Brymbo Steelworks District Heating Feasibility Study

Monday 26 August 2019

Scene Document Reference:	Brymbo District Heating Feasibility Report v2
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Date:	26th August 2019
Document Revisions:	
Version 1	Draft for Comment
Version 2	Final Version with Executive Summary

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EXECUTIVE SUMMARY

The village of Brymbo, Wrexham, is going through a period of substantial regeneration including large-scale housebuilding, the restoration of industrial heritage buildings and the development of new community recreational assets and visitor attractions. Plans are also well-advanced for the construction of a medium-scale solar farm.

The local organisation entrusted with heritage protection and community regeneration, Brymbo Heritage Trust (BHT), wishes to assess the feasibility of a community-owned district heating system on or near to the heritage site. Potential heat users could include the heritage buildings, a mixed-use community and enterprise centre, existing houses, new housing estates and the planned new non-domestic buildings (a school, medical centre, pub/restaurant and other commercial units). As well as making a significant contribution to the low-carbon thread of the area's regeneration story – and reducing heating costs for the heritage buildings – BHT wishes to assess the feasibility of whether a heat network could present an opportunity for individuals in the community to invest in a scheme that would provide social and environmental benefits alongside financial returns.

The renewable energy supply options considered included biomass boiler systems, minewater source heat pumps and ground source heat pumps. Other sources of renewable heat were discounted for reasons of resource availability, performance or cost. Although the site covered by the housing development and heritage zone is large and features substantial amounts of open space, the options for siting centralised heat extraction or generation plant are quite limited.

The preferred site for a biomass boiler (the Duck Pond area) is more than 200 metres away from the major non-domestic heat loads, with the nearest clusters of housing even further away. Even if it were possible to locate the abstraction borehole for a minewater heat scheme closer to the loads, the proposed 'reintroduction well' (through which the thermally spent minewater would be returned underground) is in a more isolated location. The final energy supply option is a ground-source system employing a group of boreholes and a low-temperature 'Shared Ground Loop' network to serve individual heat pumps located in each building. The viable sites for the borehole array include the grounds of the planned new school and part of the nearby sloping 'community park' area to the east. These locations give the ground source network option the advantage of having the heat collection system somewhat closer to the end users than is the case for the biomass or minewater options.

Whatever the energy source, the spatial spread of potential customers means that for any heat network at this site the ratio of the amount of heat supplied to the length of buried pipework will be low. The formalised measure of this ratio – the Linear Heat Density, or LHD – that is achieved by the different options for network extent and customer mix falls within the range 0.5 to 1.1 MWh/metre. The rule-of-thumb minimum LHD for commercial, fossil fuel-powered heat networks is around 2.0 MWh/metre. Although renewable heat subsidies and community ownership may enable slightly lower LHDs to be viable, the Brymbo network options display LHDs that make them challenging to deliver without a high proportion of grant funding in addition to the ongoing operational subsidies that level the playing field between low carbon sources and fossil fuels.

For heat pump-based schemes, there may be an opportunity to integrate the heat network with the solar PV installation and unlock electricity cost savings and further carbon savings. However, analysis of the benefits of using surplus PV generation to drive nearby heat pumps at certain times of year against the cost of the private wire electricity connections that would be required shows there to be no net improvement in the network's viability. Carbon savings would be boosted by 5-7%.

The strongest network and energy supply combination uses an array of boreholes as ground source heat collectors and a Shared Ground Loop network to supply 6 non-domestic heat users (the heritage 1920s machine shop, the Brymbo Enterprise Centre and new pub, school, medical centre and retail). Each connected building would house its own heat pump to generate space heating and hot water. Because the network would be operating at a low temperature, insulated pipework is not required. The key details and expected performance of this scheme are as follows:

Table E.1: Key details, revenues and costs for ground source system serving 6 non-domestic loads

Total load (not including diversity factor)	423 kW
Total annual heat supply	762 MWh
Total annual electrical input	228 MWh
Linear Heat Density	1.0 MWh/m
Network heat losses	-

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Annual electricity consumption	
Network pumping	10 MWh
Heat pumps	218 MWh
Total annual electrical input	228 MWh

	No subsidy/support	Subsidy equal to RHI
Capital cost	**£844,800**	**£844,800**
Annual revenues and avoided costs		
Heat sales	£19,227	£19,227
Saving from avoided electrical heating	£16,327	£16,327
Subsidy income	-	£59,029
Annual operating costs		
Electricity costs (with 100% grid import)	£30,743	£30,743
Fuel costs	-	-
Replacement of short-life equipment	-	-
Other O&M costs	£8,000	£8,000
Net revenues [£/year]	**-£3,189**	**£55,840**
Simple payback [years]	n/a	**15.1**
Carbon savings [tonnes CO_2e per year]	**114.9**	**114.9**

This scheme achieves a simple payback of 15.1 years when a subsidy equivalent to the RHI is received (the RHI will have closed to new applicants before a renewable heat network at Brymbo could be constructed and accredited; no details of the replacement scheme have yet been announced). Without any output-based subsidy, the scheme's operating costs exceed the revenues from heat sales to third parties and savings on the heritage building's heating costs.

Although the scheme would deliver impressive carbon savings, it will fail to generate high enough returns to provide community financial benefit and is unlikely to be attractive to individual investors in the community unless some of the capital cost can be grant-funded and an RHI-style subsidy is available. Neither does it stack up as an investment to reduce running costs for the heritage hub, especially in comparison to the case for a standalone renewable heat system for the Machine Shop. The following table compares the financial performance of a scheme financed with a blend of concessional loans and grants, and one financed with a community energy bond issue plus grant(s). In both cases, the amount of grant is set by the maximum loan – or bond issue – that the project would be able to afford.

Table E.2: Financial performance of schemes financed with concessional loans or community energy bond issues, plus grants

Concessional Loan & Grant Blend			Community Energy Bond Issue & Grant Blend	
Assumed cost increases: energy prices and heat sales 4% p.a., subsidy rates and OPEX 2.5% p.a. Discount rate 3.5% p.a. Equipment replacement cost £120,000: fund built up between Years 11 and 20.				
Loan term	15 years		Bond issue term	15 years
Interest rate	4% p.a. (payments are principal + interest)		Interest paid	5% p.a. (no capital repayment until Yr. 15)
Maximum loan that can be afforded	£600,000		Maximum value of bonds that can be issued	£500,000
Minimum grant required	£245,000		Minimum grant required	£345,000
20-year Net Present Value (NPV)	£306,000		20-year Net Present Value (NPV)	£290,000
Nominal Internal Rate of Return (IRR)	5%		Nominal Internal Rate of Return (IRR)	5%

One reason for the poor financial performance of this scheme is the fairly high capital cost (£2,000/kW), largely resulting from the expense of ground heat collector installation (challenging drilling conditions) and the poor Linear Heat Density. Another reason is that revenues from heat sales to third-party customers are kept low by the requirement to compete with the low cost of heating with natural gas. If this constraint could be removed – if new-build connections were willing to pay a higher price for heat than they would be able to achieve with natural gas – then the viability of the development could be better than presented here. This may be possible if building occupants are motivated by sustainability or reputational concerns or the desire to be part of a community initiative, or if regulation or planning requirements oblige them to use low-carbon heating sources.

The marginal financial viability of the Brymbo Heat Network is likely to mean that community ownership and operation is the only option, meaning that BHT (or in practice a new separately-constituted commercial organisation, which could be wholly owned by BHT) will take on the role of Energy Services Company (ESCo). Brymbo Heritage Trust could act as heat supplier to its own buildings, but a new Brymbo heat company which is not a charity would be required to be able to act as heat supplier to third-party customers, as the sale of energy does not form part of charitable commercial activities. In this case, decisions would need to be taken (in line with regulation) on matters such as metering and billing, tariff structures and rates and customer protection. The form of energy supply contract between supplier and customer that is normally used in this context is the Heat Supply Agreement.

The addition of the heat network to BHT's energy services activities will bring the opportunity for additional new job creation and the upskilling of individual capabilities. It is estimated that the operation of the heat network would create between 0.1 and 0.5 FTE jobs in Brymbo, depending on the number of customers and technical operational requirements. The preferred network option would create employment at the lower end of that scale.

Land ownership (current and planned) has been a critical factor in the identification of suitable locations for heat generation plant. It is anticipated that the locations for a biomass boiler or for minewater abstraction and return infrastructure will come into community ownership ahead of the construction of a heat network. However, the locations of ground source heat collectors and pipework may not be subject to transfer, and so landowner agreements would be required.

At this stage, the most significant risk for the heat network project is that the post-RHI support for renewable heat does not lead to a viable financial case. Industry organisations are calling for clarity from the government on how it intends to support renewable heat after 2021. It is not possible to mitigate this risk, and it is recommended that stakeholders wait for information on post-RHI support before further work is undertaken to develop heat network opportunities (although work to identify and line up grant funding opportunities could be undertaken). Once an announcement has been made, the financial case should be reconsidered for the frontrunner development options identified by this study.

Another important risk is the possibility that the potential heat customers on which the financial case is based do not connect to the network, but instead opt for conventional heating systems. Engagement with building managers and property developers could help to secure commitment, but as the design and construction of new buildings progresses this will be vulnerable to the uncertainty that necessarily surrounds the heat network project.

An alternative way for the community organisation to achieve its objectives may be to invest in standalone renewable heat systems rather than a network. Assuming that the default heating energy source for the 1920s Machine Shop would be electricity, both a biomass boiler and an air source heat pump system would offer attractive paybacks (< 8 years) on the capital cost of the system even if no subsidies were available. With an RHI-equivalent output-based payment, the payback could be as low as 5.3 years. Standalone systems for other buildings (where the default heating energy source is expected to be natural gas) are only marginally viable or are not viable.

It is recommended that the design process for the machine shop considers renewable heat options for the building's space heating and hot water supply, even if this rules out the building's participation in a future heat network. Professional installers of such systems will be able to provide budget quotes and preliminary design outlines to enable robust assessment of the different options versus conventional, non-renewable heat. If the result of further work was that renewable heat technologies were not found to be viable as part of the renovation project, the conventional heating system installed should be designed to be suitable for future connection to a heat network or a standalone renewable heat system. The most important component of this is enabling the heating system to operate at a lower temperature flow temperature than a fossil fuel system. Thermal efficiency of the building fabric should be maximised to the greatest extent possible within regulatory, technical and budget constraints.

Similarly, where the decision is made not to install renewable heat technologies in the first instance, it is recommended that the developers of new-build housing, commercial properties and public facilities 'futureproof' their buildings by installing heating systems that are compatible with heat networks or standalone renewable heat supplies.

Finally, the outcomes of the 'Power from the Deep' project (that will establish the size and suitability of the minewater heat resource at Brymbo) once available should be used to reassess the minewater heat network options, in the hope of identifying opportunities to add connections that improve the Linear Heat Density or to reducing the estimated capital cost to a point where a heat network becomes viable.

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GLOSSARY

BDL	Brymbo Developments Limited
BGS	British Geological Society
BHT	Brymbo Heritage Trust
DHN	District Heat Network
ESCo	Energy Services Company
LHD	Linear Heat Density
RHI	Renewable Heat Incentive

1. INTRODUCTION

1.1. SCOPE

Cadwyn Clwyd, in partnership with Brymbo Heritage Trust (BHT), secured funding through the LEADER scheme (under the Welsh Government Rural Communities – Rural Development Programme 2014 – 2020) to undertake a feasibility study to explore the potential for a community-owned district heating scheme at the Brymbo Steelworks in Wrexham. Scene Connect Ltd. were commissioned to deliver the study.

