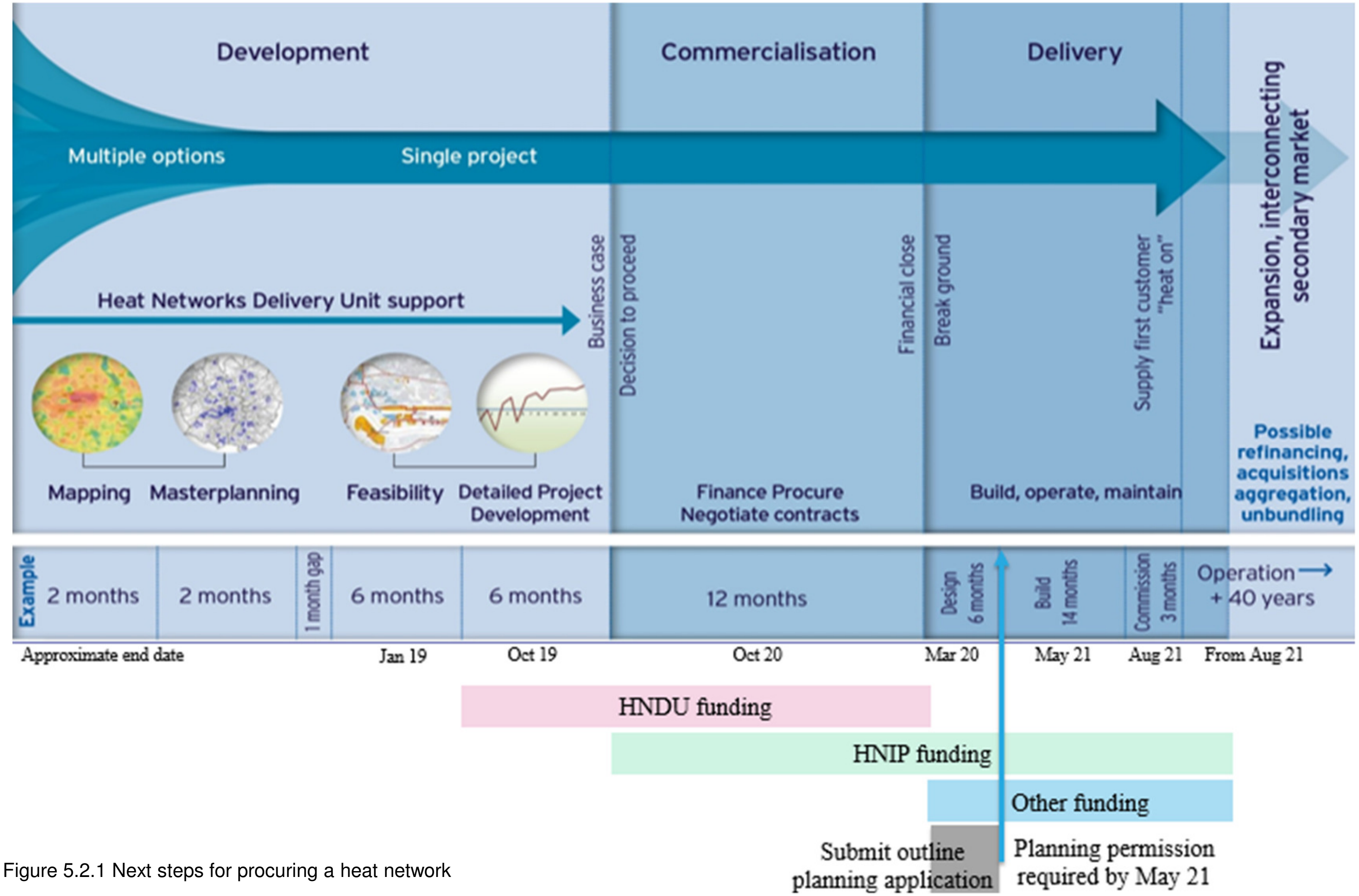
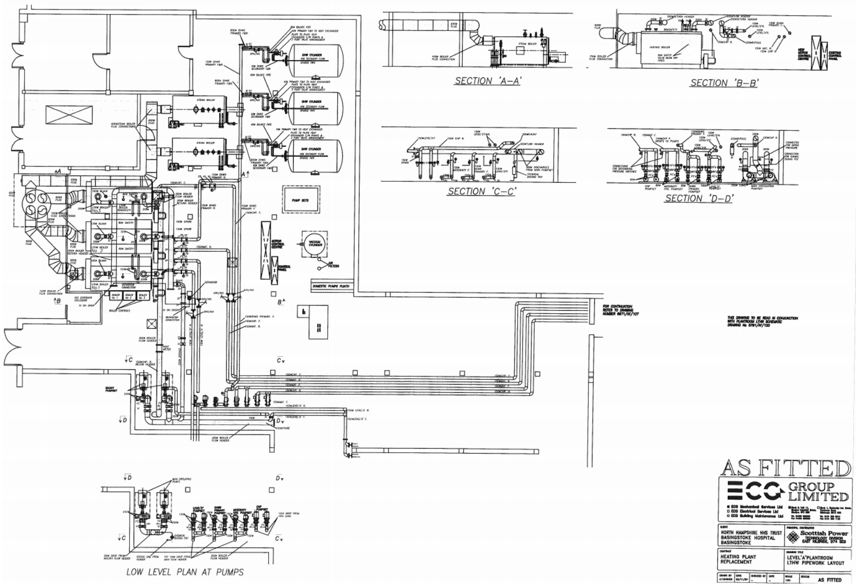
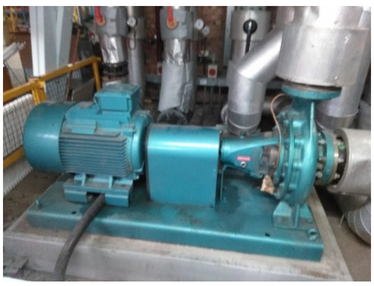


Figure 5.2.1 Next steps for procuring a heat network

Appendix A– Site visit appraisal

Basingstoke Site Visit – 30th October 2018

Undertaken by Helen Charlick, Doug Walter and Ewan Frost-Pennington

Building: Basement of the main building	
Inspection of heating system installations	 *Figure 1 schematic of the energy centre*
Secondary system	There are three heat exchangers doing the hot water, there are two shunt pumps and 4000litre hot water storage (HWS) vessel as seen in the figure below.  *Figure 2 one of the heat exchanges (left) and 4000litre HWS storage vessel (right).*  *Figure 3 Heat network shunt pump*

Primary system	The plant room had three 5MW Low Temperature Hot Water (LTHW) Viessmann boilers.  *Figure 4 5MW LTHW Viessmann boilers* In addition to this there were 2 x Cochran steam boilers as shown in the figure below. The steam boilers are used for sterilisation, and not heating. Steam is not considered in this study, because the hospital is considering outsourcing the steam.  *Figure 5 one of the 2 Cochran steam boilers and its plate*
Age of heating system	20 years old
Operating Temperatures	Assumed 80ºC
Existing Flue	Yes - 41m tall, taking the three flues into it.

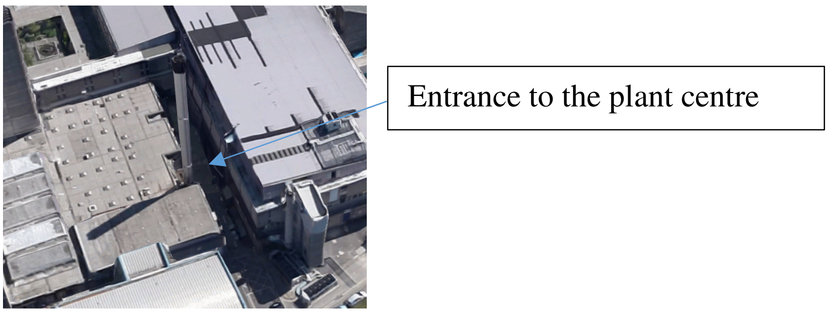
	 *Figure 6 Main hospital flue for the main plant room boilers*
Thermal Store	
Grid Connection	This is fed from the High Voltage (HV) substation on site
Gas Connection	Fed from the gas station on site
Inspect external approach to plant room	Hard dig to approach the site if new pipework was to be installed, see the figure below which is taken from the entrance indicating a difficult hard dig with access needed to the court yard.  *Figure 7 Image taken from the entrance to the plant room onto the courtyard outside*  *Figure 8 Image taken from google maps, with the entrance to the energy centre to the left of the red star*
Age and fabric of building	Some of it is 80 years old, other bits are temporary porta-cabins – a real mixture of building fabric. Asbestos pipes:

	 *Figure 9 With the temporary porta-cabins and pipes visible in the distance over the top of the 1 storey building*
Inspect spatial constraints in mechanical plant rooms	There is quite a lot of space, although not a lot of head room in this plant room. Boilers could be taken out easily with venting behind the boilers big enough for them to be removed.
Other Notes	There are plans to look at downsizing burners in all the boilers in this plant room for the time being, the end of life is the next 5-10 years, so the hospital is preparing for this. The hospital's main reason for wanting a district heating scheme to go ahead, is to get rid of asset liability.
Additional hospital buildings including	They would look to add additional buildings that have separate heating systems when their individual boilers come to end of life.  *Figure 10 Overton building one of the multiple portacabin buildings on the site with different heating systems* Overton Unit – electric heating – porta cabin The Firs – gas boilers Linac / Candover Clinc – own boilers Octivo housing – own boilers The Ark - some of its own heating and some connected to the hospital. Haemophilia centre – own boilers

Energy centre location A	This was where the laundry was done. There is a huge warehouse building which is not in use. This already has concrete foundations. There is a decommissioned gas incomer here. This used to power the laundry. There is also an electrical substation here which is connected to the hospital ring main so inside the private wire system.  *Figure 11 The unused laundry building, with an old gas connection evident on the right of the photo*  *Figure 12 The substation next to the laundry*
New energy centre location	Behind the water tank there is a space which could be accessed through the car park. The size and levels of this should be assessed from GIS.  *Figure 13 Unused space behind the water tanks, good flat space that used to have additional water tanks on it* This location is right next to the HV and gas connections.

