Bishops Stortford Goods Yard Development

Community Energy Analysis

Draft Report

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Delivering a Sustainable Future

Executive Summary

The Bishops Stortford Goods Yard Development represents a major development in the town centre and as such provides an opportunity to ensure that new buildings have minimal carbon impact and to initiate the process of making the existing building stock sustainable.

As currently proposed the development will have small block based gas fired combined heat and power (CHP) plants but that won't serve all the blocks and there will be no interconnection of the blocks. Instead of running a heat network between the buildings there will instead be a gas network.

Using the heat demand figures from the site energy strategy developed by Hurley Palmer Flatt we have analysed the potential for instead for:

a. Connecting all the buildings to a site wide heat network (of a temperature of 75 flow 55 return or lower.
b. Substituting the small gas fired CHP with a much larger single central heat pump, sourcing its heat either from boreholes or the River Stort or both.
c. Connecting the network to the Nuffield Leisure Centre and Cinema.

We have not analysed connections beyond this but we believe that this will provide the opportunity for a larger heat and potentially cooling network serving buildings in the town centre and beyond.

We would further recommend that the option of providing cooling from the borehole be explored. Preliminary analysis of this has been included in the report but only for the cooling loads on the development which are quite small. Once heat has been extracted from the borehole water by the heat pump then the water is at a suitable temperature for cooling and this can be distributed via a central chilled water network. Any new building can be designed to operate from this system and existing buildings with a central chilled water system can be connected.

Whilst the electricity grid is rapidly decarbonising through the removal of coal fired power stations and increase in renewable sources of generation we are yet to tackle the decarbonisation of heating. To do so we will need to remove gas boilers from our homes and commercial buildings and replace them with alternatives. This development provides the opportunity to begin that process in Bishops Stortford.

Abbreviations/Terms of Reference

AC	Alternating current
BEIS	Department of Business Energy and Industrial Strategy
CO_2	Carbon dioxide
DC	Direct current
DEC	Display Energy Certificate
DUoS	Distribution Use of System Charges
EE	Energy efficiency
EPC	Energy Performance Certificate
FITs	Feed-In Tariffs
kWe	Kilowatts electrical
kWh	Kilowatt-hour
MWh	Megawatt–hour
RHI	Renewable Heat Incentive
PV	Photovoltaic
Tpa	Tonnes per annum
Wp	Watt peak output

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1 Introduction

This report has been written on behalf of Bishops Stortford Climate Group by a member of the group, Chris Dunham. As a professional working in this field I have access to energyPRO software which is the industry standard software for analysing heat and cooling networks. It allows half-hourly profiling of heat, cooling and power demands and techno-economic of supply and storage options.

This work has been undertaken without access to some of the detailed schematics and modelling and has relied on publicly available data such as the Hurley Palmer Flatt Energy Strategy. Nevertheless it gives insight into the potential for modifying the design in actually quite a small way – moving from block based to communal heating to a site wide interconnected heat network. Rather than gas boiler plant and gas cHP in each block our proposal is simpler in that there would a single central energy centre served by a heat pump with back up gas boilers.

2 Heat Source Opportunities

2.1 Boreholes

As can be seen from the British Geological Survey website that retains records of boreholes in the UK Bishops Stortford has had a large number of boreholes in and around the town centre. Most of the deeper boreholes were originally drilled to serve a number of breweries.