1.2. STUDY BACKGROUND

The village of Brymbo, Wrexham, is going through a period of substantial regeneration. The former Brymbo Steelworks site, under the stewardship of Brymbo Heritage Trust, will benefit from various lottery funding grants to restore historic buildings and build new ones to create a visitor attraction, learning centre and country park. This regeneration is taking place in the context of a development of the wider area around the steelworks – the Brymbo Park development will create large amounts of new housing alongside commercial space and community facilities. BHT also has well-developed plans to construct a medium-scale solar farm on the edge of the proposed housing development, which will form an integral part of the ‘story’ of sustainable regeneration in the area and an important physical feature within the community- and visitor-oriented space.

The objective of the feasibility study is to assess the potential to install a community-owned district heating system on or near to the heritage site, supplying heat to the new housing scheme, public buildings (e.g. schools, medical centre) and commercial units within the adjacent wider development site. There are a range of possible scales for such a scheme, with the preferred development options being driven by the size of the various renewable energy resources, the availability of space to house new plant and infrastructure, likely capital availability and the level of ambition with respect to how much of the Brymbo Park development could be connected. Whatever the scale of the heat network, its development could be paired with investment in standalone renewable heat systems for users who might not receive a physical connection to the network but could still receive the benefits of paying for heat-as-a-service.

The presentation of options and recommendations is not restricted only to technical and economic aspects, but also outlines the models through which a community-owned heat network can be delivered in terms of the roles that different parties can play, including the pros and cons of a community organisation functioning as an ESCo (Energy Services Company). The focus is on options that have long-term viability.

1.3. STUDY CONTEXT

With a long history of coal mining, ore mining and steelmaking, Brymbo’s past is strongly associated with the extraction and use of fossil fuels. The vision of the community organisation entrusted with the conservation and enhancement of heritage assets and with wider local regeneration, Brymbo Heritage Trust, is one of social inclusivity and sustainability. The planned visitor attraction is intended to tell the story of man’s relationship with energy and the evolution from fossil fuel-based industry to a new future powered by energy from the sun or from renewable resources beneath our feet. Alongside the planned solar farm, a renewable heat network would greatly enhance this low-carbon message, and there may be symbiotic opportunities for the two projects to improve revenues and carbon savings through integration of surplus PV generation with network electricity demand.

The mines below Brymbo have been identified as a potential source of renewable energy, and a feasibility study for the recovery of heat from flooded mine workings has been carried out by the British Geological Society. Although some practical obstacles (blocked boreholes and shafts) meant that the study was not conclusive about the scale of the resource, it indicated that there was an opportunity worth pursuing. Minewater heat has been included alongside other renewable heat sources as energy supply options for the heat network.

24% of households in the western part of Brymbo village are estimated to suffer from fuel poverty. Rates are lower (below 20%) in the less-populous eastern part. If viable, a heat network could present a mechanism by which domestic heating costs could be reduced for homes in the vicinity of the heritage site.

The heat network is also anticipated to present an opportunity for individuals in the community to invest in a scheme that will provide social and environmental benefits alongside financial returns. Reducing future heating costs for the restored heritage buildings is also an important driver. Finally, it is hoped that the heat network will play a part in local job creation.

1.4. SITE DESCRIPTION

The site under consideration for the feasibility study includes the entirety of the 30+ hectare area owned by Brymbo Developments Ltd. (BDL) and covered by the company's 2019 Outline Planning Application, plus the following:

- Steelworks heritage buildings;
- The site of the Fossil Forest and planned Fossil Forest building;
- The site of the Brymbo Enterprise Centre;
- The strip of land in between the BDL Site and Blast Road, where various industrial heritage buildings and mine-related structure and workings are located;
- The site of the planned solar farm (the Wonder Bank);
- The 'community park' area to the east of the BDL Site;
- The housing to the north and uphill from Blast Road (mainly the street named Argoed).

The BDL site is roughly divided into two larger parts and one smaller: the extensive area west of Phoenix Drive, the slightly smaller 'Plateau' area to the east of Phoenix Drive, and a much smaller northern zone centred around the road named New High Street. The site features a number of natural and artificial hills, including steep embankments and cliffs that may not be evident from aerial photography and maps.

Much of the land under consideration is reclaimed mining or steelworks land which will contain lots of slag and rubble, with implications for the cost of digging trenches and drilling boreholes. Ground conditions are expected to vary across the Plateau – there is a thick layer of slag in the vicinity of the school that gets thinner to the south. In between the school site and the fossil forest area is a filled-in quarry.

1.5. OVERVIEW OF HEATING NETWORKS

A District Heating Network (DHN) delivers heat from one (or more) energy supply sources to a number of connected users. Heat distribution is normally achieved by the circulation of water through underground pipes, in a closed loop.

In conventional heat networks, the water circulates at high temperatures (70-90°C, although some networks operate with pressurised water or steam above 100°C) and this heat is transferred to individual buildings' internal heating systems either directly or via heat exchange and metering devices known as Heat Interface Units (HIUs). Thus, the network replaces the need for individual boilers or water heaters in each building. Modern HIUs have a similar level of user control as boilers and have similar maintenance requirements (so specialist servicing is not required). The heat is generated and transferred to the network at a central point (or a small number of points), often in a dedicated building termed the Energy Centre. Centralised heat networks can make use of a variety of heat sources and conversion technologies.

A decentralised heat network avoids the need for a separate energy centre, but rather consists of individual heat pumps housed in each building, each one of which is connected to the network. The network operates at a much lower temperature (sometimes cooler than the ambient temperature), although it is still carrying heat thanks to the temperature difference between the incoming and outgoing pipes. The heat sources for decentralised networks are normally ground-, water- or air-source heat.

The key advantages and disadvantages of the two types of network relate to the degree (and hence cost) of pipe insulation required for the network, the heat losses that can be incurred, the prospects for streamlined, centralised operation and maintenance and the economies of scale offered by larger plant. The characteristics of certain heat sources and operating modes of certain heat generation technologies can mean that one type of network is compatible where the other is not.

Whichever approach is taken, there can be significant benefits from supplying heat through heat networks, including:

- Highly efficient generation from direct supply of heat;
- Substantial reductions in CO_2 emissions;
- Cost savings from improved efficiency;
- More predictable heating costs;
- Improved load characteristics (heating requirements can be spread more evenly across different uses, with commercial properties tending to need heating through the day, while residential properties tend to need heat in the morning and evening);
- Potential to use renewable energy sources to wholly or partially generate the heat;
- Potential to use local fuel sources, increasing energy security.

To be an attractive choice for potential customers, heat networks need to provide a service equivalent to or better than conventional heat supplies, and heating charges which are equal to or lower than the alternative heating costs.

To take advantage of a connection to a heat network, it is normally necessary for a building to have a wet heating system (i.e. radiators or underfloor pipes). The new buildings that are prospective customers for the Brymbo Heat Network would need to have compatible wet heating systems installed; likewise, the currently unheated 1920s Machine Shop will require a new internal heat distribution system. Some heat network development options will require connected buildings to have good fabric thermal efficiencies, although for the new-build properties this will largely be taken care of by adherence to building regulations.

2. PLANNING AND ENVIRONMENTAL BASELINE

2.1. LAND OWNERSHIP

Except where land is owned by the community organisation, a landowner agreement will be necessary not only for the footprint of any development, but also for construction and operational access. The plans for the transfer of land from BDL to BHT are uncertain, but it is anticipated that the locations of a biomass boiler or of minewater abstraction and return infrastructure may come into community ownership ahead of the possible construction of a heat network. The locations of ground source heat collectors and pipework may not be subject to transfer, and so landowner agreements would be required.

Landowner agreements may be subject to a rental agreement or one-off payment, and the time and cost required to secure the agreement should be factored into the development programme. It is recommended that landowner agreement is in place prior to submitting any planning application for development (and may be necessary prior to that to secure pre-planning funds).

While utility companies have statutory development rights, these do not currently apply for heat and power networks installed by others. Permission from all individual landowners will be required prior to development.

2.2. LAND USE AND AMENITY

The area comprises former industrial land associated with the former Brymbo Steelworks, which was operational between 1796 and 1990. Following closure of the Steelworks the site, comprising circa 95 hectares of despoiled and contaminated land, was purchased by Brymbo Developments Limited (BDL).

The area is within the West Wrexham Ridges and Valleys Landscape Character Area. This is "a complex area of former mining villages, industry, farmland and woodland in a landscape of distinct ridges and valleys which are aligned towards Wrexham town." It is an area which continues to accommodate profound changes but is considered vulnerable to further loss of local distinctiveness.

There are a number of designated and non-designated heritage assets related to the former use, where there is positive intent to provide for their long-term stewardship, which is being taken forward through the Brymbo Heritage Trust formed in 2017, which has charitable status.

The site remediation has included some infrastructure implementation and residential and commercial planning permissions. As noted, there is also a planning application pending for a significant redevelopment – referred to by the developers as Brymbo Park - comprising 450 homes, a new primary school, civic uses and associated hard and soft landscaped areas. The potential for a heat network has considered existing and planned development.

2.3. DEVELOPMENT PLAN

The adopted Development Plan for the area is the Wrexham Unitary Development Plan (UDP) 1996 – 2011 (adopted 2005). The emerging Local Development Plan is the Wrexham Local Development Plan 2 (LDP2) 2013 – 2028. In the absence of an up-to-date development plan, development in the area must also be guided by relevant national planning policy (Planning Policy Wales) and local planning policy and guidance.

For a heat network, this policy context includes the commitments from Energy Wales (2012) and Energy Wales: A Low Carbon Transition: Delivery Plan (2014). These, together with other material considerations such as the UK

Climate Change Act, UK and Welsh Government targets for carbon emissions, provide a strong presumption in favour of proposals which promote renewable and/or low carbon sources of energy for heating.

2.4. DESIGNATIONS

As a brownfield site, there are no natural heritage designations, but there are features of cultural heritage interest. The proposals for a heat network will need to take this into account, primarily in terms of the ability to adapt buildings for improved energy efficiency.

3. HEAT DEMAND ASSESSMENT AND NETWORK SCENARIOS

3.1. INTRODUCTION

An energy demand assessment has been undertaken to understand the heating and hot water demand profile for the location, considering different development scenarios. Based on the heat demand diversity between the different buildings and their respective locations, the peak demand which would need to be met from the energy supply can then be considered in further detail.

For one building, the Enterprise Centre, recent energy bills were used to estimate that building's annual heat demand. For the other loads, energy consumption benchmarks for different types of building were applied to measurements and estimates of floor area (from site drawings, the BDL Outline Planning Application and design standards e.g. for the floor area of schools based on pupil numbers, or for housing size based on number of bedrooms). New housing was assumed to meet Level 5 of the Ene2 credit scale, on which the current Target Fabric Energy Efficiency laid out in Building Regulations is based: 52 kWh/m2/year for end-terrace, semi-detached and detached houses and 43 kWh/m2/year for apartment blocks and mid-terraces. It was assumed that two-thirds of the new houses would be end-terrace, semi-detached or detached. Domestic hot water requirements for housing was assumed to be 24 kWh/m2/year.

Figure 1 shows the total annual heat demand from the restored/redeveloped heritage buildings, new social and commercial facilities, existing housing on Argoed[1] and new housing across the BDL site to add up to almost 5 GWh per year. Given the capacity of the renewable heat resources outlined in Section 4 and considering the range of project scales that are likely to be suitable for a community organisation with limited prior experience of energy generation and supply, it is recommended that the first phase of the Brymbo Heat Network should target a small proportion of this overall demand. Steps that can be taken to ease the pathway for future expansions are detailed in Section 8.1.