	 *Figure 14 Inside the rooms containing the gas (left) and electrical (right) connections*
HV Substation	This is located next to the gas main incomer, hospital would wish to connect CHP to the HV if possible.
Gas main incomer	1.33 bar, did originally have interruptible and firm supply, but now only firm.
Oil tanks	3 of these, only using 1 now, the oil in them is 20 years old. Used very little – only for testing. The hospital can (and has) risk assess and not conform to HMT.  *Figure 15 oil tanks of which only one has been utilised*

Building:	**Hospital Sherborne Building**
Secondary heating systems	There are two hovel calorifiers here. These supply the DHW in this part of the building. There is also a manifold for the central heating for this end of the building. The routing of the heat network to reach the Sherborne building requires access through a small duct with asbestos present within it.  *Figure 16 two Hoval calorifiers (left) and the manifold for the central heating (right)* The hospital wishes to put a heat exchanger here which would take on the Sherborne Building's load and separate it from the link corridor. This could be located where the CHP is.
Primary heating systems	1MWe CHP that is no longer functional in an acoustic container. Irrespective of option opted for this CHP will need to be removed, but to do so will require it to be disassembled due to a small entrance to the plant room. The hospital could investigate selling it to Iran etc., though Scottish Power did look at selling it but didn't have any success.  *Figure 17 The acoustic casing for the CHP (left), and the CHP plate (right)*

Age of heating system	1970s
Operating Temperatures	Assumed to be 80ºC
Existing Flue	Yes, but would take out
Thermal Store	2* calorifiers here
Grid Connection	Yes
Gas Connection	Yes
Inspect external approach to plant room	Easy access through car park, would be hard dig.  *Figure 18 Access to the Sherborne Building plant room (green door) in central image*
Age and fabric of building	1970s and brick
Inspect spatial constraints in mechanical plant rooms	Very constrained, although when CHP and flue are removed there will be space. Beware that crawl corridors may have asbestos in them.
Other notes – DTC heating system	Separately from this study, the hospital wishes to put the DTC which is also fed from the link corridor on to another hydraulically separate circuit, so they can remove the (asbestos covered) pipework from the link corridor. This would need to sit in the space where the link corridor pipework is.  *Figure 19 Pipework between the Sherborne Building and Main Hospital plant rooms*

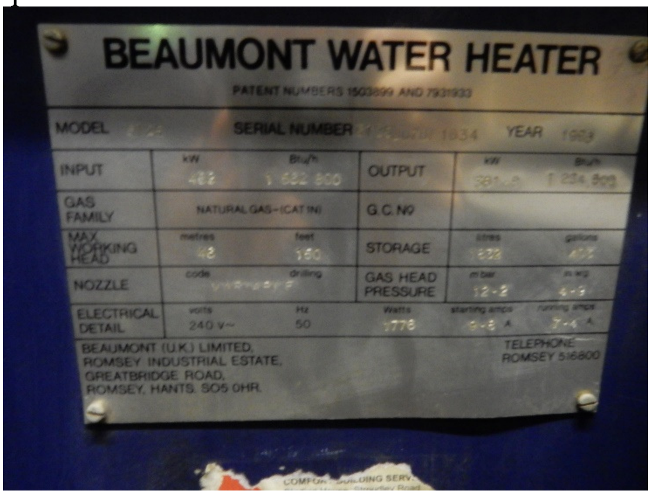
<table>
<tr><td>Building: Apollo Hotel</td><td>125 bedrooms, 32 have DHW supplied by separate boilers. Would be willing to pay to connect to a DH system to avoid heating system upgrades.</td></tr>
<tr><td colspan="2">Inspect heating system installations</td></tr>
<tr><td>Secondary system</td><td>Radiators. Water heaters are separate.</td></tr>
<tr><td>Primary system</td><td>Main boiler room:
The boilers spec sheets can be seen in the images below. They are both old and need to be replaced. There is no redundancy in this system.
They are looking at replacing with modular boilers. Has had a quote.


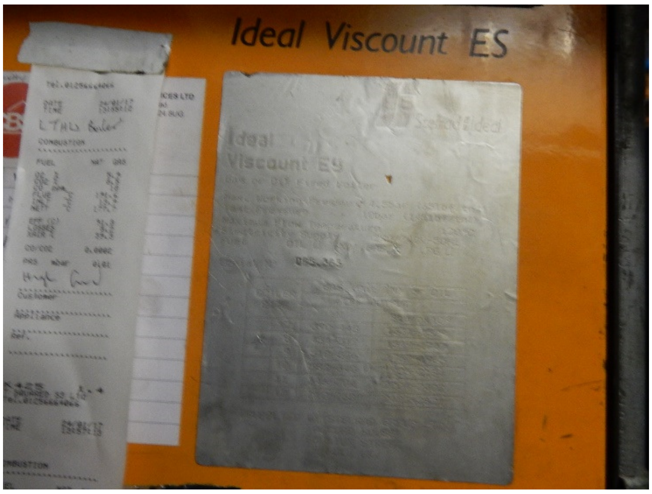
Figure 20 Beaumont water heater


Figure 21 Ideal Viscount ES 454-512kW

DHW plant room:
1987 hot water heaters.</td></tr>
</table>

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<tr><td></td><td>

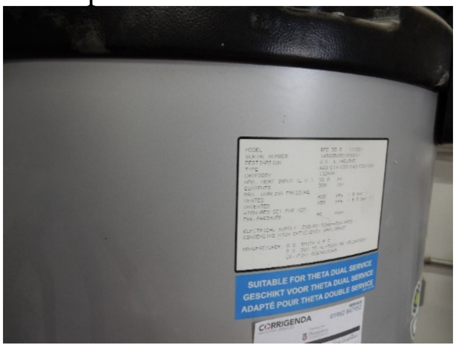
Figure 22 The hot water heaters used in the domestic hot water plant room

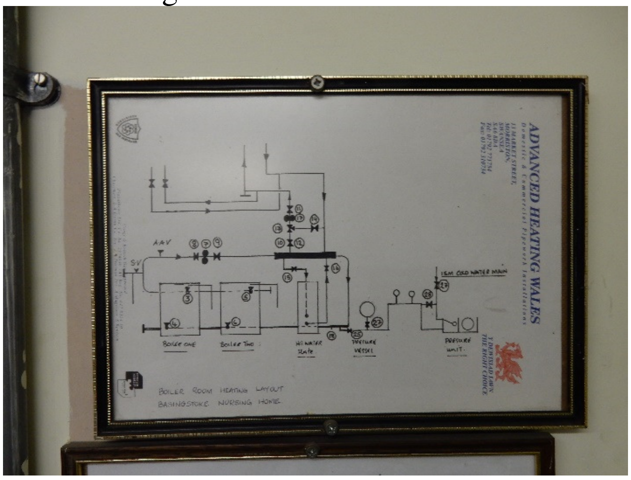
Swimming pool plant room:
Small boiler 60kW located up a ladder. Used to top up the AHUs that use the excess heat for the small swimming pool.

Figure 23 the swimming pool top up boiler that backups the air handling units is used to heat the pool water</td></tr>
<tr><td>Age of heating system</td><td>1996 / 1987</td></tr>
<tr><td>Operating Temperatures</td><td>Was operating at 40 °C, but unlikely this is the norm – midday.</td></tr>
<tr><td>Existing Flue</td><td>Looked old and like it was leaking (probably just condensate)</td></tr>
<tr><td>Thermal Store</td><td>None</td></tr>
<tr><td>Grid Connection</td><td>No info</td></tr>
<tr><td>Gas Connection</td><td>No info</td></tr>
<tr><td>Inspect external approach to plant room</td><td>The main plant room is down two flights of stairs in a basement. The heat exchanger could be located just outside the adjoining wall and the pipes taken down the stairs. There are lots of containers around the building used for archiving so it's unlikely that this would be an issue as there was low concern for the aesthetics in this part of the hotel as can be seen in the figure below.

Figure 24 the steps down to the plant room from the car park (left), the area at the top of the stairs next to the car park (right)</td></tr>
</table>

	Pipe approach would be over a mound – lots of soft dig, and then through a tunnel under the road, this would probably need hard dig to avoid making the tunnel smaller.  *Figure 25 the entrance to the area next to the car park where the plantroom can be accessed (left), car park that would need to be crossed (left)*  *Figure 26 park next to the car park that would have to be crossed to join the hospital network*
Age and fabric of building	Some of it is 80 years old, the swimming pool was 1999.
Inspect spatial constraints in mechanical plant rooms	Plant rooms are all tight and the main one is in a basement.
Other Notes	Is very keen to join the network provided it makes financial sense, as the existing equipment is outdated and in poor condition

Building: Castle Hill Primary School	
Inspect heating system installations	
Secondary system	Large radiators and modern heating system DHW provided via a hot water boiler  *Figure 27domestic hot water supply*
Primary system	Three gas meters, GM1: 20242m^3 for CH GM2: 5868m^3 for DHW Two gas boilers - Remeha – 90kW + space saved for one more
Age of heating system	2015 with new extensions being built as we visited, including putting in pipework to connect the new building to the current plant room.
Operating Temperatures	1.5 bar, at most 60 ºC Plastic pipework.
Existing Flue	
Thermal Store	none
Grid Connection	
Gas Connection	
Inspect external approach to plant room	DH pipework already in-situ to heat the new building under construction. Not much space.  *Figure 28 adjacent park that would have to be crossed in order to connect to a heat network*
Age and fabric of building	2015 for the current building/ plant room serving 230 kids. Second building under construction to serve total of 40.
Inspect spatial constraints in mechanical plant rooms	The current plant room is small, but there is space saved to connect to the new building, so a heat exchanger could potentially be put there.
Other Notes	We would expect good fabric efficiency and low demand.

Building: Homefield House	24 dementia residents.
Inspect heating system installations	
Secondary system	Radiators Heat exchanger for DHW set to 60ºC  *Figure 29 layout of the secondary heat system*
Primary system	Berkeley boilers * 2 – 1990s Duty standby.  *Figure 30 cramped boiler room with old boilers in that need to be replaced in the short term*
Age of heating system	1990s
Operating Temperatures	90ºC flow, 1.5bar
Existing Flue	Balanced flue
Thermal Store	
Grid Connection	
Gas Connection	
Inspect external approach to plant room	Hedge in the way, would need to go around back of the building.  *Figure 31 ground behind the plant room entrance*

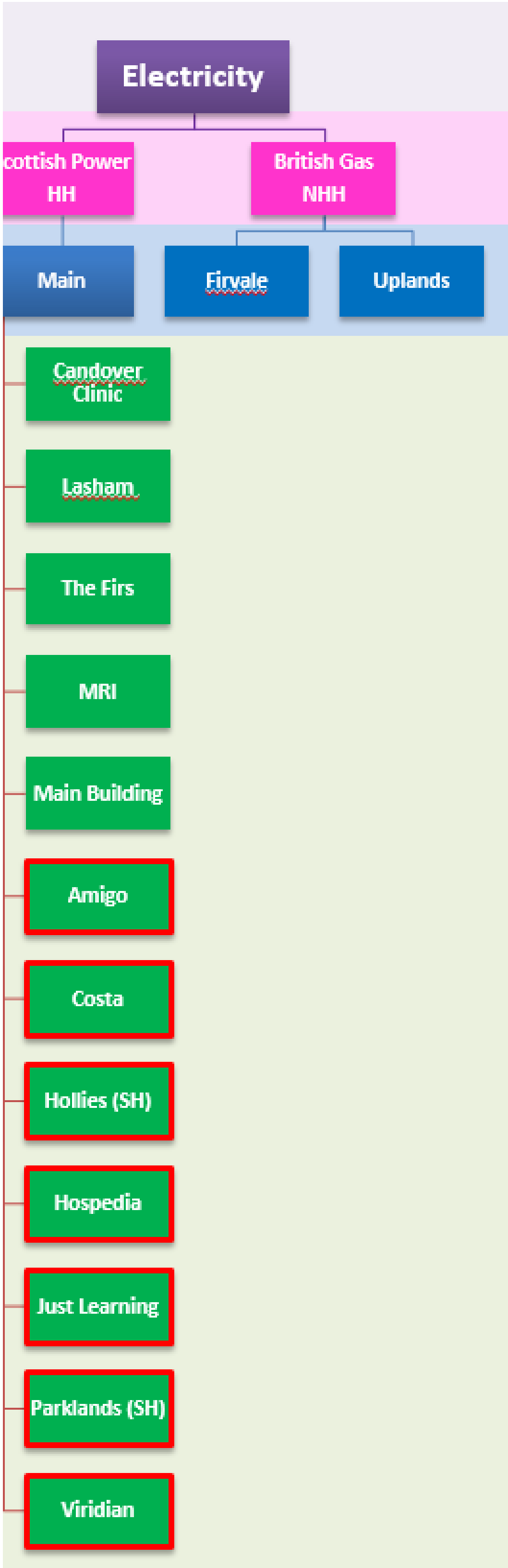
Age and fabric of building	Brick 90s?
Inspect spatial constraints in mechanical plant rooms	No space in plant room, but a fenced off bin store is behind which has space to locate a heat exchanger which could have pipework going through the wall into the plant room.
Other Notes	There is a Worcester Greenstar 25i in the ex day care centre. This is a combi.  *Figure 32 small boiler for the extension that is new and would not need replacing in the short term*