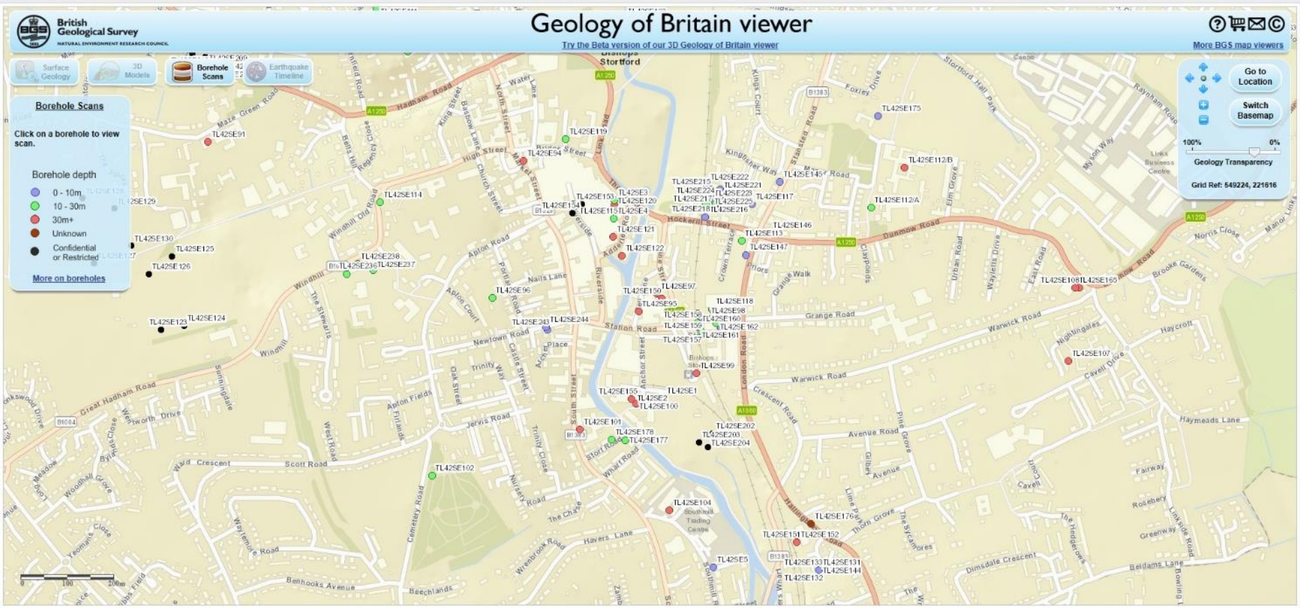


Figure 1 BGS Borehole Sites in Bishops Stortford

One of the records for Dell Lane is shown below. It can be seen that 4800 gallons per hour was achieved when the borehole was operational. The borehole depth was 96m. This equates to around 6litres per second. Two pairs of boreholes with a delta T of 6degrees C would allow for an approximately 500kWth heat pump.

TL 42 SE / 95.
4901 2105
1" : 222.

222/279 Messrs. Benskins Watford Brewery Ltd., The Maltings, Dell Lane, Bishop's Stortford. (Disused)

Surface +189. Shaft 18 × 6; rest bore. Lining tubes: 178 × 8 in from surface; 37 × 6 in from 178 down. Water struck at -121. R.W.L. +178. Venison, Feb. 1953. R.W.L. +182¾. P.W.L. +169¾ (after 6 h.). Yield 4,800 g.p.h. Electric pump. Hardness: P. O. T. 255. Anal. Mar. 1953.

Sand and Gravel (Buried channel)	...	203	203
UCk)	...	122	325
MCk)			

Figure 2 Borehole yield record for Dell Lane borehole

As most of the boreholes are no longer operational in the town centre the aquifer is presumably fully replenished.

Unlike previous uses of boreholes in the town, boreholes for heat pumps are non-extractive. The water is simply borrowed – heat or cooling is extracted and the water is reinjected via another hole. A rule of thumb is that a separation distance of 80-100m between abstraction and injection is required and 25-30m between abstraction points.

If the balance of heating and cooling is the same over a season then there is also no net heating or cooling of the aquifer – effectively the ground becomes an inter-seasonal heat store.

2.2 River Stort

According to the National Heat Map the River Stort could provide 243.62kW of heat. The Canal and River Trust (CRT) have a team that are responsible for trying to promote their canal and river network for the use of heating and cooling. They have been contacted and are keen to work with the developer to examine the use of the Stort as a heat source.

Figure 3 Heat Capacity of River Stort according the National Heat Map

There are a number of disadvantages of using the Stort as a heat source over a borehole. The charges from the Environment Agency for use of a borehole are negligible - around £50 per year for a 1MWth heat pump. Whereas for a CRT managed waterway the charges could be in the region of £50,000 a year – however these are negotiable and based on the viability. On the positive side the temperature of the Stort is much higher in the summer months than borehole water. This means that the efficiency of the heat pump, the Coefficient of Performance (COP), is higher at this time of year. It has been noted that the flow of the Stort is slow but this has already been taken into account when calculating the heat capacity.

Potentially a mixed mode scheme could be established where the heat pump draws on either the borehole or the river depending on temperatures/loads though we have not modelled that for this report. We have only used a borehole is the source of heat.

3 Heat Demands

Using the figures from the energy strategy produced by Hurley Palmer and Flatt we have estimated the total heat and cooling demands for each type of usage proposed for the site: hotel, office, residential and retail. We have also estimated the heating and hot water demands for the gym and cinema from standard benchmarks.

	Hotel	Office	Residential	Retail	Total	Total Inc cinema & gym
Domestic hot water	757,012	7,212	1,139,738	24,526	789,890	1,832,561
Heating	13,517	22,616	1,424,499	4,430	41,988	1,404,396
Cooling	8,464	12,989	-	11,296	32,749	

Figure 4 Estimated Annual kWh Demands by End Use

As can be seen from the graph the site wide heat demands when summed and profiled across a year are significant - peaking at around 2.4MW. This is without the additional connections of the cinema and Nuffield Gym (or any loads such as the new entertainment venue replacing the bowling alley or Bacchus nightclub).