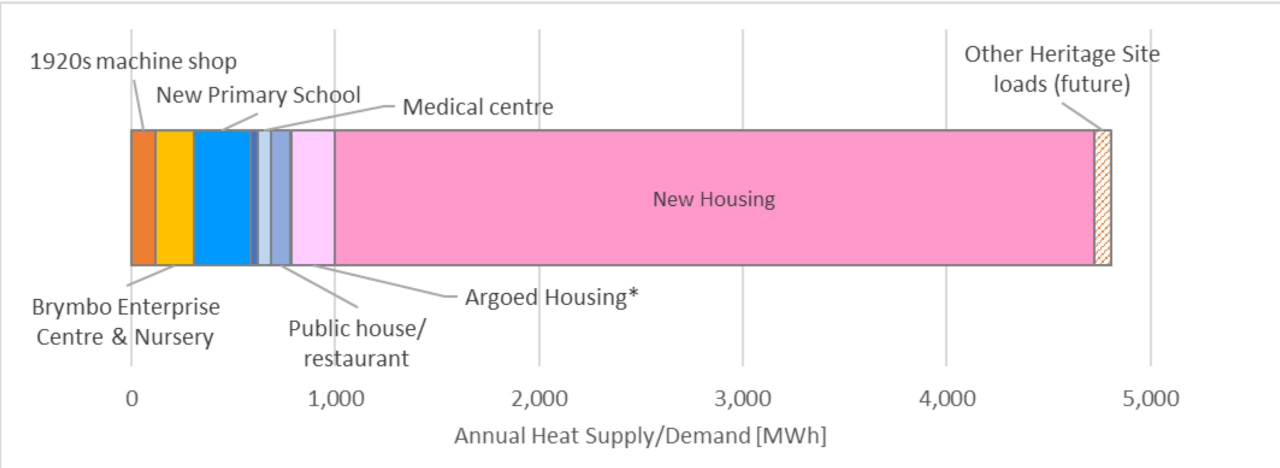


Figure 1: Estimated annual heat demand from buildings that could be connected to a heat network

Figure 2 shows these loads (in MWh) plotted on the map of the heritage site and BDL development area. The area of the circles is proportional to the annual heat demand. The non-domestic buildings (red circles) are clustered in

[1] 20 houses from the street named Argoed – 40% of the total – are assumed to be likely to connect.

the central and northern part of the site. Substantial clusters of load from new housing exist in the southwest and southeast. The heritage hub is part of a mixed-use cluster in the north of the site.

Figure 2: Estimated annual heat demand in MWh from non-domestic buildings (red) and groups of housing (blue) plotted on map[2]

Four different network extents have been modelled and assessed in terms of capital cost, financial viability and contribution to non-economic objectives. These four were selected to explore different resource and capital

[2] Map taken from BDL Outline Planning Application Land Use Plan (drawn by Barton Willmore, dated 06.09.2018).

availability scenarios and demonstrate different approaches with respect to the type of user that is connected (domestic or non-domestic, heritage or new commercial). They are the result of a high-level optimisation process that sought to minimise Linear Heat Density (LHD – a measure of the amount of heat supplied relative to the total length of pipe trenching required). The design phase of a Heat Network will involve further optimisation to minimise LHD as a major driver of the financial viability of the network.

Network Scenario A	Network Scenario B	Network Scenario C	Network Scenario D
1920s machine shop Brymbo Enterprise Centre	1920s machine shop Brymbo Enterprise Centre New primary school New pub/restaurant New supermarket New medical centre	Approximately 80 new homes (western part of site)	1920s machine shop Brymbo Enterprise Centre New primary school Approximately 34 new homes (northern part of site)

3.2. HEAT LOAD PROFILE GENERATION

The heat load profiles presented in Section 3.7 are generated by modelling the heat demand of each user in relation to climatic conditions and occupancy patterns. For each building, heating degree-day base temperatures were selected (range: 11.5°C to 15.5°C) based on assumed internal heat generation (from machinery, appliances and people) and comfort requirements. Hourly occupancy patterns were modelled, including the effect of school terms, to determine the hours during which heating would be on full and when it would be in setback mode. The resulting profiles were combined with the estimated annual loads and the connections summed for each network scenario.

3.3. NETWORK SCENARIO A

The peak load and annual heat supply for this scheme approximately match the lower end of the ranges for minewater heat potential outlined in the 2019 BGS feasibility report (164 kW, 295 MWh).

Only two buildings are connected – the Heritage Hub Machine Shop and the Brymbo Enterprise Centre – but each represents a substantial load. For a minewater project, the lowest-possible LHD is achieved by connecting these two loads (around 0.5); however, this is not an LHD that is normally considered attractive by developers of heat networks. The forthcoming Heritage Hub and Enterprise Centre represent important community assets, so it is to be expected that reducing the cost of heating those buildings will release budget that could be spent in pursuit of social benefits.

The heritage site does not currently have a gas supply, and the minimal space heating and hot water provision is electrical. This report assumes that the budget for the restoration and redevelopment of the Machine Shop will cover the installation of a heating system that is adequate for the building's intended purpose, and the installation of standard fabric energy efficiency measures such as roof and wall insulation. If a connection to a heat network is available, the heating system installed would need to be a wet system which would ideally feature underfloor heating and/or radiators sized for low-temperature (<55°C) operation.

The Enterprise Centre is currently heated by a gas boiler or boilers. It is possible that the heat emitters installed at the time of construction (2007) would not be adequately sized to heat the building when connected to the network; the financial assessments in this report assume a typical cost for heating system upgrades which varies according to the renewable heat source. Similarly, some energy efficiency measures may be required, the cost of which is included in the scheme capital cost.

For a diagram of a network route annotated with details of the loads, a heat load profile and a load exceedance curve, see Section 3.7.

3.4. NETWORK SCENARIO B

The peak load and annual heat supply for this scheme approximately match the upper end of the ranges for minewater heat potential outlined in the 2019 BGS feasibility report (492 kW, 886 MWh).

This network scenario connects six non-commercial buildings: the Machine Shop and the Enterprise Centre, plus the planned new school, pub/restaurant, supermarket and medical centre. The LHD achieved by this network is between 0.8 and 1.0 (depending on the location of the heat generation plant) – a level of LHD that is not normally considered attractive by developers of heat networks. As with Network Scenario A, this network serves a number of loads of public or community value (the heritage hub, Enterprise Centre, school and medical centre) which could translate cost savings into social benefits.

The new buildings will require new energy supplies and internal heating systems. This report assumes that the cost of installing network-ready heating systems will be borne by the property developers or building purchasers, instead of installing conventional gas or electric heating systems only. It is also assumed that the new buildings will meet stringent fabric energy efficiency criteria and will therefore be adequately insulated to allow supply from any of the renewable heat options considered.

It is noted that the medical centre may be one of the last buildings to be built on the site because Brymbo is not an NHS priority location for new health facilities. However, because the medical centre represents less than 10% of the load for this network scenario, it could be replaced by 5-10 domestic connections with negligible impact on the overall costs and benefits presented in Section 3.7.

3.5. NETWORK SCENARIO C

The peak load and annual heat supply for this scheme approximately match the upper end of the ranges for minewater heat potential outlined in the 2019 BGS feasibility report (492 kW, 886 MWh).

This network scenario connects around 80 new houses in the northernmost part of the western housing development. The homes are assumed to be a mix of sizes between 1 and 6 bedrooms, as per the newly-built estate to the south of the site. The average number of bedrooms is four, with a total floor area of 138m2. The heritage hub is not connected, as the likely locations of the heat generation plant mean that the heritage hub connection would require its own spur of the network spanning at least 150 metres. Even so, the LHD achieved by the housing-only network is between 0.6 and 0.7, still a low value for a heat network. This assumes that the houses connected are those which allow the highest LHD (not, for example, prioritising affordable homes).

This assessment assumes that the cost of installing network-ready heating systems will be borne by the property developers, who would otherwise be paying for conventional gas or electric heating systems. Building regulations should ensure that the new buildings will be adequately insulated to allow supply from any of the renewable heat options considered.

3.6. NETWORK SCENARIO D

The peak load and annual heat supply for this scheme approximately match the upper end of the ranges for minewater heat potential outlined in the 2019 BGS feasibility report (492 kW, 886 MWh).

This network scenario connects buildings of various use types in the northern portion of the BDL site. Three non-domestic buildings would be connected: the Machine Shop, Brymbo Enterprise Centre and the planned new school. An additional 34 or so houses in the New High Street area would also be supplied. The shorter network length (relative to the other scenarios) allows this network to achieve an LHD of 0.9 – 1.1 (depending on the location of the heat generation plant). While this is still low, it gets closer than any of the other network scenarios to the LHD of 2.0 that is used as a rule-of-thumb minimum for commercial, fossil fuel-powered heat networks[3].

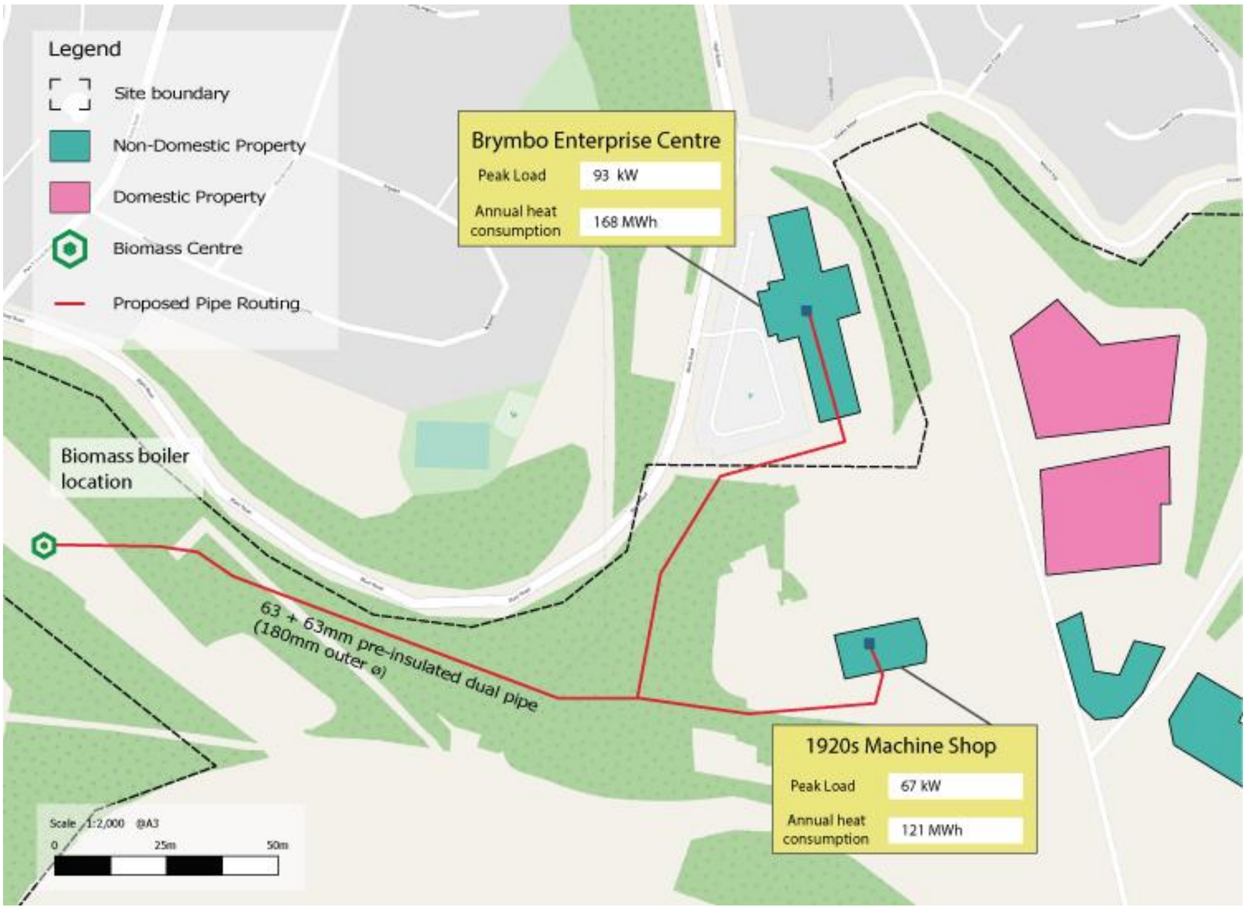
The new school and homes will require new energy supplies and internal heating systems. This report assumes that the cost of installing network-ready heating systems will be borne by the property developers or building purchasers, instead of conventional gas or electric heating systems being installed. It is also assumed that the new buildings will meet stringent fabric energy efficiency criteria and will therefore be adequately insulated to allow supply from any of the renewable heat options considered.