Appendix B – Model assumptions

Hospital electricity demand assumptions

Total site electricity 2017/18 = 11,553,300 kWh

Assume this includes all hospital buildings excluding Firvale and Uplands as per the diagram below



Assumed value for main hospital building

Meter readings were taken from 03. Consumption report (Building Summary tab) for 2017/18 for each of the buildings assumed to be in the main electricity meter with the exception of the main building. The main building reading (38,809,658 kWh) was significantly larger than the total reading and included a number of fiscal meter readings. A total for the main building was therefore found by subtracting all the other meter readings from the total site electricity.

Building	**Assumed kWh 2017 - 2018**
AAU	130,980
Ambulance	1,371
Amigo	51,172
Candover	788,095
DTC	622,716
Fairway	3,703
Headway place	14,628
Just Learning	29,828
Lasham	26,461
Main hospital building	UNKNOWN
MRI	308,325
Nightingale	4,889
Parklands	764,934
Sherborne	905,893
The Firs	86,654
Viridian	373,563
WH Smith	79,309
Willet hut	41,234
Total	**4,233,755**
Main electricity import	**11,553,000**
Calculated main hospital building value	**7,712,345**

Using hospital main building GIFA = 43,446 m^2 from 01. Sites and Utilities Details, this gives an electricity use per floor area of 177.52 kWh/m^2/year.

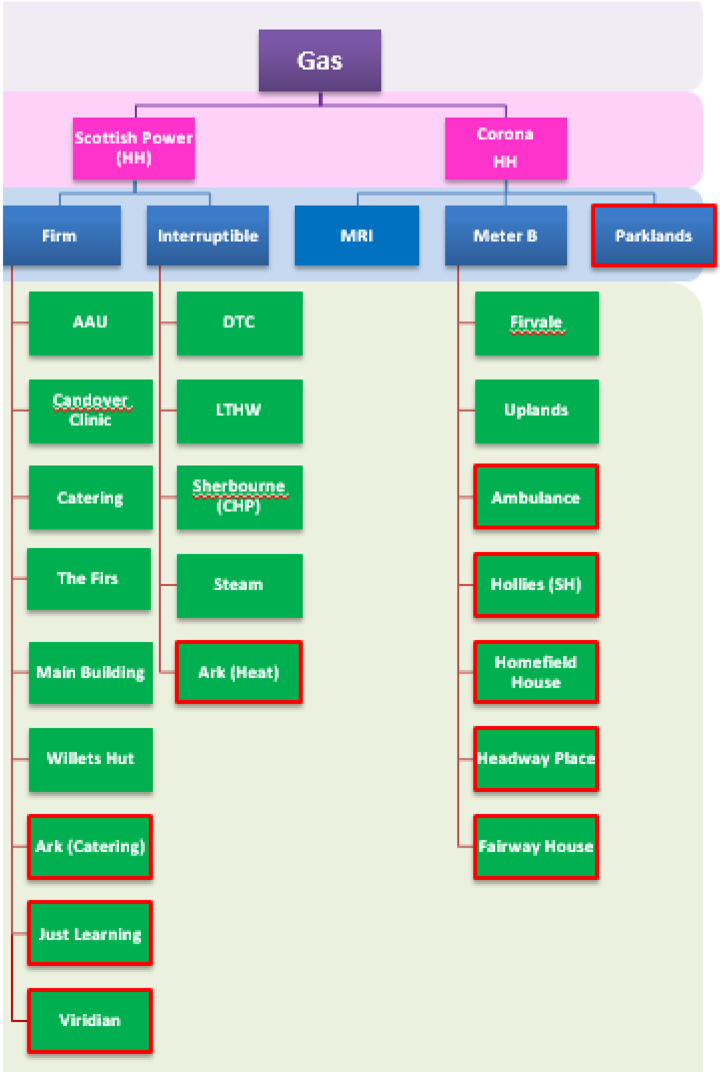
A percentage was then ascribed to each building according to the percentage of the total site import that it accounted for. This percentage was applied to the 2017 HHD for electricity for the main site.

Building	**Assumed kWh 2017 - 2018**	**Percentage of main import (%)**
AAU	130,980	1.10
Ambulance	1,371	0.01
Amigo	51,172	0.43
Candover	788,095	6.60
DTC	622,716	5.21
Fairway	3,703	0.03
Headway place	14,628	0.12
Just Learning	29,828	0.25
Lasham	26,461	0.22
Main hospital building	7,712,345	64.56
MRI	308,325	2.58
Nightingale	4,889	0.04
Parklands	764,934	6.40
Sherborne	905,893	7.58
The Firs	86,654	0.73
Viridian	373,563	3.13
WH Smith	79,309	0.66
Willet hut	41,234	0.35

Assumed profiles for Firvale and Uplands

For Firvale and Uplands, a demand profile was created from the HHD and applied to the 2017 total for electricity demand for each of these buildings to allow an assumed HHD electricity value to be compiled for these buildings.

Hospital gas demand assumption



Assumed value for main hospital building

Meter readings from 03. Consumption report (Building Summary tab) for 2017/18 show the total gas consumption for the hospital main building (58,714,829kWh) to be significantly larger than for the total import for the site.

The total of the other buildings on the firm meter was calculated and subtracted from the 2017/18 'Main N gas meter firm corrected' reading.

Building on firm gas meter	**2017 - 18 gas (kWh)**
AAU	**14,348**
Candover	**214,355**
Catering	**24,201**
The Firs	**174,390**
Main building	***UNKNOWN***
Wilets Hut	**48,626**
Ark Catering	**21,643**

Just Learning	**106,259**
Viridian	**1,245,959**
TOTAL	***1,849,780***
Firm gas meter 2017-18 total	**2,463,058**
Main building assumption	***613,279***

Using hospital main building GIFA = 43,446 m^2 from 01. Sites and Utilities Details, this gives a gas consumption of 14.12kWh/m^2/year however CIBSE TM46 recommends using a benchmark of 420kWh/m^2/year.

It is therefore assumed that this value feeds catering services within the main hospital building.

It was assumed that the heat for the main hospital building and Sherborne building currently comes from the LTHW on the interruptible gas meter. Summing the values for the other supply areas on this meter allowed the LTHW gas consumption value to be calculated.

Calculation to determine the main building gas consumption	
Building on interruptible gas meter	**2017 - 18 gas (kWh)**
DTC*	14,275
LTHW	
Sherborne CHP	
Steam	5,339,609
Ark Heat*	951,100
TOTAL	***6,304,984***
Interruptible gas meter 2017-18 total	**20,682,133**
Main building and Sherborne assumption	***14,377,149***

*Where heat metering is given rather than gas metering, the meter reading has been multiplied by 1.25 to assume a conversion efficiency of 80%. We understand that these may actually be fed from the LTHW however, subtracting them from the total value leaves the gas provided to the rest of the main hospital building and the Sherborne building.

Using hospital main building GIFA = 43,446 m^2 from 01. Sites and Utilities Details, and assuming a GIFA of 2185 m^2 for the Sherborne building this gives an gas consumption per floor area of 315 kWh/m^2/year which is still lower than expected for a hospital building as detailed above.

Therefore, the assumed gas consumption for the main hospital building is 13,688,711kWh/year and 688,437kWh/year for Sherborne.

Sheet1

Scenario Testing — Active Scenario

		Unit	1	2	3	4	5	Comment
Scenario Number	5		1	2	3	4	5	
Scenario Name	Hospital cluster		Gas CHP full network (ECB)	Biomass pellet boiler full network	Biomass woodchip boiler full network	Hospital and Hotel cluster (with hotel private wire)	Hospital cluster	
First Scenario Run	1							
	to							
Last Scenario Run	20							

Time

		Unit	1	2	3	4	5	Comment
1st model column start date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	Earliest Completion date
Months per model period	12	months	12	12	12	12	12	
Opening balance sheet date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	
Length of forecast period	40	years	40	40	40	40	40	
First modelling column financial year number	2020	year #	2020	2020	2020	2020	2020	
Financial year end month number	12	month #	12	12	12	12	12	
Forecast heat-on date	-	date						
RHI payment term	20	years	20	20	20	20	20	Current Non-Dom RHI contract period
Number of Tier 1 RHI Run hours	1314		1314	1314	1314	1314	1314	Tier 1 tariff timetable

Technical Inputs

Demand Side

Input Load Names	Load connected?	Unit	1	2	3	4	5	Comment
A. Hospital Main Building	1	flag	1	1	1	1	1	Scenario testing
B. The Firs	1	flag	1	1	1	1	1	Scenario testing
C. The Arc	0	flag	1	1	1	0	0	Scenario testing
D. MRI	1	flag	1	1	1	1	1	Scenario testing
E. AAU	1	flag	1	1	1	1	1	Scenario testing
F. DTC	1	flag	1	1	1	1	1	Scenario testing
G. Sherbourne Building	1	flag	1	1	1	1	1	Scenario testing
H. St. Michael's Hospice	0	flag	1	1	1	0	0	Scenario testing
I. Parklands	0	flag	1	1	1	0	0	Scenario testing
J. Castle Hill Primary School	0	flag	1	1	1	0	0	Scenario testing
K. Firvale	0	flag	1	1	1	0	0	Scenario testing
L. Homefield House	0	flag	1	1	1	0	0	Scenario testing
M. Rooksdown Community Centre	0	flag	1	1	1	0	0	Scenario testing
N. Fairway House	0	flag	1	1	1	0	0	Scenario testing
O. Headway Place	0	flag	1	1	1	0	0	Scenario testing
P. Apollo Hotel	0	flag	1	1	1	1	0	Scenario testing
Q. Just Learning	0	flag	1	1	1	0	0	Scenario testing
R. Viridian	0	flag	1	1	1	0	0	Scenario testing
S. Candover Clinic	1	flag	1	1	1	1	1	Scenario testing
Number of connections	7	no.						