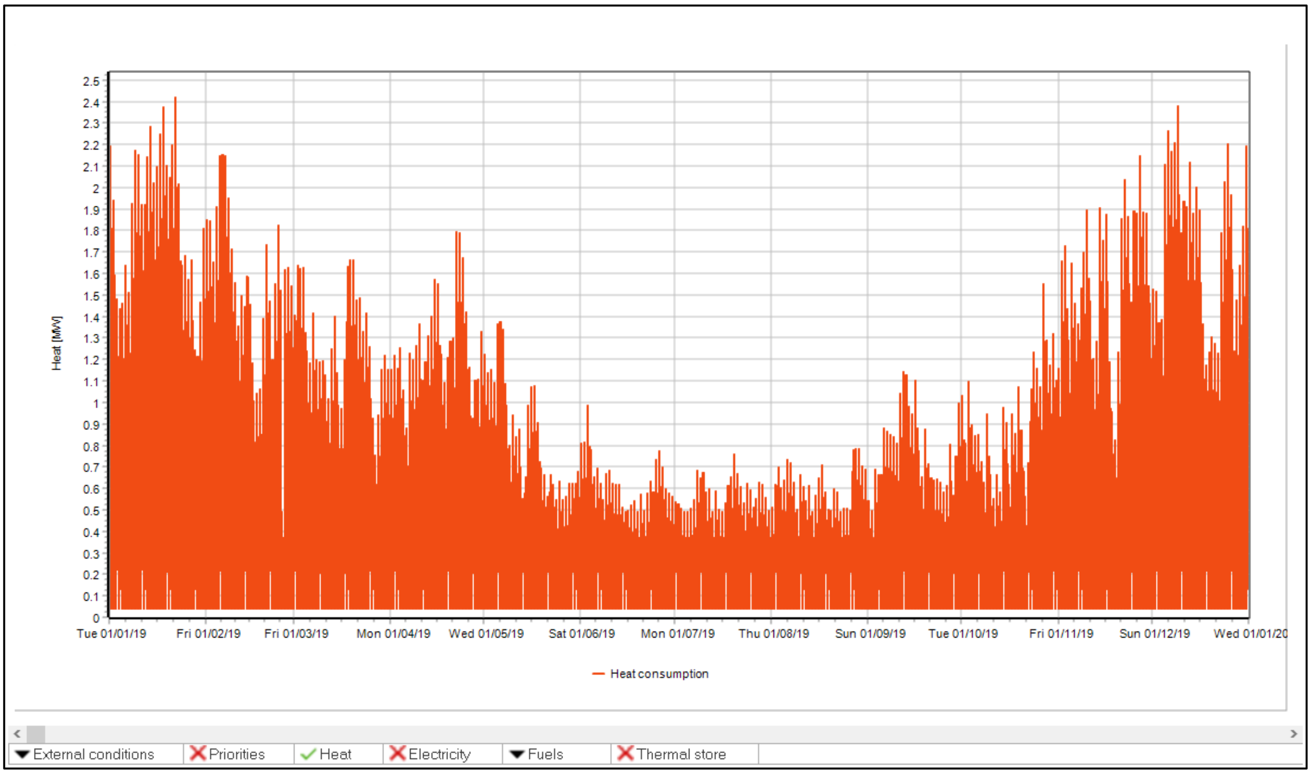


Figure 5 Site wide heat demand profile over a year (MW)

If the heat demands were constant all year round rather than varying according to usage/occupancy patterns and weather then the heat demand would be just 95kW. This shows the importance of adequate thermal storage which can to some extent smooth the demand profile.

There are a number of advantages of a site wide heat network - it allows a single central energy centre to serve all of the loads on the site – as well as to be extended to add other sources.

4 Financial and Carbon Emission Analysis

4.1.1 Carbon Savings

The choice of figure for grid carbon intensity has a significant impact on the carbon emissions associated with the various options analysed. Current Building Regulation figures for grid electricity are out of date with carbon emission factor for grid electricity at 519 kg/MWh. In 2016 the Digest of UK Energy Statistics gave an actual average emission factor for the grid of 254 kg/MWh.

Why is this significant? Heat pumps use electricity as their input whereas gas CHP generates electricity – using gas. So as the decarbonisation of the grid continues then it becomes more attractive to consume gas to displace electricity and produce heat and more attractive to consume an increasingly renewably fed electricity supply to produce heat.

The government department BEIS – formerly DECC - has a unit called the Heat Network Delivery Unit (HNDU). They argue that gas CHP will continue to save carbon because CHP doesn't displace all electricity generators on the grid but instead displaces fossil fuel generators or a mix of generators that results in a net saving.

We have therefore shown three figures below for each of our 3 scenarios: the Building Regulations figure as used by Hurley Palmer and Flatt, the DUKES 2016 average grid factor figure and finally the DECC/BEIS figures as prescribed for heat network modelling (averaged over the period of their modelling – the figure changes each year). We have included the cinema/gym in all 3 scenarios so that the figures are directly comparable. Using old Building Regulations figure shows that CHP will produce the lowest carbon emissions but either of the other options including the official BEIS figures for heat network analysis give the heat pump options the lowest emissions.