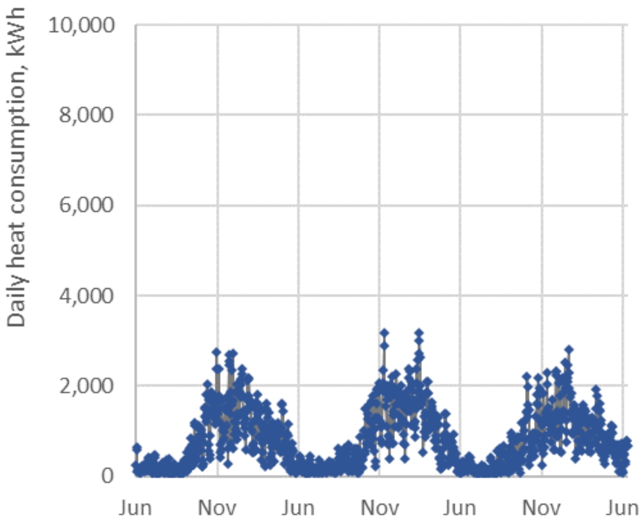
[3] Subsidies/incentives for renewable heat generation may allow lower LHDs to be viable. Similarly, low cost low-temperature networks (e.g. the Boreholes + Shared Group Loop option) can be viable with lower LHDs.

3.7. NETWORK DRAWINGS, KEY INFORMATION AND LOAD PROFILES

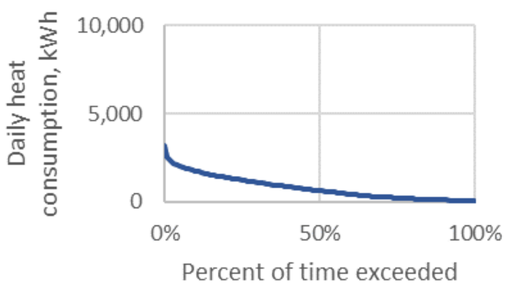
Network Scenario A

Network shown is the Minewater option.



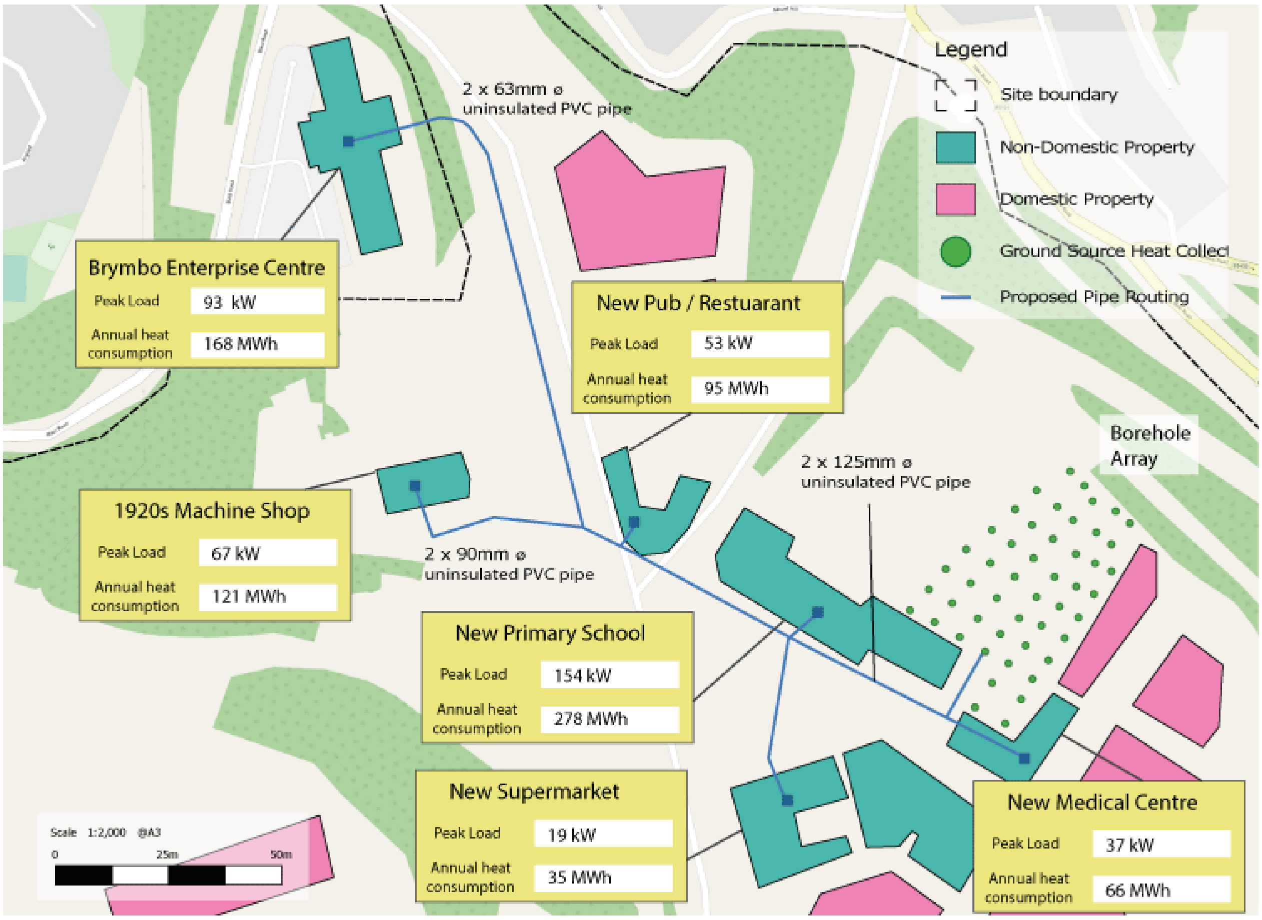


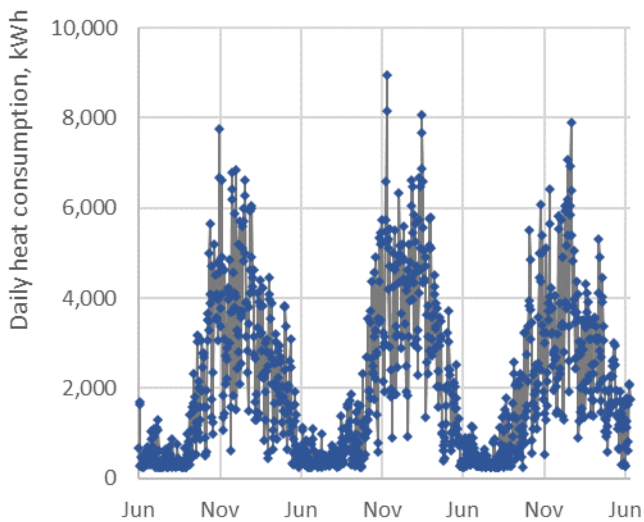
Number of connections: non-domestic	2
Number of connections: domestic	0
Total load (not inc. diversity factor)	160 kW
Total annual heat supply	288 MWh
Linear Heat Density [MWh/m]	0.5



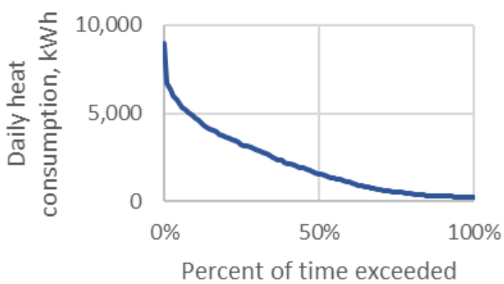
Network Scenario B

Network shown is the Boreholes + Shared Ground Loop + Individual Heat Pumps option.