Building Typologies	Primary Typology	Unit	1	2	3	4	5	Comment
A. Hospital Main Building	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
B. The Firs	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
C. The Arc	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
D. MRI	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
E. AAU	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
F. DTC	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
G. Sherbourne Building	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
H. St. Michael's Hospice	Non-domestic residential	label	Non-domestic residential	Non-domestic residential	Non-domestic residential	Non-domestic residential	Non-domestic residential	Not used in the model - only for context

I. Parklands	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
J. Castle Hill Primary School	School	label	School	School	School	School	School	Not used in the model - only for context
K. Firvale	Non-domestic residential	label	Non-domestic residential	Non-domestic residential	Non-domestic residential	Non-domestic residential	Non-domestic residential	Not used in the model - only for context
L. Homefield House	Non-domestic residential	label	Non-domestic residential	Non-domestic residential	Non-domestic residential	Non-domestic residential	Non-domestic residential	Not used in the model - only for context
M. Rooksdown Community Centre	Public	label	Public	Public	Public	Public	Public	Not used in the model - only for context
N. Fairway House	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
O. Headway Place	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context
P. Apollo Hotel	Hotel	label	Hotel	Hotel	Hotel	Hotel	Hotel	Not used in the model - only for context
Q. Just Learning	Education	label	Education	Education	Education	Education	Education	Not used in the model - only for context
R. Viridian	Residential	label	Residential	Residential	Residential	Residential	Residential	Not used in the model - only for context
S. Candover Clinic	Hospital	label	Hospital	Hospital	Hospital	Hospital	Hospital	Not used in the model - only for context

Existing or New	**Existing / New**							
A. Hospital Main Building	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
B. The Firs	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
C. The Arc	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
D. MRI	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
E. AAU	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
F. DTC	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
G. Sherbourne Building	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
H. St. Michael's Hospice	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
I. Parklands	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
J. Castle Hill Primary School	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
K. Firvale	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
L. Homefield House	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
M. Rooksdown Community Centre	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
N. Fairway House	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
O. Headway Place	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
P. Apollo Hotel	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
Q. Just Learning	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
R. Viridian	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
S. Candover Clinic	Existing	label	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context

Private Wire Network

A. Hospital Main Building Private Wire	1	flag	1	1	1	1	1	On hospital ring main
B. The Firs Private Wire	1	flag	1	1	1	1	1	On hospital ring main
C. The Arc Private Wire	0	flag	0	0	0	0	0	Not on hospital ring main
D. MRI Private Wire	1	flag	1	1	1	1	1	On hospital ring main
E. AAU Private Wire	1	flag	1	1	1	1	1	On hospital ring main
F. DTC Private Wire	1	flag	1	1	1	1	1	On hospital ring main
G. Sherbourne Building Private Wire	1	flag	1	1	1	1	1	On hospital ring main
H. St. Michael's Hospice Private Wire	0	flag	0	0	0	0	0	Not on hospital ring main
I. Parklands Private Wire	1	flag	1	1	1	1	1	On hospital ring main
J. Castle Hill Primary School Private Wire	0	flag	0	0	0	0	0	Not on hospital ring main
K. Firvale Private Wire	0	flag	0	0	0	0	0	Not on hospital ring main
L. Homefield House Private Wire	0	flag	0	0	0	0	0	Not on hospital ring main
M. Rooksdown Community Centre Private Wire	0	flag	0	0	0	0	0	Not on hospital ring main
N. Fairway House Private Wire	0	flag	0	0	0	0	0	Not on hospital ring main
O. Headway Place Private Wire	0	flag	0	0	0	0	0	Not on hospital ring main
P. Apollo Hotel Private Wire	0	flag	0	0	0	1	0	Not on hospital ring main however included in private wire for Scenario 7
Q. Just Learning Private Wire	1	flag	1	1	1	1	1	On hospital ring main
R. Viridian Private Wire	1	flag	1	1	1	1	1	Not on hospital ring main
S. Candover Clinic Private Wire	1	flag	1	1	1	1	1	On hospital ring main
Number of PW connections	0	no.	0	0	0	1	0	Only hotel PW is new

Connection Dates

A. Hospital Main Building Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	Assumed comes online at project outset
B. The Firs Connection Date	01 Jan 2030	date	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	Gas boilers currently 10 years old - Andrew rover email
C. The Arc Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	No info on boiler available however it is partially heated from the hospital
D. MRI Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	Assume fed from main hospital
E. AAU Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	Assume fed from main hospital
F. DTC Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	Fed from main hospital plant room - Andrew Drover email
G. Sherbourne Building Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	Currently fed from main hospital plant room, previously own CHP - Andrew Drover email
H. St. Michael's Hospice Connection Date	01 Jan 2025	date	01 Jan 2025	01 Jan 2025	01 Jan 2025	01 Jan 2025	01 Jan 2025	Limited communication made to date therefore allowing longer for discussions
I. Parklands Connection Date	01 Jan 2025	date	01 Jan 2025	01 Jan 2025	01 Jan 2025	01 Jan 2025	01 Jan 2025	Limited communication made to date therefore allowing longer for discussions
J. Castle Hill Primary School Connection Date	01 Jan 2035	date	01 Jan 2035	01 Jan 2035	01 Jan 2035	01 Jan 2035	01 Jan 2035	New boilers installed 2015
K. Firvale Connection Date	01 Jan 2025	date	01 Jan 2025	01 Jan 2025	01 Jan 2025	01 Jan 2025	01 Jan 2025	New boilers installed 2005 - Andrew Drover email
L. Homefield House Connection Date	01 Jan 2025	date	01 Jan 2025	01 Jan 2025	01 Jan 2025	01 Jan 2025	01 Jan 2025	Site visit
M. Rooksdown Community Centre Connection Date	01 Jan 2030	date	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	Assumed comes online at project outset
N. Fairway House Connection Date	01 Jan 2030	date	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	Assumed comes online at project outset
O. Headway Place Connection Date	01 Jan 2030	date	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	Assumed comes online at project outset
P. Apollo Hotel Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	Boilers in need of repair - site visit

Q. Just Learning Connection Date	01 Jan 2030	date	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	Assumed comes online at project outset
R. Viridian Connection Date	01 Jan 2030	date	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	01 Jan 2030	Assumed comes online at project outset
S. Candover Clinic Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	Boilers are 10 years old - Andrews Drover email

Heat Loads

Sensitivity Test Heat Demand Change	-		-	-	-	-	-	
Proportion of heat load that are losses	10%	%	**10%**	**10%**	**10%**	**10%**	**10%**	
A. Hospital Main Building Heat Load	11,441,593	kWh	11,441,593	11,441,593	11,441,593	11,441,593	11,441,593	From 264528-00 NHH Assumptions table and profile
B. The Firs Heat Load	139,512	kWh	139,512	139,512	139,512	139,512	139,512	From 264528-00 NHH Assumptions table and profile
C. The Arc Heat Load	760,880	kWh	760,880	760,880	760,880	760,880	760,880	From 264528-00 NHH Assumptions table and profile
D. MRI Heat Load	167,471	kWh	167,471	167,471	167,471	167,471	167,471	From 264528-00 NHH Assumptions table and profile
E. AAU Heat Load	11,478	kWh	11,478	11,478	11,478	11,478	11,478	From 264528-00 NHH Assumptions table and profile
F. DTC Heat Load	11,420	kWh	11,420	11,420	11,420	11,420	11,420	From 264528-00 NHH Assumptions table and profile
G. Sherbourne Building Heat Load	550,750	kWh	550,750	550,750	550,750	550,750	550,750	From 264528-00 NHH Assumptions table and profile
H. St. Michael's Hospice Heat Load	1,286,712	kWh	1,286,712	1,286,712	1,286,712	1,286,712	1,286,712	From 264528-00 NHH Assumptions table and profile
I. Parklands Heat Load	1,085,167	kWh	1,085,167	1,085,167	1,085,167	1,085,167	1,085,167	From 264528-00 NHH Assumptions table and profile
J. Castle Hill Primary School Heat Load	132,376	kWh	132,376	132,376	132,376	132,376	132,376	From 264528-00 NHH Assumptions table and profile
K. Firvale Heat Load	52,824	kWh	52,824	52,824	52,824	52,824	52,824	From 264528-00 NHH Assumptions table and profile
L. Homefield House Heat Load	379,978	kWh	379,978	379,978	379,978	379,978	379,978	From 264528-00 NHH Assumptions table and profile
M. Rooksdown Community Centre Heat Load	453,600	kWh	453,600	453,600	453,600	453,600	453,600	From 264528-00 NHH Assumptions table and profile
N. Fairway House Heat Load	371,127	kWh	371,127	371,127	371,127	371,127	371,127	From 264528-00 NHH Assumptions table and profile
O. Headway Place Heat Load	73,584	kWh	73,584	73,584	73,584	73,584	73,584	From 264528-00 NHH Assumptions table and profile
P. Apollo Hotel Heat Load	1,419,384	kWh	1,419,384	1,419,384	1,419,384	1,419,384	1,419,384	From 264528-00 NHH Assumptions table and profile
Q. Just Learning Heat Load	85,007	kWh	85,007	85,007	85,007	85,007	85,007	From 264528-00 NHH Assumptions table and profile
R. Viridian Heat Load	996,767	kWh	996,767	996,767	996,767	996,767	996,767	From 264528-00 NHH Assumptions table and profile
S. Candover Clinic Heat Load	171,484	kWh	171,484	171,484	171,484	171,484	171,484	From 264528-00 NHH Assumptions table and profile
Sensitivity check - Change in heat demand		kWh	-	-	-	-	-	

Peak Demands

A. Hospital Main Building Peak Demand	3,013	kW	3,013	3,013	3,013	3,013	3,013	From 264528-00 NHH Assumptions table and profile
B. The Firs Peak Demand	37	kW	37	37	37	37	37	From 264528-00 NHH Assumptions table and profile
C. The Arc Peak Demand	200	kW	200	200	200	200	200	From 264528-00 NHH Assumptions table and profile
D. MRI Peak Demand	44	kW	44	44	44	44	44	From 264528-00 NHH Assumptions table and profile
E. AAU Peak Demand	3	kW	3	3	3	3	3	From 264528-00 NHH Assumptions table and profile
F. DTC Peak Demand	3	kW	3	3	3	3	3	From 264528-00 NHH Assumptions table and profile
G. Sherbourne Building Peak Demand	145	kW	145	145	145	145	145	From 264528-00 NHH Assumptions table and profile
H. St. Michael's Hospice Peak Demand	437	kW	437	437	437	437	437	From 264528-00 NHH Assumptions table and profile
I. Parklands Peak Demand	286	kW	286	286	286	286	286	From 264528-00 NHH Assumptions table and profile
J. Castle Hill Primary School Peak Demand	44	kW	44	44	44	44	44	From 264528-00 NHH Assumptions table and profile
K. Firvale Peak Demand	14	kW	14	14	14	14	14	From 264528-00 NHH Assumptions table and profile
L. Homefield House Peak Demand	100	kW	100	100	100	100	100	From 264528-00 NHH Assumptions table and profile
M. Rooksdown Community Centre Peak Demand	167	kW	167	167	167	167	167	From 264528-00 NHH Assumptions table and profile
N. Fairway House Peak Demand	98	kW	98	98	98	98	98	From 264528-00 NHH Assumptions table and profile
O. Headway Place Peak Demand	19	kW	19	19	19	19	19	From 264528-00 NHH Assumptions table and profile
P. Apollo Hotel Peak Demand	482	kW	482	482	482	482	482	From 264528-00 NHH Assumptions table and profile
Q. Just Learning Peak Demand	54	kW	54	54	54	54	54	From 264528-00 NHH Assumptions table and profile
R. Viridian Peak Demand	789	kW	789	789	789	789	789	From 264528-00 NHH Assumptions table and profile
S. Candover Clinic Peak Demand	45	kW	45	45	45	45	45	From 264528-00 NHH Assumptions table and profile