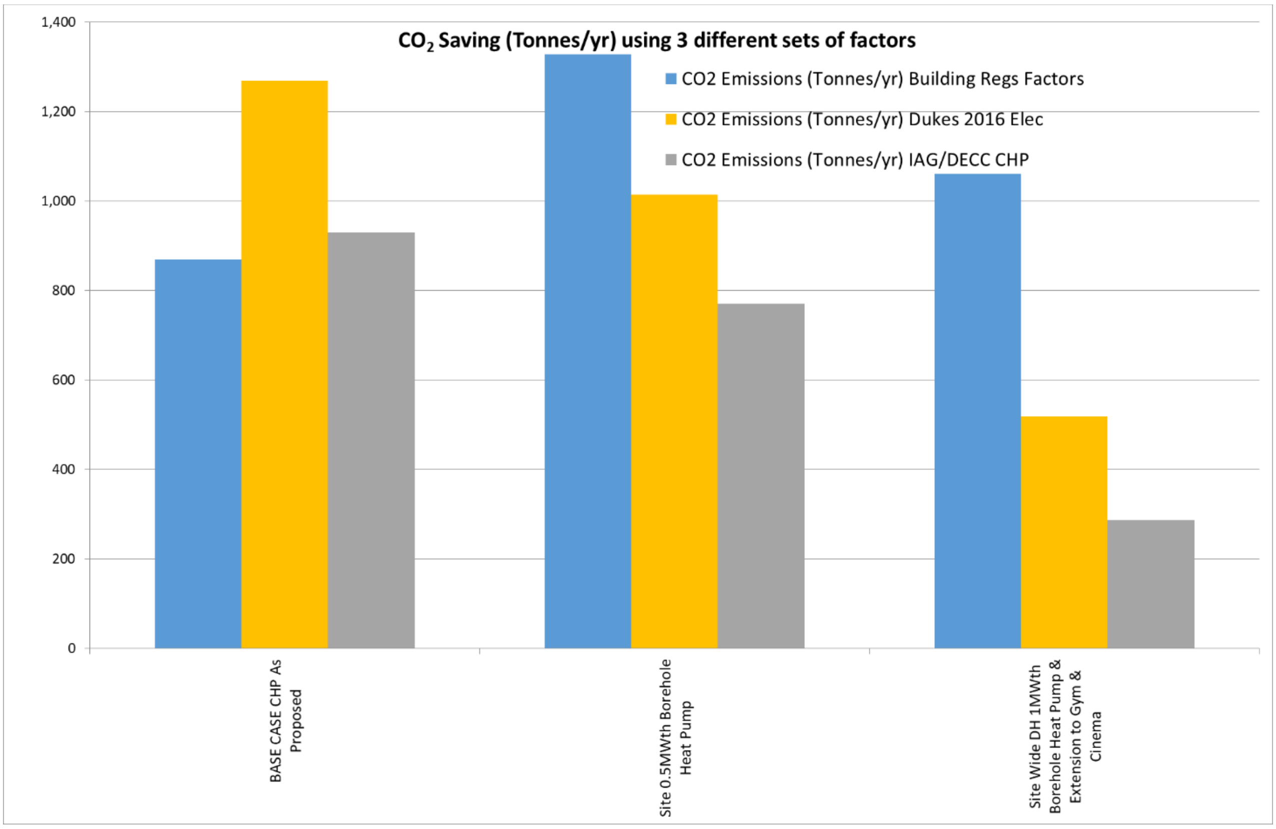


Figure 6 CO2 emissions for the 3 scenarios using different grid CO2 factors

4.2 Capital costs

The difference in capital costs between a site wide heat network served a single energy centre are difficult to estimate without a better understanding of the current plans ie location of plant rooms etc. However we have estimated that the total length of network outside of the buildings is approximately 630m. We estimate the additional cost of laying heat network over laying a gas network at £600 per metre so an additional £380k to lay a sitewide heat network over and above a new gas network. A further 100m of flow and return pipework would be required to connect to the gym/cinema complex.

There are other significant additional costs for a borehole heat pump solution – namely the borehole itself which costs up to £100 per metre. We also envisage much larger thermal storage than currently planned though this would take the form of a single central store rather than 6 individual stores so the cost per m3 should be cheaper. More detailed analysis would be required to give truly accurate figures but these give a sense of the additional capital cost of what we a site wide scheme with heat pumps. Please note the values below are in £1,000s.

The site wide scheme is significantly more expensive but as we show later this additional cost pays for itself in higher operational surpluses.

CAPEX Breakdown in £k	**BASE CASE CHP As Proposed**	**Site 0.5MWth Borehole Heat Pump**	**Site Wide DH 1MWth Borehole Heat Pump & Extension to Gym & Cinema**
WSHP Plant	£57	£450	£900
CHP Plant	£500		
Building Works	£100	£50	£50
Plant room M&E	£175	£80	£80
Abstraction/Discharge Pipework and M&E	£0	£147	£177
Abstraction/Discharge Civils	£0	£220	£440
Cooling pipework and M&E	£0	£120	£145
Electrical supply	£40	£50	£95
District Heating Pipework	£0	£632	£732
Gas Network	£253	£0	£0
Design, Commission, Contingency etc	£226	£385	£576
Total	**£1,351**	**£2,134**	**£3,196**