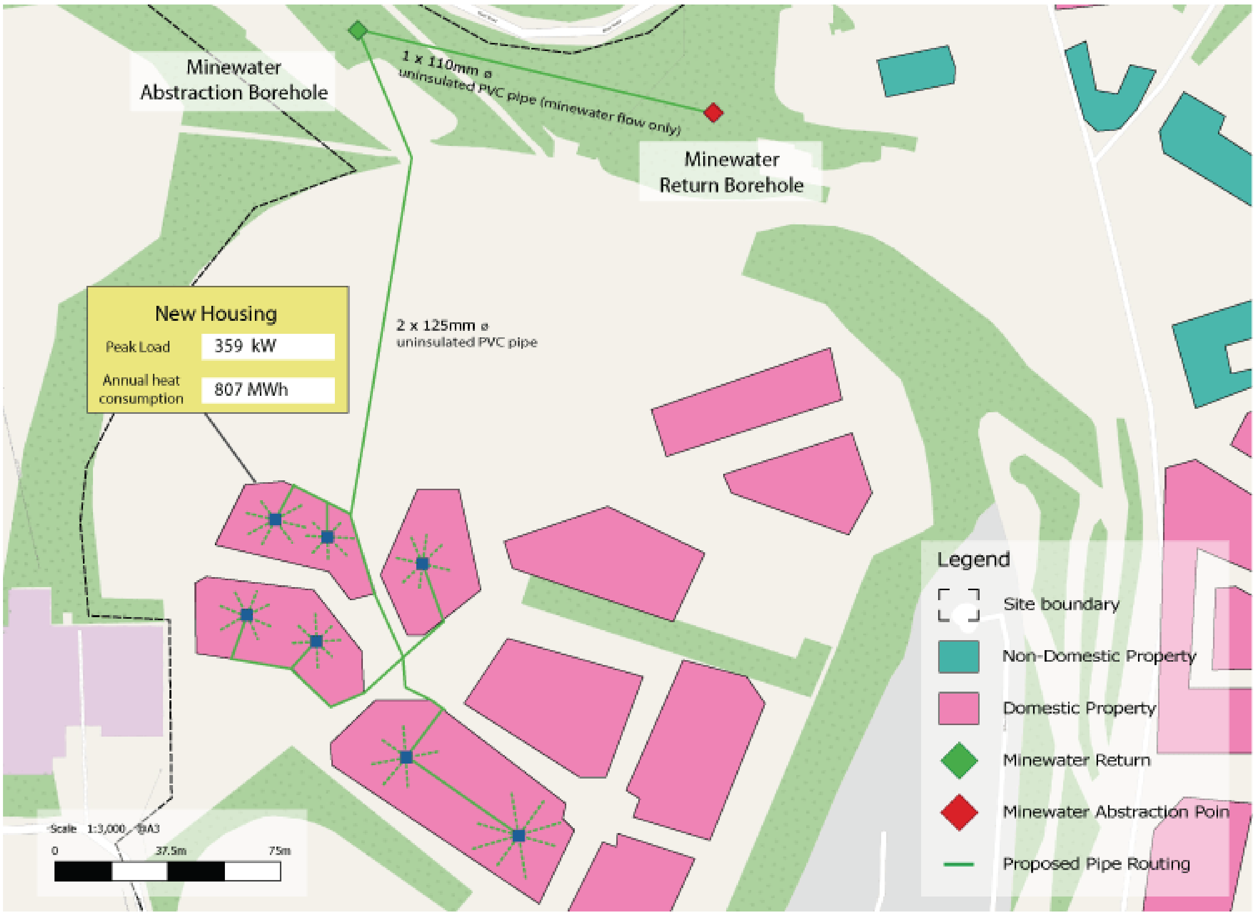


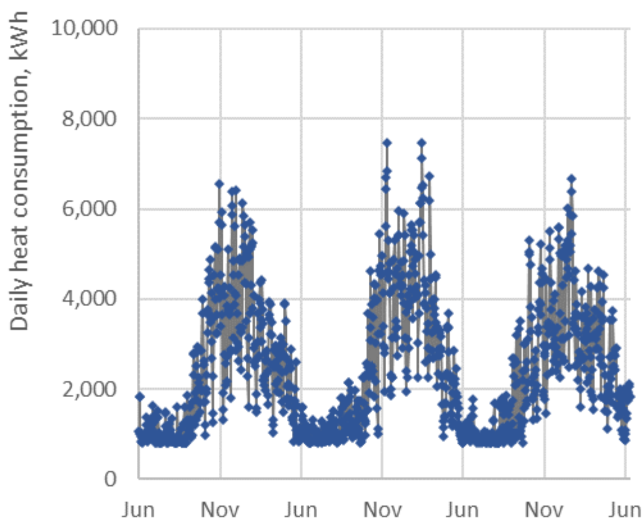
Number of connections: non-domestic	6
Number of connections: domestic	0
Total load (not inc. diversity factor)	423 kW
Total annual heat supply	762 MWh
Linear Heat Density [MWh/m]	0.8 – 1.0



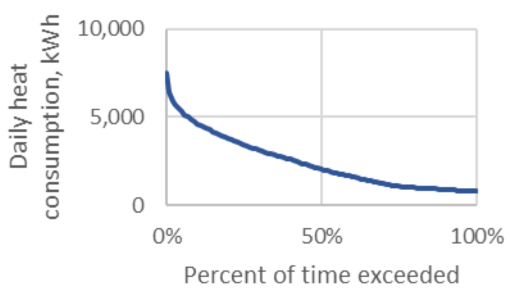
Network Scenario C

Network shown is the Minewater option.



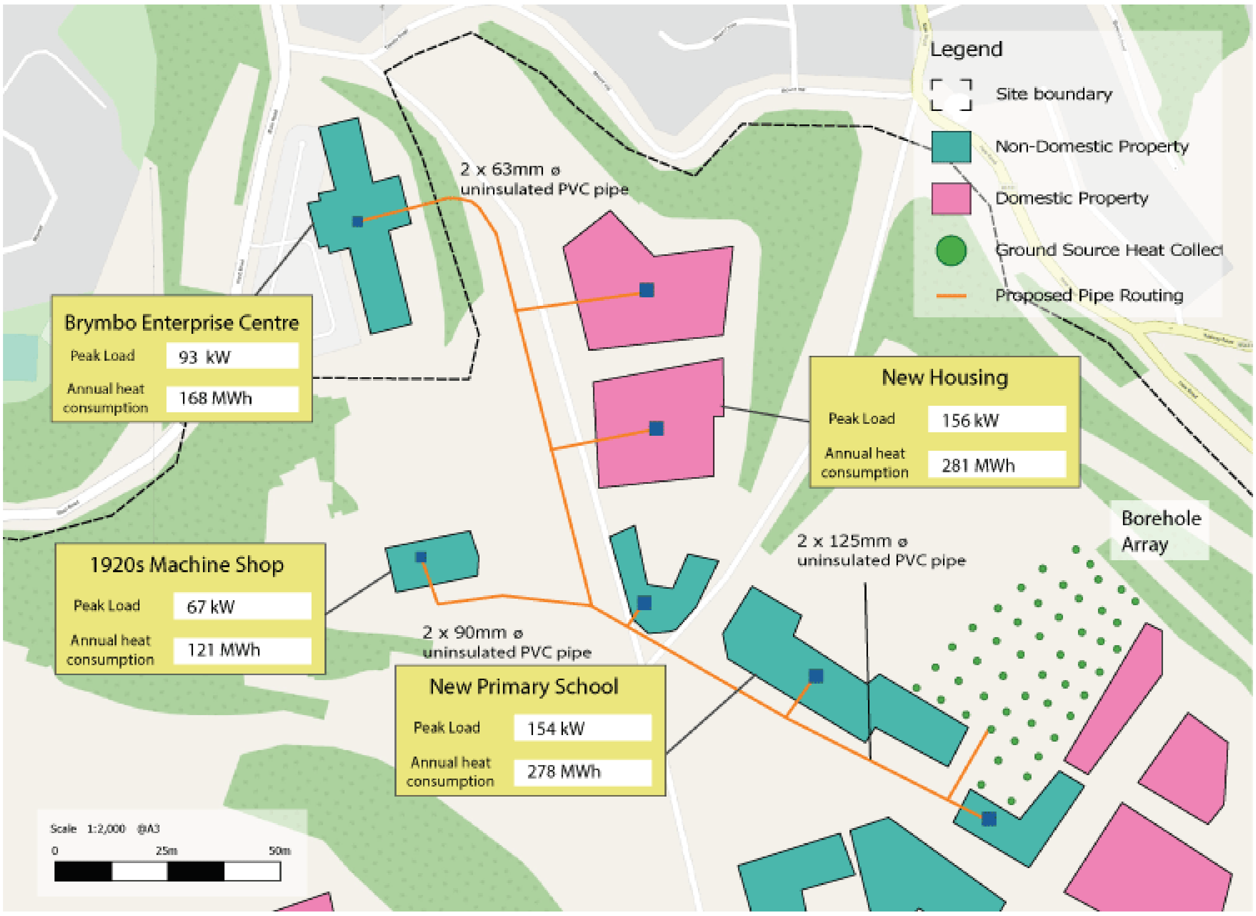


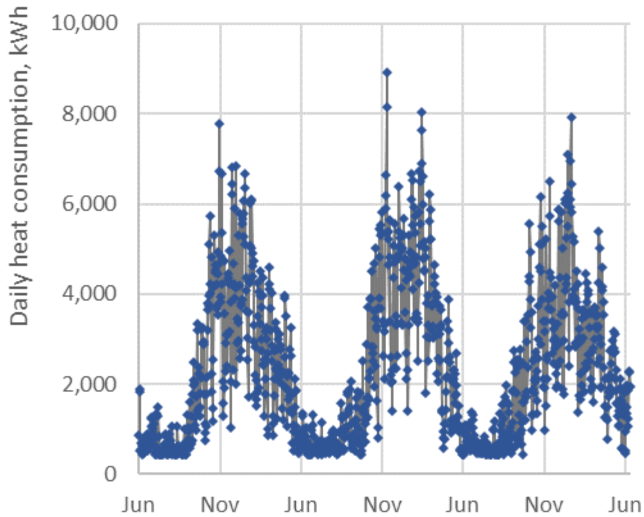
Number of connections: non-domestic	0
Number of connections: domestic	80
Total load (not inc. diversity factor)	449 kW
Total annual heat supply	807 MWh
Linear Heat Density [MWh/m]	0.6 – 0.7



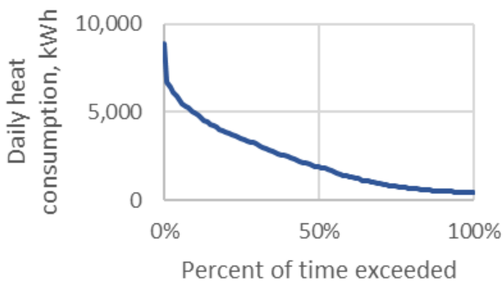
Network Scenario D

Network shown is the Boreholes + Shared Ground Loop + Individual Heat Pumps option.





Number of connections: non-domestic	3
Number of connections: domestic	34
Total load (not inc. diversity factor)	471 kW
Total annual heat supply	847 MWh
Linear Heat Density [MWh/m]	0.9 – 1.1



4. ENERGY SUPPLY OPTIONS

4.1. INTRODUCTION

A range of renewable heat sources and technology options for the Brymbo Heat Network have been reviewed. The three viable options that have been subject to technical and financial modelling include:

- **A biomass boiler system**
- **Minewater source heat pumps**
- **Ground source heat pumps**

Discounted renewable heat sources include:

- **Solar thermal:** resource availability not matched to space heating demand (although there may be a role for solar hot water generation on new-build properties);
- **Biogas or liquid biofuel:** no feedstock identified, and unit costs substantially higher than woodchip biomass;
- **Air source heat pumps:** poorer performance in comparison with ground and minewater source heat pumps (although there may be a role for ASHPs in new-build properties not connected to the heat network, and where GSHPs are not suitable);
- **Surface water source heat pumps:** no substantial water bodies present.

The renewable heat generation technologies can deliver heat to the network at different temperatures and can be deployed in centralised or distributed arrangements. The following sections present the features of each heat generation technology in the local context and discuss the pros and cons of different network operating temperatures and designs.

4.2. BIOMASS BOILER SYSTEMS

Biomass-powered heat networks are normally of the centralised type, with heat generation taking place in an Energy Centre and high-temperature water being distributed to heat users via the network's insulated pipes and a Heat Interface Unit[4] for each of the loads.

A wide range of biomass boiler designs are available to burn a variety of fuel types, including agricultural residues, wood pellets and wood chips. The biomass type that delivers the lowest cost of heat for projects of this type is normally wood chips. Several major forestry areas are located within 20 miles of Brymbo (Llandegla, Corwen, Clocaenog Forests) and there is a choice of suppliers of woodchips. The existence of other medium-to-large scale biomass schemes in the area may present opportunities to negotiate favourable fuel supply contracts.

Biomass boilers are well-suited to provide the heat generation for heat networks, being able to supply at a range of temperatures and, in combination with thermal storage, to respond to the changes in loads that occur over the course of a day and through the seasons. The capability to deliver heat at higher temperatures (80°C or hotter) means that buildings connecting to heat networks powered by biomass do not normally require extensive modifications to their internal heating systems, although some fabric energy efficiency measures may be required. That means that, if it were to be connected to a network, the Brymbo Enterprise Centre might only require minor

[4] A Heat Interface Unit combines a heat exchanger with metering devices to deliver heat to the building's own circuits and hot water system, and measure how much heat has been supplied for billing purposes.

modifications and the heating systems of new-build connections (including the re-fitted Machine Shop) could be installed according to standard designs.

At present, biomass-based renewable heat installations can receive Renewable Heat Incentive payments for every eligible unit of heat generated. The rate that would apply to schemes of the size and load profile relevant for Brymbo is currently 3.11 p/kWh. The RHI will close to new accreditations in March 2021, and the UK government has yet to announce how it will support renewable heat beyond this date. The financial assessments later in this report consider scenarios with and without a renewable heat payment at a level equivalent to the RHI.