Electricity Loads

A. Hospital Main Building Electricity Load	7,732,532	kWh	7,732,532	7,732,532	7,732,532	7,732,532	7,732,532	From 264528-00 NHH Assumptions table and profile
B. The Firs Electricity Load	92,122	kWh	92,122	92,122	92,122	92,122	92,122	From 264528-00 NHH Assumptions table and profile
C. The Arc Electricity Load	42,435	kWh	42,435	42,435	42,435	42,435	42,435	From 264528-00 NHH Assumptions table and profile
D. MRI Electricity Load	326,127	kWh	326,127	326,127	326,127	326,127	326,127	From 264528-00 NHH Assumptions table and profile
E. AAU Electricity Load	135,002	kWh	135,002	135,002	135,002	135,002	135,002	From 264528-00 NHH Assumptions table and profile
F. DTC Electricity Load	687,030	kWh	687,030	687,030	687,030	687,030	687,030	From 264528-00 NHH Assumptions table and profile
G. Sherbourne Building Electricity Load	933,920	kWh	933,920	933,920	933,920	933,920	933,920	From 264528-00 NHH Assumptions table and profile
H. St. Michael's Hospice Electricity Load	248,917	kWh	248,917	248,917	248,917	248,917	248,917	From 264528-00 NHH Assumptions table and profile
I. Parklands Electricity Load	828,200	kWh	828,200	828,200	828,200	828,200	828,200	From 264528-00 NHH Assumptions table and profile
J. Castle Hill Primary School Electricity Load	42,530	kWh	42,530	42,530	42,530	42,530	42,530	From 264528-00 NHH Assumptions table and profile
K. Firvale Electricity Load	86,620	kWh	86,620	86,620	86,620	86,620	86,620	From 264528-00 NHH Assumptions table and profile
L. Homefield House Electricity Load	308,295	kWh	308,295	308,295	308,295	308,295	308,295	From 264528-00 NHH Assumptions table and profile
M. Rooksdown Community Centre Electricity Load	127,900	kWh	127,900	127,900	127,900	127,900	127,900	From 264528-00 NHH Assumptions table and profile
N. Fairway House Electricity Load	4,070	kWh	4,070	4,070	4,070	4,070	4,070	From 264528-00 NHH Assumptions table and profile
O. Headway Place Electricity Load	17,246	kWh	17,246	17,246	17,246	17,246	17,246	From 264528-00 NHH Assumptions table and profile
P. Apollo Hotel Electricity Load	759,264	kWh	759,264	759,264	759,264	759,264	759,264	From 264528-00 NHH Assumptions table and profile
Q. Just Learning Electricity Load	31,797	kWh	31,797	31,797	31,797	31,797	31,797	From 264528-00 NHH Assumptions table and profile
R. Viridian Electricity Load	393,804	kWh	393,804	393,804	393,804	393,804	393,804	From 264528-00 NHH Assumptions table and profile
S. Candover Clinic Electricity Load	832,867	kWh	832,867	832,867	832,867	832,867	832,867	From 264528-00 NHH Assumptions table and profile

Non-Domestic Floor Area

A. Hospital Main Building Non-domestic Floor Area	43,446	m2	43,446	43,446	43,446	43,446	43,446	Gillian Brown email 08/11/18 - not used in model, for context only

B. The Firs Non-domestic Floor Area	629	m2	629	629	629	629	629	Gillian Brown email 08/11/18 - not used in model, for context only
C. The Arc Non-domestic Floor Area	674	m2	674	674	674	674	674	Assumed from GIS - not used in model, for context only
D. MRI Non-domestic Floor Area	498	m2	498	498	498	498	498	Gillian Brown email 08/11/18 - not used in model, for context only
E. AAU Non-domestic Floor Area	745	m2	745	745	745	745	745	Gillian Brown email 08/11/18 - not used in model, for context only
F. DTC Non-domestic Floor Area	4,183	m2	4,183	4,183	4,183	4,183	4,183	Gillian Brown email 08/11/18 - not used in model, for context only
G. Sherbourne Building Non-domestic Floor Area	3,043	m2	3,043	3,043	3,043	3,043	3,043	Gillian Brown email 08/11/18 - not used in model, for context only
H. St. Michael's Hospice Non-domestic Floor Area	4,255	m2	4,255	4,255	4,255	4,255	4,255	Assumed from GIS - not used in model, for context only
I. Parklands Non-domestic Floor Area	-	m2						
J. Castle Hill Primary School Non-domestic Floor Area	-	m2						
K. Firvale Non-domestic Floor Area	602	m2	602	602	602	602	602	Gillian Brown email 08/11/18 - not used in model, for context only
L. Homefield House Non-domestic Floor Area	5,270	m2	5,270	5,270	5,270	5,270	5,270	Assumed from GIS - not used in model, for context only
M. Rooksdown Community Centre Non-domestic Floor A	1,500	m2	1,500	1,500	1,500	1,500	1,500	Assumed from GIS - not used in model, for context only
N. Fairway House Non-domestic Floor Area	-	m2						
O. Headway Place Non-domestic Floor Area	-	m2						
P. Apollo Hotel Non-domestic Floor Area	16,834	m2	16,834	16,834	16,834	16,834	16,834	Assumed from GIS - not used in model, for context only
Q. Just Learning Non-domestic Floor Area	-	m2						
R. Viridian Non-domestic Floor Area	-	m2						
S. Candover Clinic Non-domestic Floor Area	2,149	m2	2,149	2,149	2,149	2,149	2,149	Gillian Brown email 08/11/18 - not used in model, for context only
Supply Side								
Emissions Factors								
SAP 10 gas factor	210	gCO_2e/kWh	210	210	210	210	210	https://bregroup.com/download/10480/
SAP 10 electric factor	233	gCO_2e/kWh	233	233	233	233	233	https://bregroup.com/download/10480/
HNDU gas factor	184	gCO_2e/kWh	184	184	184	184	184	IAG Data Table 2a Natural Gas Series Published 2/1/18
SAP 2012 gas factor	216	gCO_2e/kWh	216	216	216	216	216	http://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf
SAP 2012 electric factor	519	gCO_2e/kWh	519	519	519	519	519	http://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf
SAP 10 biomass factor	23	gCO_2e/kWh	53	53	23	23	23	https://bregroup.com/download/10480/
HNDU biomass factor	-	gCO_2e/kWh		21	50			GHG Reporting Conversion Factors (full set) published 4/8/17 - scope 1 (bionergy) + scope 3 (WTT- bioenergy) emissions
SAP 2012 biomass factor	16	gCO_2e/kWh	39	39	16	16	16	http://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf
CHP Electrical Efficiency	40%	% HHV	40.00%	40.00%	40.00%	40.00%	40.00%	Veolia Data Sheet - 12/2017 - Veolia 2000kWe - 1999MT in all apart from hospital only
CHP Thermal Efficiency	43%	% HHV	40.00%	40.00%	40.00%	40.00%	42.76%	Veolia Data Sheet - 12/2017 - Veolia 2000kWe - 1999MT in all apart from hospital only
Gas Boiler Efficiency	80%	% HHV	80.00%	80.00%	80.00%	80.00%	80.00%	From assumptions profile
Biomass Boiler Efficiency	0%	%		90%	85%			CIBSE AM15 • https://www.carbontrust.com/media/31667/ctg012_biomass_heating.pdf - assumes 85% efficiency (likely to be in the range 75-90%) "While many biomass plants have a stated seasonal efficiency of 90%, this should be confirmed with operational data."
Asset Lifetimes								
CHP Lifetime	15	years	15	15	15	15	15	Standard industry assumption
Biomass Boiler Lifetime	20	years	20	20	20	20	20	Standard industry assumption
Gas Boiler Lifetime	20	years	20	20	20	20	20	Standard industry assumption
HIU and Meter Lifetime	15	years	15	15	15	15	15	Standard industry assumption
Network Side								
Private Wire Length								
Private Wire Network Length	-	m		-	-	834		GIS calculations, all other scenarios private wire connection assumed existing
Financial Inputs								
Financial Indices								
RPI Inflation Rate	0%	%	0%	0%	0%	0%	0%	Beyond Scope, included for customer to test
Fuel price inflation switch	1	Flag	1	1	1	1	1	
Gas Price Inflation Rate	See InpS tab	%	0%	0%	0%	0%	0%	See InpS tab
Biomass Price Inflation Rate	See InpS tab	%	0%	0%	0%	0%	0%	Beyond Scope, included for customer to test
Electricity Price Inflation Rate	See InpS tab	%	0%	0%	0%	0%	0%	See InpS tab
Heat Price Inflation	See InpS tab	%	0%	0%	0%	0%	0%	See InpS tab
Local Authority discount rate (r)	3.5%	%	3.5%	3.5%	3.5%	3.5%	3.5%	Green book for local authorities
Company discount rate	12%	%	12.0%	12.0%	12.0%	12.0%	12.0%	IRR required for private investment
Revenues								
Heat Pricing Variable Charge								
Heat Price Discount	0%	%	0%	0%	0%	0%	0%	Industry wide assumption to incentivise connection
A. Hospital Main Building	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied

B. The Firs	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
C. The Arc	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
D. MRI	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
E. AAU	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
F. DTC	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
G. Sherbourne Building	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
H. St. Michael's Hospice	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
I. Parklands	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
J. Castle Hill Primary School	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
K. Firvale	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
L. Homefield House	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
M. Rooksdown Community Centre	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
N. Fairway House	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
O. Headway Place	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
P. Apollo Hotel	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
Q. Just Learning	0.036	£/kWh	0.036	0.036	0.036	0.036	0.036	Based on Hospital bill -0.029p/kWh for gas then 80% eff boiler applied
0	-	£/kWh						
0	-	£/kWh						

Heat Pricing Fixed Charge (Annualised REPEX & OPEX Cost)