Table 1 of Capex Estimate in £k

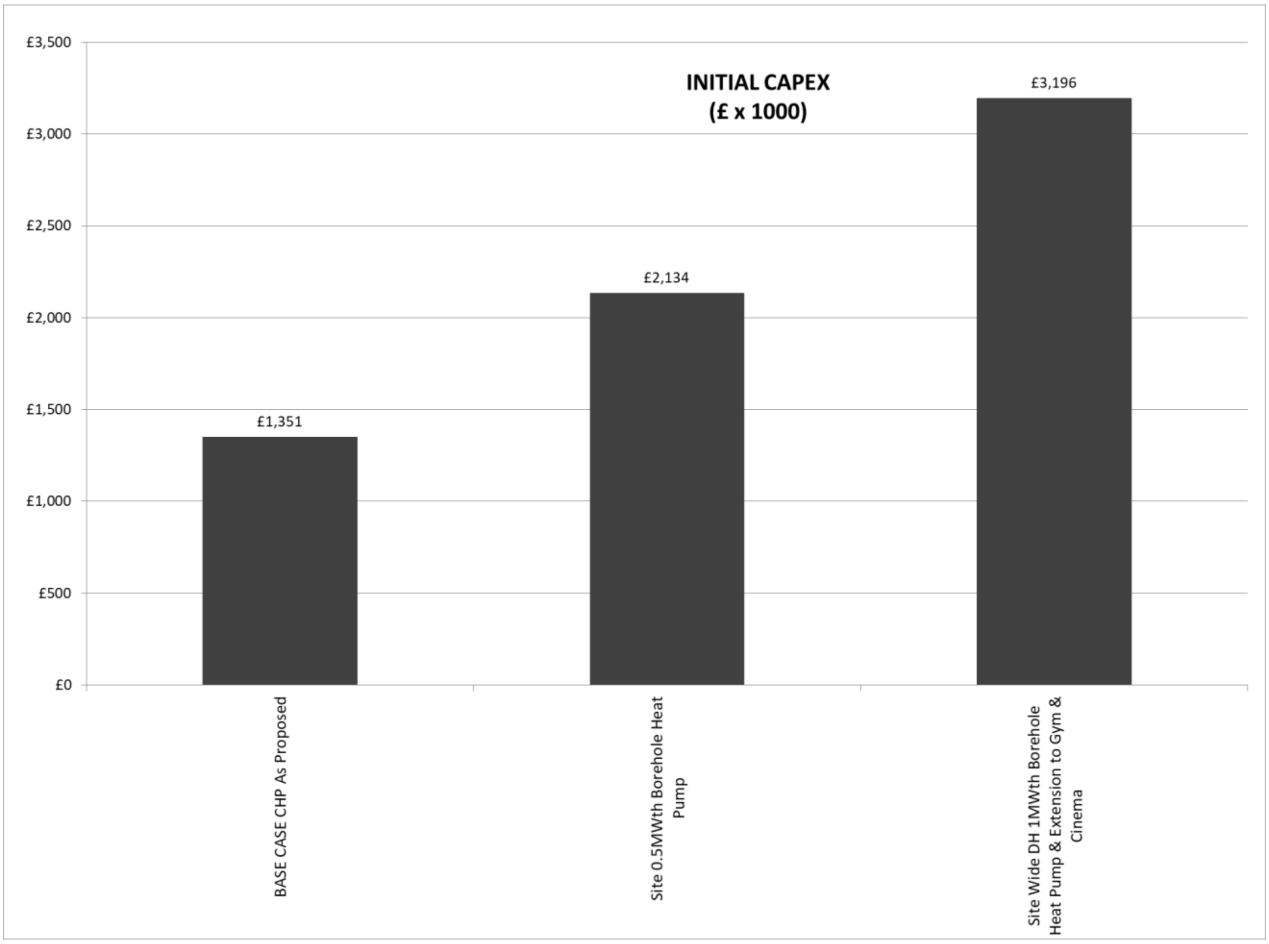


Figure 7 Capital Costs £k

4.3 Operating Costs/Surpluses

The figure below shows the estimated difference in operational surplus between three schemes we have modelled. The largest scheme ie connecting the gym and cinema to the network fed by a 1MWth heat pump shows the biggest surplus. We have assumed a heat price of 4p per kWh for commercial customers and 6p/kWh for residential customers. 2017 spot market prices for import and export have been used from Elexon.

Additionally Eastern Region Distribution Use of System (DUoS) charges and Generator DUoS charges for 2019 have been used. Heat pump efficiencies under different borehole temperatures were provided by Star Refrigeration.

Our analysis indicates that a heat pump fed network would produce a significantly better operational surplus than a block based CHP scheme.