The price of woodchip depends mainly on the size of the contract, the distance and plant requirements for delivery and the quality of the fuel (mainly the moisture content). The optimum cost of heat may be achieved with partially dried fuel (30%-40%), which represents a compromise between energy content and price. In a context of rising timber prices, this assessment has assumed that a woodchip price of £90/tonne delivered (30-40% moisture content) is achievable for the Brymbo Heat Network. This equates to a unit fuel cost of 2.6 p/kWh, and a unit cost of heat of 3.3 p/kWh (broadly equivalent to the cost of heat from natural gas).

With no space available in existing buildings to house a biomass boiler or fuel store, containerised solutions would be most appropriate for the Brymbo site. Shipping containers are already made use of at various locations around the site, including at the Duck Pond area which has been identified as the most viable location for a biomass boiler. This area benefits from relatively easy road access to enable plant construction and fuel deliveries during operation, offers sufficient space to allow some flexibility with container siting (e.g. for fire risk mitigation) and will be an area of visitor interest – but not heritage sensitivity - once the solar farm and narrow-gauge railway are complete.

The limit on size for containerised biomass boilers is normally 500 kW[5], with the boiler being housed in a 40ft container and an optional additional fuel store occupying a second container. Containerised systems of this size are available from a range of manufacturers. The average fuel consumption of a 500 kW boiler with a load profile in line with the scenarios presented in the previous section is approximately 1 tonne per day, meaning one or two 20m^3 truck deliveries per week. The peak weekly fuel consumption during particularly cold winter weather would be a little over 3 tonnes per day, meaning a truck delivery every 1 or 2 days. Vehicle access will also be required for ash removal (although this may be possible to combine with fuel deliveries).

The main air pollutants associated with biomass boilers are nitrous oxides (NOx), particulates and sulphur dioxide (SO2). The 2018 Air Quality Progress Report for the North Wales Combined Authority[6] does not identify any locations in the Wrexham County Borough Council area where pollutant levels exceed Welsh Air Quality Objectives, and new local developments are not expected to jeopardise air quality. Therefore, air quality considerations are not prejudicial to a biomass boiler scheme at Brymbo.

[5] 1MW packages are available (consisting of 2 x 500 kW boilers in one 40ft container), but fuel stores and fuel feed systems have to be located outside the container which somewhat negates the advantage of a containerised system.

[6] https://www.wrexham.gov.uk/assets/pdfs/air_quality/progress_2017.pdf

Table 1: Biomass boiler heat network assumptions

Variable	Value
Biomass boiler efficiency (gross calorific value basis)	77%
Heat network flow/return temperatures	75°C / 60°C
Heat network *delta T*	15°C
Biomass fuel energy content	3500 kWh/tonne
Biomass fuel unit cost	2.6 p/kWh

Standalone biomass boilers for properties not connected to the network may be appropriate for some of the larger non-domestic loads. Provided that space could be found to house the boiler and its fuel store (either inside the building or in a dedicated enclosure/container), a biomass boiler could directly replace existing gas boilers (Enterprise Centre) or be installed instead of a conventional gas or electric heating system (Machine Shop and new-build). Provision of heat-as-a-service via the ESCo (see Section 7.3) could mean that the building operator does not have to worry about fuel procurement, fuel loading, ash removal and disposal, maintenance or servicing.

For small and medium standalone boilers, the convenience of wood pellets as a fuel may favour their selection over the cheaper woodchip option. The non-domestic RHI currently offers the same level of payment for standalone systems as for heat network-connected biomass boilers.

The density of the new build housing and consumer acceptance are likely to rule out standalone domestic biomass boilers in new-build homes. Biomass boilers require 3-4 times more space than gas boilers, and the fuel loading/ash removal/cleaning responsibilities that would fall on housing occupants are likely to be off-putting for most future purchasers. For these reasons, standalone domestic biomass systems will be a hard sell to property developers in comparison to conventional heating systems or heat pumps.

4.3. MINEWATER SOURCE HEAT PUMPS

The Brymbo site sits on top of extensive coal and iron ore mines that were worked over a period of several centuries until the Brymbo Colliery closed in 1914. The underground voids left by mining are now thought to be filled with water in most parts of the Denbighshire Coalfield. This subterranean water is generally warmer than surface water and can therefore be a promising source for heat generation via water source heat pumps.

At Brymbo, the records from a pumping test carried out in 1977 on a newly drilled water supply borehole reveal information about the pumped flow rates that were proven to be sustainable from the borehole, the water depth, temperature and the chemistry of the minewater that was pumped.

A report prepared for Cadwyn Clwyd and Brymbo Heritage Trust by Gareth Farr and Alan Holden of the British Geological Society (BGS) estimates the heat extraction potential of a minewater heat scheme on the former steelworks site to be between 164 kW and 492 kW. However, the unusable condition of the 1977 borehole means that there remains substantial uncertainty about the true size of this resource, and of key parameters that influence the viability of a minewater scheme such as the depth from which water must be pumped.

A heat network using heat pumps with minewater as the heat source can take either a centralised or decentralised form. A centralised scheme would house a set of heat pumps in an Energy Centre, where they would extract heat from minewater and deliver it to a high-temperature network that connects to each building via a Heat Interface Unit. A decentralised scheme would circulate lower temperature water around the network, and each building would have its own heat pump or pumps to generate space heating and hot water locally. Although larger (i.e. centralised) heat pumps can achieve higher efficiencies at a given operating point, when they are used to power a heat network they are required to supply at performance-reducing high temperatures at all times - whereas the heat pumps of a decentralised scheme can select optimum supply temperatures to match the loads they serve.

The high concentrations of iron and other minerals dissolved in the minewater mean that the design of a heat network scheme involving minewater is likely to avoid passing minewater directly through the heat pump(s). Instead, an intermediate closed circuit, warmed by the minewater in a heat exchanger, would be used. In the case of a decentralised network design this intermediate circuit would form the network itself.

As with all heat pumps, the efficiency with which electrical power can be used to extract low-grade heat from the source and generate higher-grade heat for supply to a user or to a network depends on both the source temperature and the supply temperature. While the minewater source temperature is expected to be reasonably warm (around 14°C), the temperature drop necessitated by the inclusion of an intermediate hydraulic circuit means that the source temperature for the heat pump(s) would be at least 2 - 3°C cooler.

On the supply-side, the output temperatures are likely to be limited to around 55 - 70°C. Heat pumps capable of delivering temperatures higher than 70°C are less widely available and consume more electricity for every unit of heat delivered (their Coefficient of Performance is lower), so are assumed not to be suitable for the Brymbo Heat Network. The limitation on supply temperature means that buildings connecting to heat networks powered by minewater heat pumps are likely to require some modifications to their internal heating systems (or, in the case of new build, have systems installed that are capable of operating at lower temperatures than standard designs). In older buildings, fabric energy efficiency measures are likely to be required. For new build, adherence to standards and regulations should mean that buildings are compatible with lower temperature heating systems by default.

At present, ground and water-source (including minewater source) heat installations can receive Renewable Heat Incentive payments for every eligible unit of heat generated. The rate that would apply to schemes of the size and load profile relevant for Brymbo is currently 9.56 p/kWh for most[7] of the heat generated over the course of the year (the remainder attracts the 'Tier 2' rate of 2.85 p/kWh). Because of the uncertainty regarding the support that will be available after the closure of the RHI scheme in March 2021, the financial assessments later in this report consider scenarios with and without a renewable heat payment at a level equivalent to the RHI.

For a centralised system, the electricity consumed by the Energy Centre's heat pumps would be purchased by the network operator. This assessment has assumed that the average unit price paid by the operator would be 13.5 p/kWh. The design of a centralised minewater heat network could incorporate a thermal store to allow the heat pumps to be switched off at peak times of day when electricity prices are highest, which would bring down this average unit price somewhat.

There may also be an opportunity to liaise with the solar farm to secure a direct electrical supply. While there would be a capital cost associated with this, it would provide a lower unit cost of electricity than from the grid for the network operator, and an equal or higher sale price of electricity for the solar operator – a win-win – as well as contributing further to the sustainable credentials of the network.

[7] The 'Tier 1' rate can be paid on heat generated up to an annual limit which is the capacity of the scheme (in kW) multiplied by 1314 hours.

Although potentially cheaper than drilling a new borehole, the BGS report cautions that re-drilling the old borehole for use as the scheme's production well[8] carries a high risk of failure. It has therefore been assumed that a new borehole is drilled, and that it is able to be located closer to the heritage hub than the old borehole. This also means that the production well would be further away from the proposed location for returning the minewater to the ground (the Downcast shaft), reducing the risk and severity of 'thermal breakthrough' (whereby the reintroduced water cools the production water, reducing efficiencies and heat yields).

Table 2: Minewater source heat pump assumptions

Variable	Value
Heat pump year-round average coefficient of performance (SCoP)	3.5
Heat pump peak load coefficient of performance	3.0
Minewater flow/return temperatures	14°C / 8-10°C
Minewater *delta T*	4-6°C [9]
Intermediate circuit flow/return temperatures at peak load	9°C / 4°C
Intermediate circuit *delta T*	5°C
Depth of production well borehole	120 metres
Depth of production well submersible pump	100 metres
Diameter of production well submersible pump (for all schemes)	6"
Efficiency of production well submersible pump	60%

4.4. GROUND SOURCE HEAT PUMPS

As is the case when minewater is the heat source, a heat network using ground source heat pumps can take either a centralised or decentralised form. A centralised scheme would feature ground heat collectors clustered around an Energy Centre, where the heat pumps would extract heat from the closed 'ground loop' and deliver it to a high-temperature network that connects to each building via a Heat Interface Unit. A decentralised scheme would circulate the low temperature ground loop water itself around the network, and each building would have its own heat pump or pumps to generate space heating and hot water locally. The same considerations regarding the operating temperatures of heat pumps in centralised and decentralised arrangements apply.

Unlike the described minewater scheme, a closed-loop ground source system does not need an intermediate circuit because there are no issues with chemical impurities affecting heat pumps. The closed-loop arrangement also means that the whole ground loop can be pressurised, and the pumping power required is much lower.

The same limitations on supply temperature apply to ground source heat pumps – maxima in the range 55 - 70°C – with the same implications for internal heating system and fabric energy efficiency upgrades. The levels of support currently available through the RHI are the same. The way that commercial electricity supplies are billed

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[8] The point from which minewater is pumped, also known as the abstraction well or abstraction point.

[9] The smaller the temperature difference, the greater the flow rate of minewater that is required to produce a certain amount of heating. The large depths from which water will need to be pumped (100m assumed) mean that a large amount of electric power is required to bring the minewater up to the surface where the heat exchanger and heat pumps are located. If flow rates are too high, the amount of power consumed by the minewater pumps will cause the system's "H2" Seasonal Performance Factor (the ratio between the heat delivered and the electrical energy consumed by the heat pumps and source pumps) to be less than 2.5, the current threshold for RHI eligibility. A temperature difference of 4°C is the smallest value that will allow an SPF_{H2} of at least 2.7.

may also favour the inclusion of a thermal store to avoid heat pumps having to operate during the most expensive times of day.

This assessment assumes that a vertical heat collector design – an array of boreholes – is chosen over a horizontal trench collector design. Although horizontal schemes are typically cheaper for smaller schemes with straightforward excavation, the challenging ground conditions present on the former steelworks site are likely to mean that horizontal collectors are favoured.

The possible locations for an array of boreholes are the area set out for the grounds of the new primary school and the upper part of the sloping 'community park' area to the east of the Plateau[10]. The school grounds area would be more accessible for a drilling rig but is likely to contain a thicker 'cap' of slag material (from former land use and reclamation). Drilling on the community park area (which has a slope of approximately 22°) would require additional ground works to create level drilling sites or require the use of specialist slope-climbing drilling rigs. In either location, the boreholes and interconnecting pipework would be fully buried, meaning that there would be no lasting visual impact or restrictions on land use (other than activities that could disturb the buried infrastructure).