A. Hospital Main Building	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
B. The Firs	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
C. The Arc	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
D. MRI	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
E. AAU	16	£/kW	16	16	16	16	16	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
F. DTC	16	£/kW	16	16	16	16	16	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
G. Sherbourne Building	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
H. St. Michael's Hospice	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
I. Parklands	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
J. Castle Hill Primary School	7	£/kW	7	7	7	7	7	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
K. Firvale	7	£/kW	7	7	7	7	7	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
L. Homefield House	7	£/kW	7	7	7	7	7	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
M. Rooksdown Community Centre	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
N. Fairway House	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
O. Headway Place	7	£/kW	7	7	7	7	7	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
P. Apollo Hotel	6	£/kW	6	6	6	6	6	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
Q. Just Learning	7	£/kW	7	7	7	7	7	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
0	-	£/unit						
0	-	£/kW						

Connection Charge (representative of the CAPEX)

Discount applied to connection charge	0%	%	0%	0%	0%	0%	0%	Industry wide assumption to incentivise connection
A. Hospital Main Building	92	£/kW	92	92	92	92	92	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
B. The Firs	97	£/kW	97	97	97	97	97	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
C. The Arc	96	£/kW	96	96	96	96	96	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
D. MRI	97	£/kW	97	97	97	97	97	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
E. AAU	235	£/kW	235	235	235	235	235	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
F. DTC	237	£/kW	237	237	237	237	237	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
G. Sherbourne Building	93	£/kW	93	93	93	93	93	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
H. St. Michael's Hospice	92	£/kW	92	92	92	92	92	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
I. Parklands	94	£/kW	94	94	94	94	94	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
J. Castle Hill Primary School	102	£/kW	102	102	102	102	102	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
K. Firvale	102	£/kW	102	102	102	102	102	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
L. Homefield House	99	£/kW	99	99	99	99	99	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
M. Rooksdown Community Centre	94	£/kW	94	94	94	94	94	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
N. Fairway House	95	£/kW	95	95	95	95	95	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
O. Headway Place	110	£/kW	110	110	110	110	110	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
P. Apollo Hotel	93	£/kW	93	93	93	93	93	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
Q. Just Learning	105	£/kW	105	105	105	105	105	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
Annual runtime as STOR	-	hours	0	0	0		0	

Fuel Costs

Gas Price	0.024	£/kWh	0.024	0.024	0.024	0.024	0.024	Representative of the Hospital August gas bill
Parasitic Electricity Cost (pumps & Aux equip)	0.112	£/kWh	0.112	0.112	0.112	0.112	0.112	energy-and-emissions-projections-2017
Wholesale Electricity Price	0.046	£/kWh	0.046	0.046	0.046	0.046	0.046	https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017

Private Wire Electricity Price	0.117	£/kWh	0.117	0.117	0.117	0.117	0.117	2019 projected services electricity cost - Annex M - https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017
Biomass Price	-	£/kWh		0.045	0.015			See Email from William Hamer - Hampshire Woodfuel Cooperative - 21/11/2018
Operational Costs								
Main Plant and Energy Centre Maintenance								
CHP Maintenance Cost	0.010	£ / kWhe	0.010	0.010	0.010	0.010	0.010	Veolia Spreadsheet - 11/2017
Gas Boiler Maintenance Cost	0.0025	£ / kWh	0.0025	0.0025	0.0025	0.0025	0.0025	Arup Estimation
Energy Centre Maintenance	30,000	£ / year	30,000	30,000	30,000	30,000	30,000	Quote from 3 different suppliers for a similar energy centre (2017). The Additional cost for the Wood chip boiler is due to the additional labour cost involved
Substation and Network Maintenance Cost								
Substation & Network maintenance cost	7.350	£ / kW	7.35	7.35	7.35	7.35	7.35	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
Other Operational Costs								
Business Rates	-	£ / kWh	-	-	-	-	-	
Bad Debt	0%	% of revenue	0%	0%	0%	0%	0%	Not in Scope - Client input
Insurances	0.0%	% of capex	0.0%	0.0%	0.0%	0.0%	0.0%	Not in Scope - Client input
Capital Costs								
Plant Costs								
Gas Boiler Capital Cost	36	£/kW	36	36	36	36	36	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
CHP Capital Cost	330	£/kWth	330	330	330	330	330	V-1560MW-070-NG-50-500 - Veolia model - includes both the installation cost and the capital cost
Biomass Boiler Capital Cost	-	£/kWth		670	860			£670/kW for a pellet boiler and £860/kW for woodchip. This includes capital, cost of boiler, feed system, flue system, transport and delivery and mechanical and electrical costs. Based on real case studies from the Carbon trust: https://www.carbontrust.com/media/84806/cts298-plockton-biomass.pdf, https://www.carbontrust.com/media/84786/cts292-sewstern-biomass.pdf and https://www.renewableenergyhub.co.uk/biomass-boiler-information/biomass-boilers-system-cost.html
HIU Costs	-	£ / unit	-	-	-	-	-	Included in connection costs for the building
Total network cost	1,620,061	network cost	6,034,680	6,034,680	6,034,680	3,066,611	1,620,061	See pipe schedule in App B for build up
	-		-	-	-	-	-	Arup experience Doug Walters - 20-11-2018
Energy Centre Cost								
Energy Centre Cost	831,833	£	831,833	924,920	1,287,361	831,833	831,833	Calculated based on floor area - consult energy centre costing spreadsheet. Three quotes for an energy centre from Arup cost consultants
Energy Centre Gas Boiler Capital Cost	25	£/kW	25	25	25	25	25	Previous PG quote
Energy Centre CHP Capital Cost	116	£/kWth	116	-	-	116	116	V-1560MW-070-NG-50-500 - Veolia model - includes both the installation cost and the capital cost
Energy Centre Biomass Boiler Capital Cost	-	£/kWth						Included in the CAPEX pricing
Space Cost	-	£/m2						
Gas Connection Cost								
Gas Connection Cost	-	£						Existing large gas connection
Private Wire Costs								
MV Distribution Cable 500kVA	-	£/m				84		Spon 2015 Page 550
Terminations, cable ties etc	-	£/connection				5,000		Spon 2015 Page 553
Step down transformer	-	£/connection				12,200		Spon 2015 Page 553
MV Circuit Breakers	-	£/connection				27,423		Spon 2015 Page 552
Electricity Connection Costs								
Connection costs for electricity export	-	£				200,000		existing large electrical connection
Connection Costs	*This is the substation and HIU cost (not pipe)*							
A. Hospital Main Building	20	£/kW	20	20	20	20	20	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
B. The Firs	120	£/kW	120	120	120	120	120	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
C. The Arc	100	£/kW	100	100	100	100	100	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
D. MRI	120	£/kW	120	120	120	120	120	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
E. AAU	120	£/kW	120	120	120	120	120	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
F. DTC	120	£/kW	120	120	120	120	120	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
G. Sherbourne Building	100	£/kW	100	100	100	100	100	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
H. St. Michael's Hospice	100	£/kW	100	100	100	100	100	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
I. Parklands	100	£/kW	100	100	100	100	100	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
J. Castle Hill Primary School	120	£/kW	120	120	120	120	120	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
K. Firvale	120	£/kW	120	120	120	120	120	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx

L. Homefield House	100	£/kW	100	100	100	100	100	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
M. Rooksdown Community Centre	100	£/kW	100	100	100	100	100	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
N. Fairway House	100	£/kW	100	100	100	100	100	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
O. Headway Place	120	£/kW	120	120	120	120	120	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
P. Apollo Hotel	100	£/kW	100	100	100	100	100	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
Q. Just Learning	120	£/kW	120	120	120	120	120	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
0	-	£/kW						
0	-	£/dwelling						
Project Costs								
Testing and commissioning	2%	% of CAPEX	1.5%	1.5%	1.5%	1.5%	1.5%	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
Builders work	3%	% of CAPEX	3%	3%	3%	3%	3%	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
Preliminaries	15%	% of CAPEX	15%	15%	15%	15%	15%	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
Overheads and profit	5%	% of CAPEX	5%	5%	5%	5%	5%	Costing and Pricing Assumptions_2018-11-22_Draft.xlsx
Professional fees	12%	% of CAPEX	12%	12%	12%	12%	12%	12% of Professional fees & 10% for optimism bias
Sensitivity test - CAPEX	0%	% of CAPEX	-	0%	0%	0%	0%	
Sensitivity test - OPEX	0%	% of OPEX	-	0%	0%	0%	0%	
Optimism bias (applied after the above)	20%	% of CAPEX	20%	20%	20%	20%	20%	5% design risk, 5% client change risk, 5% construction risk, 5% client any other risk - Optimism Bias from green book
Network contingency	20%	% of network CAPEX	20%	20%	20%	20%	20%	Applied to Network CAPEX. Based on specific contingencies for different parts of transmission network according to route survey. Distribution contingencies assumed 10%. EfW set at 20% due to additional risks.
Other contingencies	0%	% of CAPEX (except netwo	0%	0%	0%	0%	0%	Applied to total CAPEX minus network CAPEX
Tax Costs								
Tax Contingency	0%	% of Annual Total Costs	0%	0%	0%	0%	0%	Applied to total CAPEX minus network CAPEX