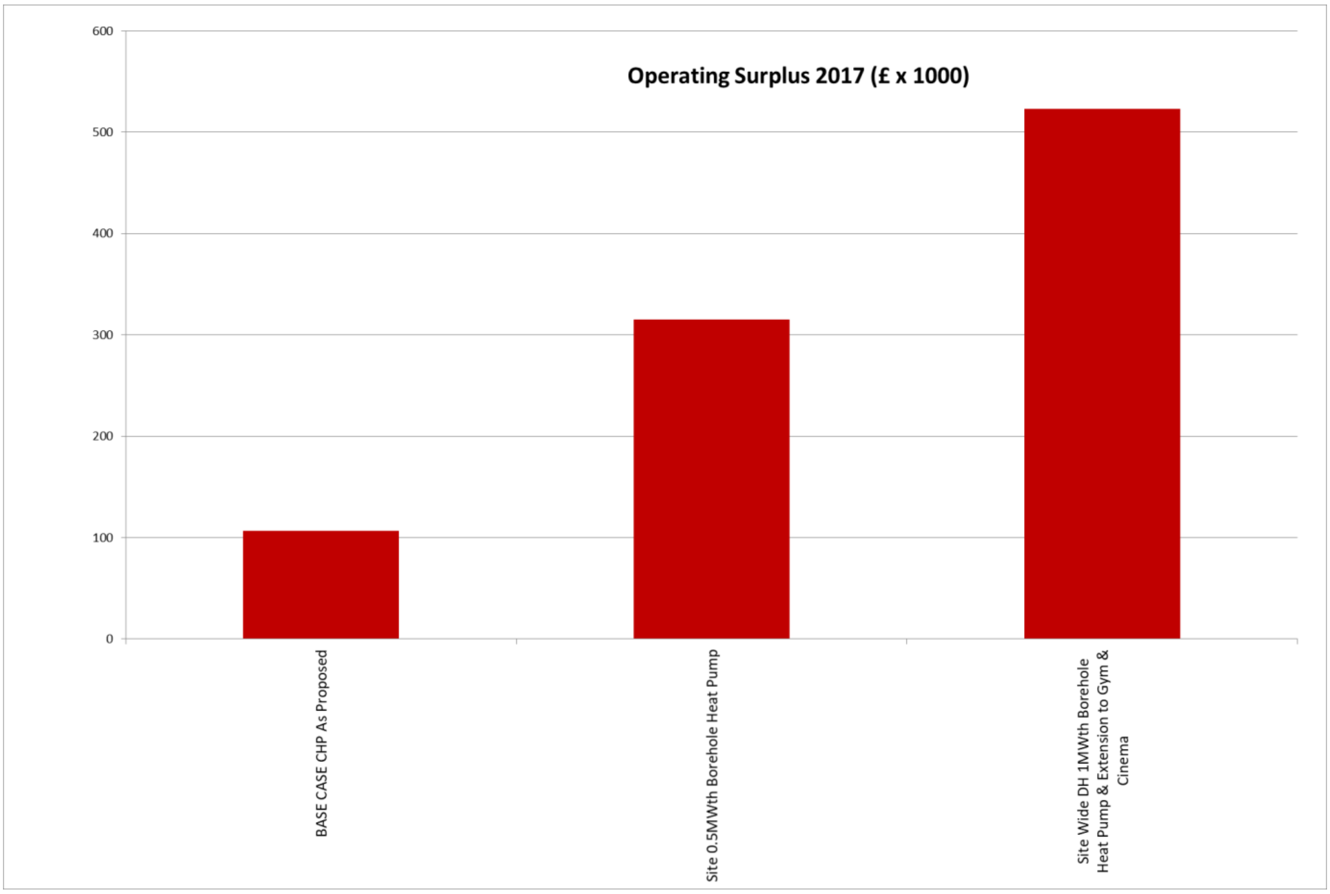


Figure 8 Operating Surplus £k

4.4 Net Present Value

As can be seen below despite the increased capital costs of the two heat pump site wide network options once the superior operational surplus is taken into account the net profit (discounted to present day costs using a treasury discount factor of 3.5%) over 20 years is sufficiently better.