The Wonder Bank area would not be suitable for any kind of excavation or drilling due to the presence of dangerous contaminants (the land is a former waste disposal site). The contaminated material is covered by a 1m-thick clay cap.

As with the minewater heat pump option, there may be an opportunity to secure a direct electrical supply from the solar farm such that the heat pumps are able to utilise surplus generation.

Table 3: Ground source heat pump assumptions

Variable	Value
Heat pump year-round average coefficient of performance (SCoP)	3.5
Heat pump peak load coefficient of performance	3.0
Ground loop average flow/return temperatures	9°C / 4°C
Ground loop flow/return temperatures at peak load	5°C / 0°C
Ground loop *delta T*	5°C
Depth of boreholes	150 metres

Standalone ground source heat pumps for properties not connected to the network may be viable for all types of heat users, provided that space is available to locate the heat collectors. If the new primary school was not connected to the network, it could benefit from a ground source system installed under the open space in its grounds and sized to match its heat demand. For loads such as the supermarket and pub/restaurant, installation under car park areas at the time of construction may be possible. Likewise, ground heat collectors could be placed in the gardens of new-build houses, under roads or along street verges prior to grass-laying. Bulk installation of standalone systems would offer economies of scale relative to an installation being arranged for each property separately, and if trenching for heat collectors could be carried out at the same time as trenching for utility

[10] The trees at the bottom of the community park slope are about 40 years old and covered by a Tree Preservation Order so a development near to these trees is not possible. The trees further up the slope are more like 15 years old. Borehole installation along pathways or in areas of low tree density would minimise the number of younger trees that would be affected.

connections, significant cost savings could be made. However, high levels of cooperation with the housing developer(s) would be required in order for such installations to be incorporated into the designs for construction and buried services.

Because GSHPs operate automatically in a similar way to conventional heating systems and offer lower heating costs, they should be attractive features for potential purchasers or tenants of homes or commercial properties. Provision of heat-as-a-service via the ESCo (see Section 7.3) could mean that homeowners and building operators do not have to worry about maintenance or servicing of their heat pump, with tariffs and charges set such that the cost of heating is less than it would have been from a non-renewable heating system. Provided that the benefits are effectively communicated, property developers may agree to new buildings' heat supplies being provided by an ESCo.

The RHI rules currently present barriers to the installation and operation of standalone domestic GSHPs through an ESCo model (though it is possible), but future renewable heat support schemes may make this a more attractive proposition.

5. DEVELOPMENT OPTIONS

5.1. INTRODUCTION

This chapter presents the development options which integrate the network scenarios (Chapter 3) with the energy supply options (Chapter 4). Not all energy supply options are suitable for all network scenarios, for reasons related to the Linear Heat Density. Although technically feasible, the spatial separation between the loads and the possible locations of ground heat collectors for network scenario A or C mean that the capital cost of ground source scheme would far exceed the cost of the minewater or biomass-powered alternatives. For all network scenarios, medium- or high-temperature networks driven by centralised heat pumps have been found to be unsuitable, for the following reasons:

- High capital cost for an insulated network, only offset to a small degree by the economies of scale offered by centralised heat pump equipment;
- Heat losses from the network mean that extra capital is spent installing generation that is ‘wasted’ and electricity costs are incurred generating heat that is never used or sold;
- Centralised heat pumps have to supply at high temperatures year-round, whereas the heat pumps of a decentralised scheme can select optimum supply temperatures to match the loads they serve and thereby boost their seasonal coefficient of performance (‘weather compensation’).

The key technical details and broken-down capital costs, operating costs and benefits are laid out for the ‘preferred’ energy supply option for each network scenario. The ‘preferred’ energy supply option is that which offers the lowest simple payback on its capital cost. The capital costs, net revenues, payback and carbon savings of the alternative energy supply combinations are shown for comparison.

With none of the network development options presenting a strong financial case for investment, the options for investing in standalone systems are considered for the heritage hub, new-build non-domestic and new-build housing.

Although the community organisation has indicated that it would consider a phased implementation of a heat network, the marginal viability of the network development options identified – which, despite their poor Linear Heat Density, represent the most compact designs that could be found given the locations of resources and plant – means that investigation of later steps in a phased approach will not reveal a viable pathway.

Simple payback is used as a straightforward indicator of financial viability for the options presented. Because paybacks are generally long, more sophisticated indicators (IRR, NPV etc.) have not been developed for each option. However, the financial performance of the most attractive network development option (Option B) is further investigated in the following ‘Financial Analysis’ chapter, which also considers the funding of major equipment replacement and the cost of capital.

5.1.1. HEAT SALES

It is assumed that the ESCo operating the network sells heat to each of the connected users, except for the Machine Shop where the benefits manifest as an avoided cost (for electrical heating).

The heat tariff charged to non-domestic customers is 3.0 p/kWh, a level slightly below the cost of heating with natural gas for a large building like the Enterprise Centre[11]. The heat tariff for domestic customers is modelled at 6.0 p/kWh, again to provide at least a small saving over the cost of conventional heating for most users.

5.1.2. REPLACEMENT OF SHORT-LIFE EQUIPMENT

Although the replacement of major items of plant such as heat pumps and biomass boilers is not factored in to the assessments presented in this chapter, the replacement of short-lifetime (<5 years) equipment is included as an operating cost. The equipment which fits this description relates to minewater abstraction: the down-borehole submersible pumps and minewater-to-network heat exchanger replacement cycle is expected to be as short as 2 years.

5.1.3. OTHER O&M COSTS

This line includes:

- the cost of servicing and maintenance for the main items of plant (heat pumps, boilers, pumps);
- the cost of administering heat billing and subsidy/grant claims (where applicable);
- the cost of biomass fuel procurement/contracting;
- any other non-energy operating costs.

It should be noted that this assessment attempts to account for the full cost of staff time that will be required to operate the scheme (but not including costs for line management and governance). This may be in contrast to the way in which other renewable energy project feasibilities have been presented – for example the solar farm, where OPEX costs allowed for 'Administration & contingency' were only £310 per year for a 288 kWp scheme. If staff costs associated with heat network operation are likely to be covered by other budgets, and therefore should not be included in the financial assessment of heat network options, then the net revenues and paybacks presented here would appear slightly better.

5.1.4. INTEGRATION WITH SOLAR PV GENERATION

If a connection to the planned 288kW$_p$ ground-mounted Wonder Bank solar array were to be installed such that the heat network could make use of surplus PV generation, there would be an opportunity to reduce electricity costs (particularly for the minewater and ground source schemes, which use large amounts of electricity to power heat pumps and – in the case of minewater - abstraction pumps).

To model surplus generation, we assumed that the heritage hub was the only user connected to the solar farm, and that the hub's 105 MWh/year electricity demand varies from 7 MWh/month in the summer to 10 MWh/month in winter. Subtracting the heritage hub's demand from the modelled monthly PV output, a profile of surplus PV generation was created. Comparing this with the electricity demand of a particular development option, the amount of surplus PV generation that could be used by the network was calculated.

If this surplus was not used by the network, we have assumed that it would have been exported to the grid with a PPA strike rate price of 5.25 p/kWh[12]. This means that the effective saving from the network using PV surplus electricity rather than grid imports (at 13.5 p/kWh) is 8.25 p/kWh.

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[11] The Enterprise Centre currently pays around 2.8 p/kWh for gas. With a boiler efficiency of 87%, the cost of heat is therefore 3.2 p/kWh.

[12] Smarter Energy Interim Report – Brymbo Heritage.

5.2. DEVELOPMENT OPTION A

Network Scenario A – Preferred Heat Source		
	Heat source	Biomass Boiler
	Heat generation arrangement	Centralised
	Network type	High temperature (75°C)

Number of connections: non-domestic	2	1920s Machine Shop; Brymbo Enterprise Centre
Number of connections: domestic	0	

Total load (not including diversity factor)	160 kW
Total annual heat supply	288 MWh
Total annual electrical input	6 MWh
Total annual fuel consumption	152 tonnes

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Biomass fuel consumption – woodchips	
Avg. weekly fuel consumption	2.9 tonnes
Peak weekly fuel consumption	9.5 tonnes
Boiler integrated fuel storage	12.0 tonnes
Additional external storage	None

Linear Heat Density	0.5 MWh/m
Network heat losses	29%
Distribution Loss Factor	1.42

Capital costs		
Biomass System • Biomass boiler in 40ft container • Additional external fuel store (40ft container) • Preparation of biomass delivery route and offloading area	£85,000	500 kW boiler package w/ small fuel store Total storage: 8 days' peak winter use
Heat Network • Trenching • Pipework, including fittings • Distribution pump • Electrical connection	£119,300	~350 metres trenching ~700 metres 63mm dia. PVC pipe
Heat Interface Units (2 no.)	£7,500	
Brymbo Enterprise Centre internal heating system upgrade	£10,000	Budget figure - may be less than this or zero
Balance of plant	£7,000	
Installation and commissioning	£15,000	
Site costs and preliminaries	£34,600	
Contingency	£25,100	
TOTAL	**£303,500**	

ANNUAL BENEFITS AND COSTS	**Subsidy/grant scenario**		
	No subsidy/support	**Subsidy equal to RHI**	**50% capital grant**
Revenues and avoided costs			
Heat sales	£5,025	£5,025	£5,025
Saving from avoided electrical heating	£16,327	£16,327	£16,327
Subsidy income	-	£8,970	-
Operating costs			
Electricity costs (with 100% grid import)	£762	£762	£762
Fuel costs	£13,655	£13,655	£13,655
Replacement of short-life equipment	-	-	-
Other O&M costs	£2,000	£2,000	£2,000
Net revenues	**£4,935**	**£13,906**	**£4,935**
Simple payback [years]	**61.5**	**21.8**	**30.8**
Carbon savings [tonnes CO_2e per year]	**50.4**	**50.4**	**50.4**

5.2.1. DISCUSSION OF VIABILITY

The preferred network and energy supply combination only achieves a simple payback of 21.8 years when a subsidy equivalent to the RHI is received. Without any output-based subsidy, the scheme's net revenues are reduced such that simple payback extends beyond 60 years. Although the scheme would deliver impressive carbon savings, it fails to generate sufficient returns to provide community financial benefit. Neither does it stack up as an investment to reduce running costs for the heritage hub.

The reasons for the poor financial performance of this combination include:

- High capital costs (£1,900/kW), driven by the high cost of an insulated heat network resulting from the poor Linear Heat Density;
- High heat losses from the network mean that extra capital is spent installing generation that is 'wasted' and fuel costs are incurred generating heat that is never used or sold;
- Low revenues from heat sales (the heat tariff for the Enterprise Centre is constrained by the requirement to compete with the current low cost of heating).

5.2.2. ALTERNATIVE ENERGY SUPPLY COMBINATIONS

The minewater heat option achieves a slightly worse simple payback when RHI-style subsidies are received. Without such subsidies, the minewater scheme fails to generate positive net revenues.

	PREFERRED OPTION: Biomass boiler, Centralised	**Minewater, Decentralised**
Capital cost	£303,500	£470,500
Electricity and fuel costs	£14,417	£14,533
With no subsidy/support		
Net revenues	£4,935	-£3,306
Simple payback [years]	61.5	n/a
With subsidy equal to RHI		
Net revenues (with subsidy equal to RHI)	£13,906	£19,043
Simple payback [years]	21.8	24.7
With 50% capital grant		
Net revenues	£4,935	-£3,306
Simple payback [years]	30.8	n/a
Carbon savings [tonnes CO_2e per year]	**50.4**	**38.3**

If the surplus generation from the planned Wonder Bank solar farm was able to be used by the minewater heat network, modelling suggests that 44 MWh of grid imports could be avoided. We assume that the cost of the heritage hub private wire electricity connection (£120,000) would be borne by the solar farm project, but the cost of the Enterprise Centre connection (£50,000) would be borne by the heat network project. The effective saving of 8.25 p/kWh would reduce electricity costs by £3,655/year, meaning that the no-subsidy minewater heat scheme would just break even. With RHI-equivalent subsidy, the simple payback for the minewater heat scheme would reduce to 22.9 years.