END OF SHEET

Pipework schedule for recommended route

Pipe number	Pipe length (m)	Connected non-domestic load (kWh/year)	Connected total peak load (kW)	Flowrate (kg/s)	Transmission Pipe Diameter (mm)	Soft dig percentage	Soft dig length (m)	Soft dig cost (£/m)	Soft dig cost (£)	Hard dig percentage	Hard dig length (m)	Hard dig cost (£/m)	Hard dig cost (£)	Total cost (£)
1	17	15,447,517	4,283	37.5	200.0	1.0	17.0	£2,000	£34,000	0.0	0.0	£3,000	£0	£34,000
2	25	15,447,517	4,283	37.5	200.0	0.5	12.5	£2,000	£25,000	0.5	12.5	£3,000	£37,500	£62,500
3	76	3,245,044	1,200	10.5	200.0	0.3	22.8	£2,000	£45,600	0.7	53.2	£3,000	£159,600	£205,200
4	77	2,934,049	1,110	9.7	200.0	0.7	53.9	£2,000	£107,800	0.3	23.1	£3,000	£69,300	£177,100
5	54	562,170	423	3.7	80.0	1.0	54.0	£1,548	£83,589	0.0	0.0	£2,449	£0	£83,589
6	21	550,750	144	1.3	50.0	1.0	21.0	£1,435	£30,134	0.0	0.0	£2,311	£0	£30,134
7	54	2,371,879	687	6.0	100.0	0.0	0.0	£1,623	£0	1.0	54.0	£2,541	£137,209	£137,209
8	14	1,085,167	314	2.8	65.0	0.0	0.0	£1,491	£0	1.0	14.0	£2,380	£33,323	£33,323
9	136	1,085,167	314	2.8	65.0	1.0	136.0	£1,491	£202,836	0.0	0.0	£2,380	£0	£202,836
10	72	1,085,167	314	2.8	65.0	0.8	57.6	£1,491	£85,907	0.2	14.4	£2,380	£34,275	£120,182
11	13	1,085,167	314	2.8	65.0	0.0	0.0	£1,491	£0	1.0	13.0	£2,380	£30,943	£30,943
12	110	1,286,712	373	3.3	65.0	0.0	0.0	£1,491	£0	1.0	110.0	£2,380	£261,824	£261,824
13	41	1,286,712	373	3.3	65.0	0.0	0.0	£1,491	£0	1.0	41.0	£2,380	£97,589	£97,589
14	41	11,420	279	2.4	65.0	0.0	0.0	£1,491	£0	1.0	41.0	£2,380	£97,589	£97,589
15	29	139,512	40	0.4	32.0	0.4	11.6	£1,367	£15,859	0.6	17.4	£2,229	£38,780	£54,638
16	95	1,598,334	632	5.5	100.0	0.0	0.0	£1,623	£0	1.0	95.0	£2,541	£241,386	£241,386
17	41	1,598,334	632	5.5	100.0	0.0	0.0	£1,623	£0	1.0	41.0	£2,541	£104,177	£104,177
18	16	167,471	49	0.4	32.0	0.0	0.0	£1,367	£0	1.0	16.0	£2,229	£35,659	£35,659
19	28	1,430,862	583	5.1	80.0	0.0	0.0	£1,548	£0	1.0	28.0	£2,449	£68,574	£68,574
20	17	11,478	52	0.5	32.0	0.0	0.0	£1,367	£0	1.0	17.0	£2,229	£37,888	£37,888
21	15	996,767	868	7.6	100.0	0.0	0.0	£1,623	£0	1.0	15.0	£2,541	£38,114	£38,114
22	51	171,484	50	0.4	32.0	0.0	0.0	£1,367	£0	1.0	51.0	£2,229	£113,664	£113,664
23	65	1,419,384	531	4.6	80.0	0.0	0.0	£1,548	£0	1.0	65.0	£2,449	£159,190	£159,190
24	67	1,419,384	531	4.6	80.0	0.0	0.0	£1,548	£0	1.0	67.0	£2,449	£164,088	£164,088
25	98	1,419,384	531	4.6	80.0	1.0	98.0	£1,548	£151,699	0.0	0.0	£2,449	£0	£151,699
26	57	1,419,384	531	4.6	80.0	0.0	0.0	£1,548	£0	1.0	57.0	£2,449	£139,598	£139,598
27	52	1,419,384	531	4.6	80.0	0.0	0.0	£1,548	£0	1.0	52.0	£2,449	£127,352	£127,352
28	74	1,419,384	531	4.6	80.0	1.0	74.0	£1,548	£114,548	0.0	0.0	£2,449	£0	£114,548
29	48	1,419,384	531	4.6	80.0	1.0	48.0	£1,548	£74,302	0.0	0.0	£2,449	£0	£74,302
30	23	1,419,384	531	4.6	80.0	1.0	23.0	£1,548	£35,603	0.0	0.0	£2,449	£0	£35,603
31	80	1,419,384	531	4.6	80.0	1.0	80.0	£1,548	£123,836	0.0	0.0	£2,449	£0	£123,836
32	84	1,419,384	531	4.6	80.0	0.1	8.4	£1,548	£13,003	0.9	75.6	£2,449	£185,151	£198,153
33	21	1,419,384	531	4.6	80.0	0.0	0.0	£1,548	£0	1.0	21.0	£2,449	£51,431	£51,431
34	35	996,767	868	7.6	100.0	0.0	0.0	£1,623	£0	1.0	35.0	£2,541	£88,932	£88,932
35	41	85,007	60	0.5	32.0	0.8	32.8	£1,367	£44,842	0.2	8.2	£2,229	£18,275	£63,117
36	35	18,042,618	5,783	50.7	200.0	0.1	3.5	£2,000	£7,000	0.9	31.5	£3,000	£94,500	£101,500
37	52	2,371,879	687	6.0	100.0	0.0	0.0	£1,623	£0	1.0	52.0	£2,541	£132,127	£132,127
38	30	12,202,473	3,083	27.0	150.0	0.0	0.0	£1,812	£0	1.0	30.0	£2,770	£83,114	£83,114
39	34	11,441,593	2,863	25.1	150.0	0.0	0.0	£1,812	£0	1.0	34.0	£2,770	£94,195	£94,195
40	14	11,441,593	2,863	25.1	150.0	0.0	0.0	£1,812	£0	1.0	14.0	£2,770	£38,786	£38,786
41	16	760,880	220	1.9	65.0	0.0	0.0	£1,491	£0	1.0	16.0	£2,380	£38,083	£38,083
													Total cost	£4,247,772

Appendix C – Advice for other local developments

Advice for other local developments

Manydown

The Manydown development has the following key characteristics:

- Includes two commercial areas, link road, 3,520 homes
- A 12 years delivery plan with regional developers.
- Currently at outline planning stage.
- Does not have an energy strategy.
- It is a greenfield site.
- The Council is undertaking the development with a Joint Venture partner - Urban and Civic.
- Looking at gas and electricity infrastructure.
- Some interest in exploring digital.

The main risk of looking at a heat network would be buy in would be required from multiple developers. However the opportunity is that the development could have a medium and long term carbon plan which would be consistent across the board, allowing for equality and affordability.

We would recommend that an energy strategy for the development is undertaken at all stages, and updated as more information comes to light. Having a clear and shared vision for low carbon / zero carbon from the outset leads to the right decisions being made along the way. For instance if it was decided early on that all properties were going to have heat pumps, there would be no requirement to look at gas infrastructure. We would recommend a workshop with the JV to help them understand their options for the energy infrastructure and to start testing scenarios that would be help meet the objectives for the development, including likely future building regulations and changes under SAP 10.

An energy strategy is important to look at solutions for different parts of the site, heat networks can work for low density housing as well as higher density town centres, depending on what the comparator is. Heat networks are preferred in comparison to electric heaters because they allow for easy retrofit and change as the technology transitions in the UK.

It is also important when considering the cost of district heating infrastructure, to compare to that of gas infrastructure. Typically gas infrastructure is a sunk cost, and there is no discussion of payback for it, however when heat networks are discussed payback appears to be an important factor for most stakeholders. Having a clear playing field is important to ensure that the costs are included in the development viability.

HNDU funding round opens in April 2019, which could fund looking at the feasibility of a heat network vs. a gas counterfactual or a heat pump counterfactual.

ARUP

Advice for other local developments
Basingstoke Leisure Park

The Basingstoke Leisure Park development has the following key characteristics:

- 1million sqft, with 600,000sqft of leisure and 220,000sqft of designer outlet retail units.
- Leisure includes: aquadrome, cinema, icerink,
- Planning application target date of 2020
- Signed development agreement with New River Developments

Risks are each unit wants its own heating device. Opportunities are economies of scale of having only one energy centre and one maintenance contract, can choose a low carbon technology and establish one place to change technology in an future upgrade / retrofit.

Our recommendations would be to consider energy from the early stages, this will avoid abortive work being undertaken on gas infrastructure. Considering energy in the round, including the time scales and the incoming SAP 10, which will impact on Building Regulations and directly impact the carbon reduction benefit currently associated with gas CHP, the development must have a long term strategy planned from the beginning.

An understanding of the heating and cooling profiles of each user is an important factor, it may be possible to use 5th generation heat networks to heat and cool at the same time, whereby low distribution temperatures move heat and coolth between different users allowing the collection and reuse of waste heat.

If GSHPs would be a good solution, energy piles could be an option or looking into adjacent land such as the golf course for boreholes.

A commercial heat network example which includes leisure facilities would be the Olympic park, more information on this can be found here: https://www.queenelizabetholympicpark.co.uk/the-park/attractions/around-the-park/energy-centre

Appendix D – Heat network roles

Appendix D
Heat network roles

The following is adapted from the Arup 2016 guidance for BEIS on strategic and commercial case for heat networks:

There are certain roles that need to be performed if a heat network is to be successfully implemented. These roles should be distinguished from the parties that might undertake them, since one party may take multiple roles and, likewise, a role could be fulfilled by multiple parties. The main roles that need to be undertaken during the delivery of any heat network are:

Promotion: The Promoter is a party with the motivation to establish a successful heat network and which takes responsibility for driving delivery.

Customer: The Customer (domestic or non-domestic) purchases heat delivered by the heat network.

Governance: The Governance role includes setting objectives, prescribing policies and rules of conduct and overseeing performance. These objectives, rules and policies will need to be prescribed by the contract(s) under which the network is operated.

Regulation: The Regulation role is focussed on consumer protection and to prevent abuse of the monopoly position of a heat network.

Funding: The Funder provides or arranges finance. Funders will normally require security against the funding they are providing, to mitigate their risk of financial losses.

Asset Ownership: The Asset Owner legally owns the physical assets of the network. Ownership could be split for different classes of assets (for example, generation assets, primary network and secondary networks).

Development of Property: In the context of heat networks, Developers of Property are the parties responsible for constructing or maintaining the buildings which will receive heat from the heat network.

Land Ownership: The role of the land owner, in this context, is to grant leases and easements for the siting of network assets and provide rights of access for the installation, operation and maintenance of plant and equipment.

Landlordship: The Landlord role, for buildings connected to heat networks, usually involves responsibilities for some network assets within the building, which may include the secondary and tertiary systems.

Installation: The installer designs and installs the heat network. Typically, this is the energy centre and primary network, with the secondary network being the responsibility of the Property Developer.

Operation: An Operator is responsible for the operation and maintenance of the heat network in such a manner as to ensure that heat (and potentially cooling and electricity) of suitable quality and quantity can be delivered to Customers.

Sale of heat: The sale of heat as a service is a logically distinct role from the physical delivery of heat to customers, as can be seen in the nationally regulated UK electricity and gas markets.

Supplier of last resort: Since heat is not regulated like gas or electricity, it is best practice to make alternative provision for a "supplier of last resort". This role involves providing heat to the customers if the scheme's provider is unable to do so.

Parties will need to be identified who can take on the responsibilities, risks and opportunities associated with each role. In many cases the roles will fall naturally to one or more parties – the Landlord role, for example – but in other cases a deliberate choice will have to be made to play a particular role. Each role comes with responsibilities that results in a set of risks and opportunities. Therefore where a role allocation is not pre-determined, the appetite of a Local Authority, or any other party, to take on a particular role will be influenced by their perception of the risks and opportunities.

The arrangement of parties and roles into a defined set of relationships, responsibilities and rights is referred to as a delivery model. Delivery vehicles might involve formal corporate entities created for the purpose of heat network delivery (e.g. a Joint Venture body or Special Purpose Vehicle), or they may make use of existing organisational structures.

There are many ways in which a heat network can be set up, from a wholly private sector solution with no public sector involvement to an entirely public sector funded, owned and operated scheme.

Agreeing the parties to undertake the roles will help determine this commercial setup. The process of allocating parties to roles is inherently iterative; needing to be aligned with the workable contract structures and procurement routes and also tested with the parties themselves. It is very important that proposed parties are engaged and their appetite for given roles tested before completion of the business plan and commitment made to a particular delivery model.