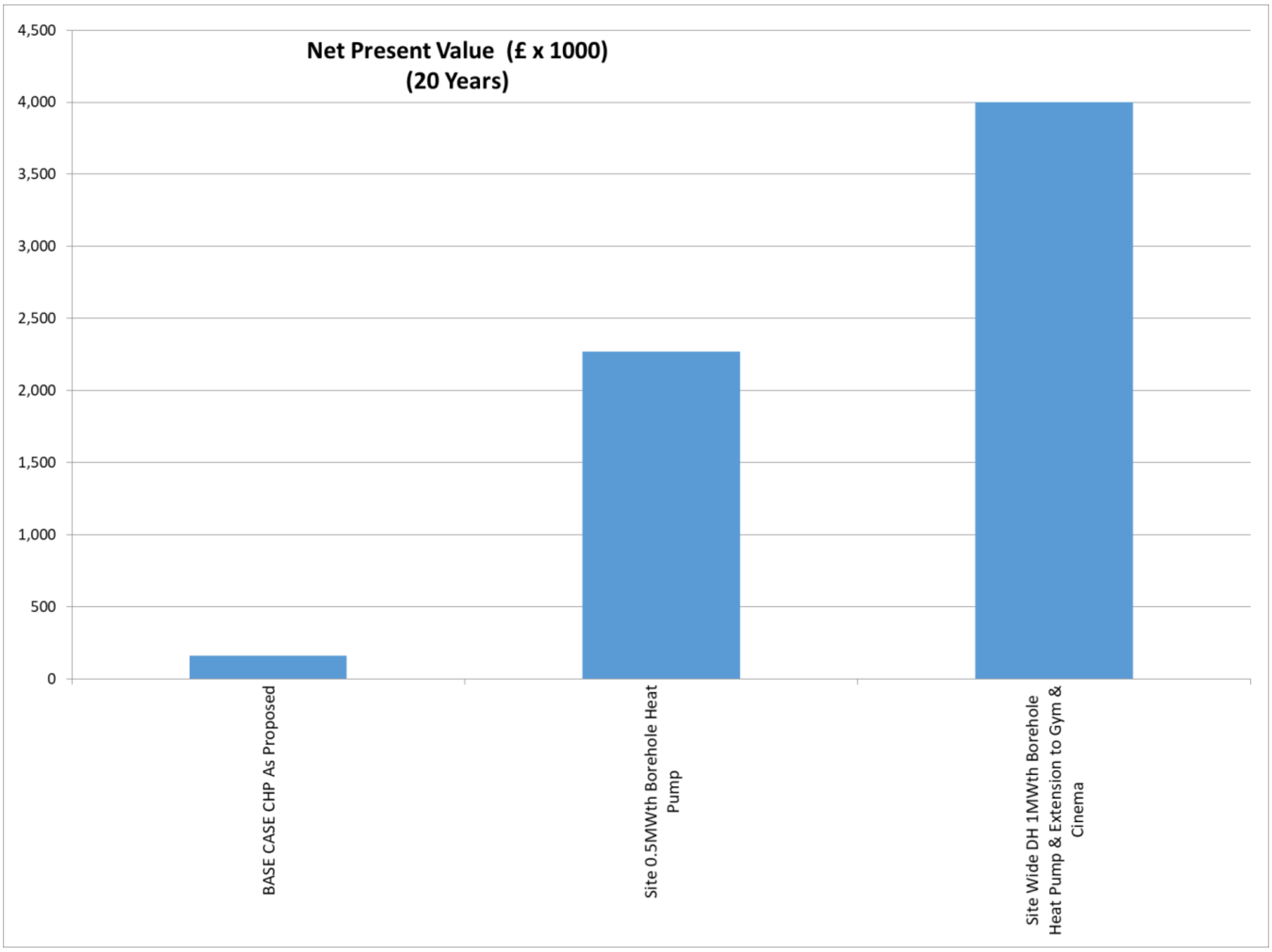
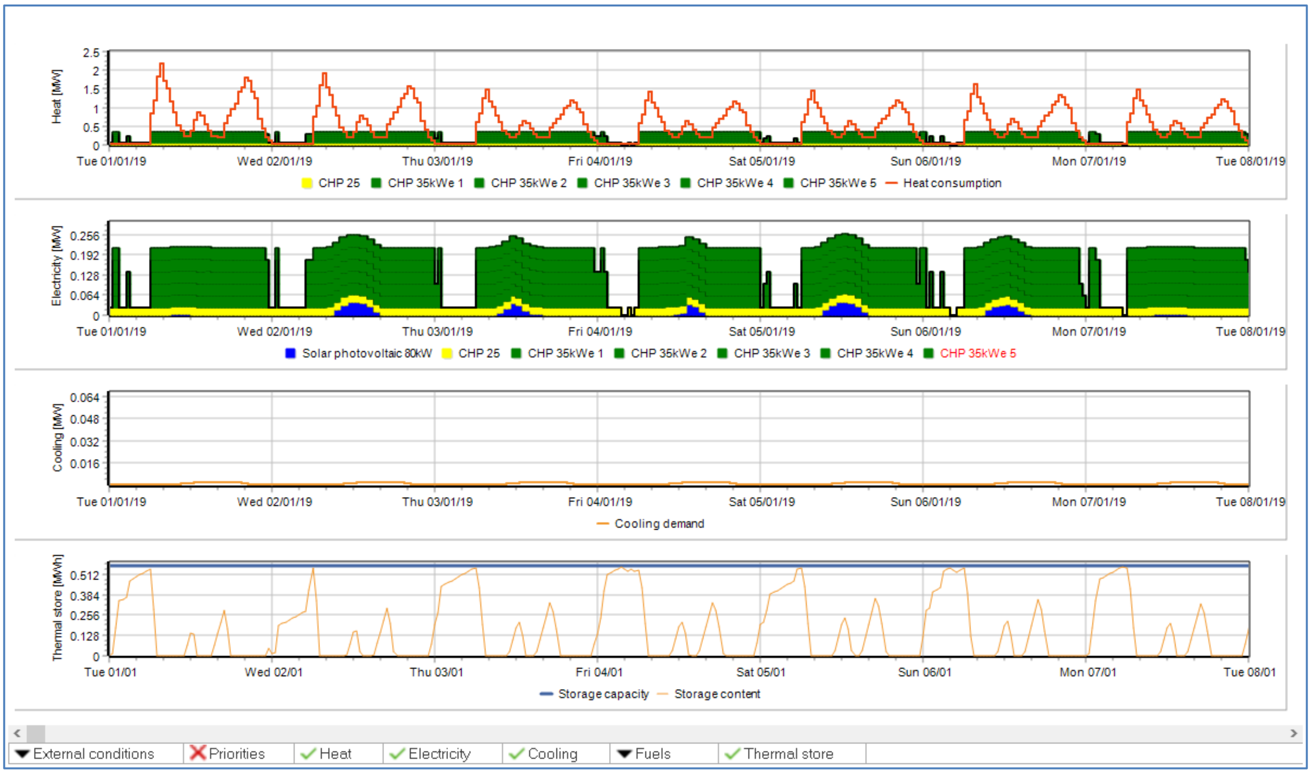


Figure 9 Net present value over 20yrs at 3.5% discount rate in £k

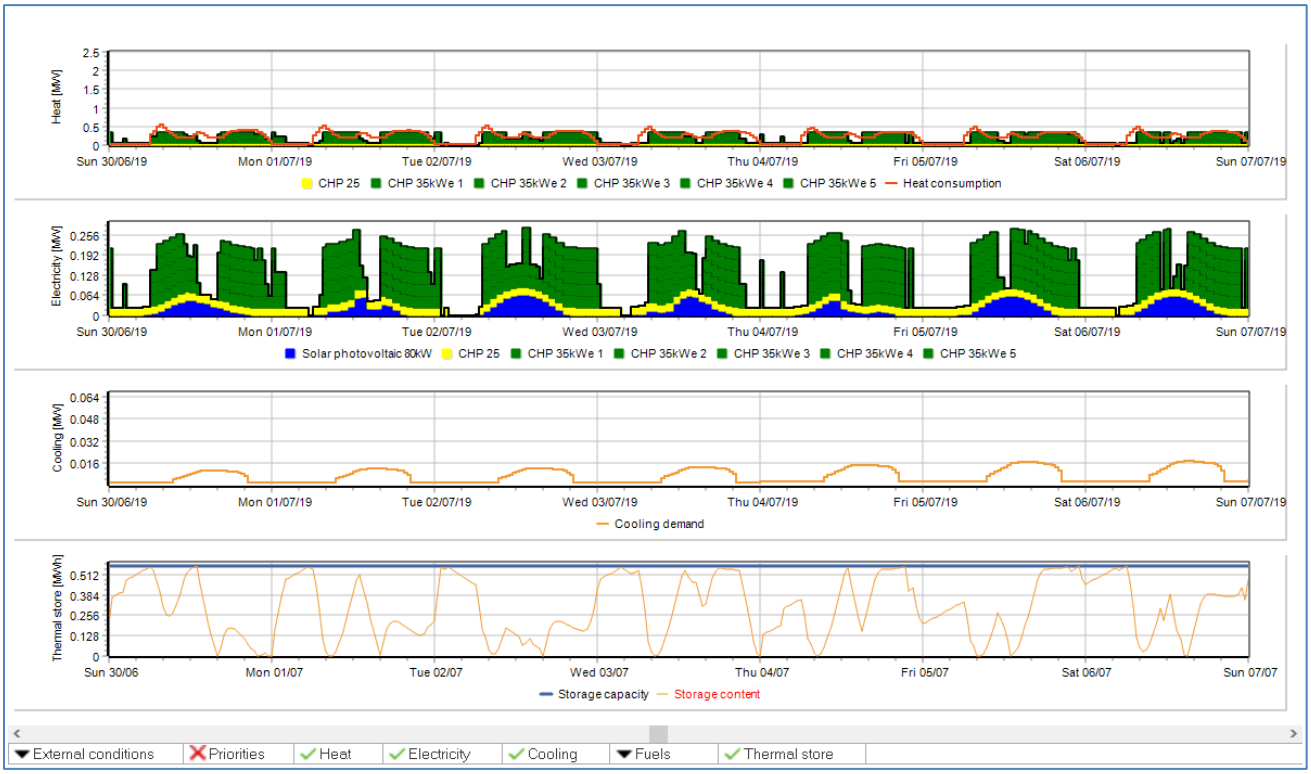
Appendix

4.5 energyPRO Operational Diagrams

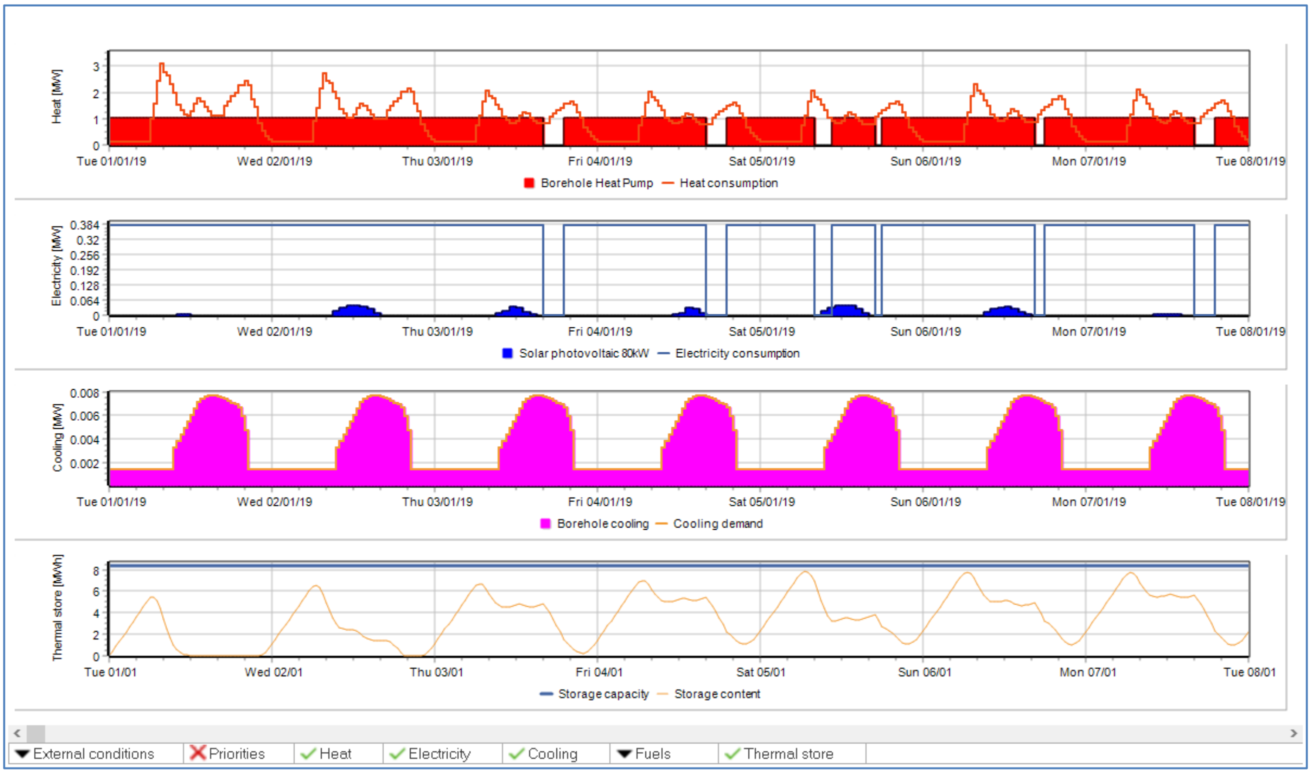
4.5.1 Winter Week As Proposed CHP



4.5.2 Summer Week – As Proposed CHP



4.5.3 Winter Week Site Wide Plus Cinema/Gym



4.5.4 Summer Week Site Wide Plus Cinema/Gym