[1] Arup 2016. Heat Network Detailed Project Development Resource: Guidance on Strategic and Commercial Case. Arup with Lux Nova Partners, Mazars and Willis Towers Watson for the Department for Business, Energy & Industrial Strategy. Can be found here: https://www.arup.com/-/media/arup/files/publications/h/strategic_comm_hn_guide_issue_1_22072016.pdf

Appendix E – Risk register

Risk category	***Risk number***	***Risk title***	***Description***	***Likelihood***	***Severity***	***Mitigation***
Demand	D1	Risk of connections not materialising	Lack of engagement from potential building operators	Medium	High	Secure key stakeholders through continuous engagement. For instance NHH has been engaged throughout the process.
Demand	D2	Risk of lower heat demand than expected	Incorrect assumptions related to the heat demand. Renovations to buildings reducing their energy demand.	Low	Medium	We have used actual data wherever possible and informed benchmarks in situations when this is not the case. Understanding the future plans of stakeholders for their buildings.
Demand	D3	Hospital extending to the Eli Lilly building (or relocating to the Eli Lilly building)	There is a risk of the hospital demand being significantly higher than expected if the hospital extends into the current Eli Lilly building.	Low	High	Establishing and maintaining good communication with key stakeholders in the local area. Performing sensitivity analysis on the model results so that the resulting design is flexible to changes in the needs of end users
Demand	D4	Hospital relocation	As the hospital accounts for the most significant heat load in the area, future relocation of the hospital would significantly alter the heat and electricity demand of the network.	Medium	High	Establishing and maintaining good communication with key stakeholders in the local area. Performing sensitivity analysis on the model results so that the resulting design is flexible to changes in the needs of end users

Demand	D5	Phasing/ timing of connections	As majority of buildings are already existing and operational, their renovations or unexpected changes in layouts could cause disruption.	High	Low	Understanding the future plans of stakeholders for their buildings If existing energy centres are replaced, ensure replacement is timed such that it doesn't coincide with winter months
Demand	D6	Contractual Risk	If existing boilers are to stay in the buildings, there is a risk that the infrastructure is installed then the building operator decides not to use the scheme and instead uses their boilers.	Low	Low	Careful contract writing to ensure that the ESCO is not exposed to large risk, or the boilers are controlled by the ESCO.
Demand	D7	Early replacement of hotel boiler	The Apollo Hotel boilers are currently nearing the end of their lifetime. There is therefore a risk that these may need to be replaced before the heat network is installed.	High	Low	Establishing and maintaining good communication with Apollo Hotel Ensuring that Apollo Hotel is included in the first phase of the heat network
Demand	D8	Hospital heat demand	Retrofitting to a hospital requires good planning and programming, because it is not acceptable to have a hospital with no heat in the winter.	Medium	Medium	Careful programming, and back-up in place during commissioning.
Supply	S1	Spacing assumptions	Risk that there is insufficient space within existing plant rooms to accommodate new biomass or gas CHP equipment.	Low	Medium	High level assessment of the space available for plant installation.

Supply	S2	Low carbon options	The network is installed with gas CHP, and no transition plan comes forward.	Medium	Low	Allow for space in energy centre so future biomass boiler could replace gas boiler.
Supply	S3	Future of electric grid and carbon factors	The electric grid becomes overburdens and has lots of blackouts	Medium	Medium	CHP helps NHH have a more stable electric grid.
Supply	S4	Future of gas grid and carbon factors	The gas grid becomes defunct and doesn't transition to hydrogen or a lower carbon gas.	High	High	If use CHP and there is no gas, there would be no network, likelihood of this happening in the next 15 years is low, so transition to future technology requires further thought in 10 years.
Supply	S5	AQMA	The area could become an AQMA and more stringent requirements could impact gas CHP or biomass boilers	Low	Low	Leave space for additional abatement measures to be installed around the technology.
Supply	S6	Availability of sustainable biomass	There is no available sustainable biomass suitable for use with the biomass boilers.	Medium	High	Sign up for a long term contract with a reliable supplier.
Supply	S7	Energy from waste becoming available	If energy from waste becomes available in the future as an energy source for the heat network, this would mean that plant equipment is oversized	Low	Low	Establishing and maintaining good communication with key stakeholders in the local area.
Network route	N1	Gas utility crossing	Crossing of SGN medium pressure mains increases cost of network installation.	High	Low	Crossing of gas mains kept to a minimum
Network route	N2	Hard dig/soft dig ratio	More hard dig than anticipated due to misc. pipes/cables in the verges	Medium	Low	Early trial pits and GPR to be undertaken

Network route	N3	Road crossing	Heat networks in the road may cause disruption to hospital access and may risk a cable strike if there are other utilities already in the road.	Medium	Medium	Heat network to use underpass under main road to minimise disruption Partial road closures
Network route	N4	Land ownership permission	The land owners do not allow the crossing of their land.	Low	Low	Early engagement. Seen as low risk as the majority of the land is owned by the hospital, council or properties that are proposed to join the scheme.
Network route	N5	Crossing the road to Apollo hotel	It is difficult to tunnel under the road, and an option could be to contain the heat pipes in a false cavity in the tunnel.	High	Low	Route feasibility on the road/tunnel crossing
Network route	N6	Future proofing the scheme	Other buildings wishing to connect to the network without sufficient capacity	Low	Medium	Thorough analysis of local area has been undertaken Understanding the future plans of stakeholders for their buildings
Technical	T1	Private wire	Risk that private wire and onsite electrical consumption is not possible	Low	High	Dialogue with hospital and other stakeholders to ensure that private wire is possible Prioritising private wire connections within the hospital trust network
Technical	T2	Redundancy	Insufficient redundancy in primary generation technology	Medium	High	N+1 boilers has been considered as the back up with oil burners

Technical	T3	Energy centre size	The energy centre is not large enough to cater for the generation equipment needed	Medium	Medium	High level assessment of the energy centre size and assumption that some equipment will be able to included outside the energy centre or in another location.
Technical	T4	Energy centre space provision	Both the proposed locations are on the hospital site. The hospital could build other things on them.	Low	Low	NHH has been engaged throughout the process.
Technical	T5	Network heat losses	Increased network heat losses can affect the carbon output and the energy requirements of the technologies supplying heat.	High	Low	Best practice design should be undertaken. Sensitivity analysis examined options with different heat losses.
Technical	T6	Asbestos in the hospital	The hospital is known for having a large amount of asbestos, it could be that asbestos in the ground is found which may increase costs of the heat pipes, but also in connecting to the buildings there could be more asbestos, which would need removing.	High	Medium	Asbestos surveys to be requested
Technical	T7	Compatibility of different buildings	The hospital's heating system is old, and the pipes could be holey/contain loose iron. While the school has a much newer heating system.	High	Low	Hydraulic separation between the hospital network and the heat network is required.
Technical	T8	Phasing	The phasing could mean that certain buildings do not connect and the equipment is oversized.	Medium	Medium	Engagement to be continued with stakeholders.

Technical	T9	Higher than expected connection costs	That the connection costs are not representative of what the parties are expecting.	High	Low	Contingency has been included in the analysis and a cost consultant has reviewed the connection costings.

Financial	F1	Price and availability of biomass	The biomass must be compliant with the RHI and the supply chain is considered to be less secure than gas.	High	High	Consideration must be given to what happens if no biomass can be found and a sensitivity modelled for gas boilers only.
Financial	F2	Capex too high or too low	Early stage assumptions have been made.	High	High	Optimism bias of 20% has been applied as per HMRC Green Book guidance.
Financial	F4	RHI	RHI for biomass is confirmed until 2021, however this could be degressed.	High	High	Sensitivity testing to be undertaken
Financial	F5	Heat tariffs	The heat tariffs has been tested against the expectations of NHH. It could be higher than anticipated for affordable heating.	High	Medium	Sensitivity analysis tested different options for discounting in WP2 which resulted in IRR reduction.
Financial	F6	Political instability	The impact of Brexit could cause political and economic uncertainty.	High	High	Impact of higher/lower capex of the project was examined in the sensitivity testing.
Financial	F7	Opex fluctuations	Multiple opex parameters based on the different supply technologies.	Low	Low	Sensitivity testing to be undertaken
Financial	F8	Fuel prices risks	of increasing and the BEIS fuel projections are uncertain and only project until 2035.	High	High	Sensitivity testing to be undertaken

Financial	F9	Customer satisfaction risks	Customers may feel that heat networks are expensive.	Medium	Medium	Market engagement must be undertaken throughout the purchase/rental engagement with potential purchasers/tenants.
Financial	F10	HNIP funding	HNIP funding may be considered for the supply options examined to a maximum of £5million as a grant fund. This can increase up to £10 million in the form of a loan.	High	High	Interested parties should consider the timescales of HNIP funding, along with the timescales of the phasing of the project to ensure that the funding can be obtained.
Commercial - Hospital led	C1	NHH has limited capital	NHH has stated that they have no capital.	Low	High	Can get Salix loans or use RE:FIT or potentially HNIP funding
Commercial - Hospital led	C2	NHH only connects their buildings	NHH only connects their buildings, and the wider benefits of a network are not realised	High	Medium	Council to continue to engage others if wish to have a larger network
Commercial - Hospital led	C3	NHH takes on asset liability	NHH has stated that they do not wish to have liability for the assets, however currently has liability for the boilers.	Low	Medium	They are currently managing this risk
Commercial - Hospital led	C4	Low carbon solutions	Lack of larger network may exclude lower carbon solutions in the future.	High	High	Land would be required for heat pumps, and buy in from Council required for EfW to reach the hospital.
Commercial - BDBC led	C5	Risks	The public sector takes most of the risks, including the demand risk	Low	High	The demand is relatively well known, with monthly metered gas data provided by NHH.

Commercial - BDBC led	C6	Skills and resources	BDBC does not have access to necessary skills and resources to deliver and own a heat network.	Medium	High	Input from specialists is key to avoiding poor contracts and/or poor network performance
Commercial - BDBC led	C7	Loss of heat demand	Hospital pulls out late in the process.	Low	High	Engagement with the hospital required throughout the process
Commercial - Shared leadership	C8	Risk allocation	Agreement between NHH and BDBC means that both parties are unhappy.	Medium	Medium	Agreement between NHH and BDBC needs to allocate risks appropriately to enable success of scheme
Commercial - Shared leadership	C9	NHH has limited capital	NHH has stated that they have no capital.	Low	High	Can get Salix loans or use RE:FIT or potentially HNIP funding
Commercial - Shared leadership	C10	NHH only wishes to connect their buildings	Hospital may not wish to connect all loads.	High	Medium	Council to continue to engage others and NHH if wish to have a larger network
Commercial private sector led	C11	Procurement	The procurement takes too long and hospital / hotel build stand-alone solutions	Medium	High	Promoter needs to take ownership and push forward to meet the timescales required.
Commercial private sector led	C12	Expansion and decarbonisation	Future network expansion and decarbonisation may be difficult to achieve	Medium	High	Get specialist advice to support the contractual side of things