5.3. DEVELOPMENT OPTION B

Network Scenario B – Preferred Heat Source	Heat source	Boreholes + Shared Ground Loop
	Heat generation arrangement	Decentralised (Individual Heat Pumps)
	Network type	Low temperature

Number of connections: non-domestic	6
Number of connections: domestic	0

1920s Machine Shop Brymbo Enterprise Centre
Pub School Medical Centre Supermarket

Total load (not including diversity factor)	423 kW
Total annual heat supply	762 MWh
Total annual electrical input	228 MWh

→

Annual electricity consumption	
Network pumping	10 MWh
Heat pumps	218 MWh
Total annual electrical input	228 MWh

Linear Heat Density	1.0 MWh/m
Network heat losses	-

Capital costs		
Ground heat collector • Drilling of ~50 boreholes • Installation of heat collector probes + grouting • Interconnecting trenching + pipework • Manifold chambers	£330,000	Borehole depth: 100 – 200 metres
Heat Network • Trenching • Pipework, including fittings	£70,500	~750 metres trenching ~1,500 metres PVC pipe, dia. 40 – 125mm
Heat Pumps	£127,000	
Brymbo Enterprise Centre internal heating system upgrade and energy efficiency works	£50,000	Budget figure - may be less than this or zero
Balance of plant	£60,000	Including ground loop fill
Installation and commissioning	£48,000	
Site costs and preliminaries	£87,400	
Contingency	£71,900	
TOTAL	**£844,800**	

ANNUAL BENEFITS AND COSTS	**Subsidy/grant scenario**		
	No subsidy/support	**Subsidy equal to RHI**	**50% capital grant**
Revenues and avoided costs			
Heat sales	£19,227	£19,227	£19,227
Saving from avoided electrical heating	£16,327	£16,327	£16,327
Subsidy income	-	£59,029	-
Operating costs			
Electricity costs (with 100% grid import)	£30,743	£30,743	£30,743
Fuel costs	-	-	-
Replacement of short-life equipment	-	-	-
Other O&M costs	£8,000	£8,000	£8,000

Net revenues	**-£3,189**	**£55,840**	**-£3,189**
Simple payback [years]	n/a	**15.1**	n/a
Carbon savings [tonnes CO_2e per year]	**114.9**	**114.9**	**114.9**

5.3.1. DISCUSSION OF VIABILITY

The preferred network and energy supply combination achieves a simple payback of 15.1 years when a subsidy equivalent to the RHI is received. Without any output-based subsidy, the scheme's operating costs exceed the revenues from heat sales to third parties and savings on the heritage building's heating costs. Although the scheme would deliver impressive carbon savings, it will fail to generate high enough returns to provide community financial benefit and is unlikely to be attractive to individual investors in the community unless some of the capital cost can be grant-funded and an RHI-style subsidy is available. Neither does it stack up as an investment to reduce running costs for the heritage hub, especially in comparison to the case for a standalone renewable heat system for the Machine Shop.

The reasons for the poor financial performance of this combination include:

- Fairly high capital costs (£2,000/kW), resulting from the high cost of ground heat collector installation (given the likely challenging drilling conditions posed by layers of slag and/or sloping ground) and the poor Linear Heat Density;
- Low revenues from heat sales (the heat tariff for the third-party customers is constrained by the requirement to compete with the low cost of heating with natural gas).

If the latter constraint can be removed – if new-build connections are willing to pay a higher price for heat than they would be able to achieve with natural gas – then the viability of the development could be better than presented here. This may be possible if building occupants are motivated by sustainability or reputational concerns or the desire to be part of a community initiative, or if regulation or planning requirements oblige them to use low-carbon heating sources.

5.3.2. INTEGRATION WITH SOLAR PV GENERATION

The previous table presents the electricity costs if 100% of the network's demand is met by grid imports at 13.5 p/kWh. If the surplus generation from the planned Wonder Bank solar farm was able to be used by the network (specifically, by the heat pumps in the Machine Shop and the Enterprise Centre and the network distribution pumps), modelling suggests that 41 MWh of grid imports could be avoided. The effective saving of 8.25 p/kWh would reduce electricity costs by £3,415/year. If it is assumed that the cost of the heritage hub private wire electricity connection (£120,000) is borne by the solar farm project, but the cost of the Enterprise Centre connection (£50,000) is borne by the heat network project, the integration would have the following impact on net revenues, payback and carbon emissions:

	Subsidy/grant scenario		
	No subsidy/support	**Subsidy equal to RHI**	**50% capital grant**
Net revenues	**£225**	**£59,255**	**£225**
Simple payback [years]	**>100**	**15.1**	**>100**
Carbon savings [tonnes CO_2e per year]	**123.1**	**123.1**	**123.1**

If it can be achieved within the cost estimated, the integration of the solar farm and Shared Ground Loop heat network has no impact on the network's viability, and the development is still dependent on an output-based subsidy to deliver a significant return on investment. Integrating solar PV improves the carbon savings achieved by the network.

Installing additional private wire connections to the other heat users (school etc.) is not expected to be cost-effective.

5.3.3. ALTERNATIVE ENERGY SUPPLY COMBINATIONS

The alternative heat pump-based scheme, using minewater as the heat source, achieves a similar payback when RHI-equivalent subsidies are received. However, its high operating and equipment replacement costs leave it considerably worse off if no output-based subsidies are available.

A biomass boiler-driven heat network could be installed at the lowest capital cost. RHI-equivalent subsidies are lower for biomass schemes, resulting in lower net revenues.

	PREFERRED OPTION: Boreholes + Shared Ground Loop, Decentralised	Minewater, Decentralised	Biomass boiler, Centralised
Capital cost	£844,800	£674,900	£510,300
Electricity and fuel costs	£30,743	£36,552	£33,138
With no subsidy/support			
Net revenues	-£3,189	-£17,624	-£1,584
Simple payback [years]	n/a	n/a	n/a
With subsidy equal to RHI			
Net revenues (with subsidy equal to RHI)	£55,840	£41,406	£22,109
Simple payback [years]	15.1	16.3	23.1
With 50% capital grant			
Net revenues	-£3,189	-£17,624	-£1,584
Simple payback [years]	n/a	n/a	n/a
Carbon savings [tonnes CO_2e per year]	**114.9**	**106.3**	**139.1**

5.4. DEVELOPMENT OPTION C

Network Scenario C – Preferred Heat Source		
	Heat source	**Minewater**
	Heat generation arrangement	**Decentralised**
	Network type	**Low temperature**

Number of connections: non-domestic	0
Number of connections: domestic	80

New-build housing in the northernmost part of the western housing development

Total load (not including diversity factor)	359 kW
Total annual heat supply	807 MWh
Total annual electrical input	284 MWh
Minewater abstraction flow rate (peak)	9.5 litres/s

→

Annual electricity consumption	
Minewater abstraction pumping	40 MWh
Network pumping	13 MWh
Heat pumps	230 MWh
Total annual electrical input	284 MWh

Linear Heat Density	0.6 MWh/m
Network heat losses	-

Capital costs		
Minewater Circuit • Abstraction borehole • Preparation of recharge point • Submersible pump • Minewater return pipeline, including trenching	£198,500	~25 kW submersible pump ~200 metres of buried pipe
Heat Network • Minewater Circuit/Network Heat Exchanger • Trenching • Pipework, including fittings • Distribution pump • Electrical connection (for both pumps)	£128,300	~1,200 metres trenching ~2,400 metres PVC pipe, dia. 40 – 125mm
Heat Pumps	£400,000	
Balance of plant	£95,000	Including network fluid fill
Installation and commissioning	£160,000	
Site costs and preliminaries	£65,100	
Contingency	£99,200	
TOTAL	**£1,146,100**	

ANNUAL BENEFITS AND COSTS	**Subsidy/grant scenario**		
	No subsidy/support	**Subsidy equal to RHI**	**50% capital grant**
Revenues and avoided costs			
Heat sales	£48,398	£48,398	£48,398
Saving from avoided electrical heating	-	-	-
Subsidy income	-	£72,364	-
Operating costs			
Electricity costs (with 100% grid import)	£38,370	£38,370	£38,370
Fuel costs	-	-	-
Replacement of short-life equipment	£6,625	£6,625	£6,625
Other O&M costs	£25,000	£25,000	£25,000

Net revenues	**-£21,598**	**£50,766**	**-£21,598**
Simple payback [years]	n/a	**22.6**	n/a
Carbon savings [tonnes CO_2e per year]	**114.7**	**114.7**	**114.7**

5.4.1. DISCUSSION OF VIABILITY

The preferred network and energy supply combination only achieves a simple payback of 22.6 years when a subsidy equivalent to the RHI is received. Without any output-based subsidy, the scheme's operating costs substantially exceed the revenues from heat sales to the connected homes. Although the scheme would deliver impressive carbon savings, it fails to generate sufficient returns to provide community financial benefit.

The reasons for the poor financial performance of this combination include:

- High capital costs (£3,200/kW), driven by the cost of the individual domestic heat pumps, the installation and commissioning of 80 domestic systems and the minewater abstraction infrastructure;
- High electricity costs, with minewater abstraction pumping costs of £5,400 per year;
- High costs for the replacement of short-lifespan equipment, such as the submersible minewater pump and minewater/network heat exchanger (chemical and biological fouling can be expected to reduce life expectancy to as low as 2 years);
- High maintenance costs for the minewater abstraction equipment;
- High administration costs for metering and billing 80 customers.

The previous table presents the electricity costs if 100% of the network's demand is met by grid imports at 13.5 p/kWh. Using the surplus generation from the planned Wonder Bank solar farm is unlikely to be feasible for a decentralised Shared Ground Loop network with so many connections, as it would require the installation of an extensive private wire 'mini-grid' at considerable additional cost.

5.4.2. ALTERNATIVE ENERGY SUPPLY COMBINATIONS

The alternative scheme, using a biomass boiler as the heat source, can be installed at a much-reduced capital cost. However, in the scenario where RHI-equivalent subsidies are received, the net revenues for the biomass scheme are much lower because of the lower rates of support that the technology receives. Without an output-based subsidy, the biomass scheme's lower operating costs mean that the development, while still failing to generate revenues, comes closer to breaking even than the minewater scheme.

	PREFERRED OPTION: Minewater, Decentralised	**Biomass boiler, Centralised**
Capital cost	£1,146,200	£717,400
Electricity and fuel costs	£38,370	£36,423
With no subsidy/support		
Net revenues	-£21,598	-£8,025
Simple payback [years]	n/a	n/a
With subsidy equal to RHI		
Net revenues (with subsidy equal to RHI)	£50,766	£17,061
Simple payback [years]	22.6	42.0
With 50% capital grant		
Net revenues	-£17,624	-£8,025
Simple payback [years]	n/a	n/a
Carbon savings [tonnes CO_2e per year]	**114.7**	**147.7**

5.5. DEVELOPMENT OPTION D

Network Scenario D – Preferred Heat Source

Heat source	**Boreholes + Shared Ground Loop**
Heat generation arrangement	**Decentralised (Individual Heat Pumps)**
Network type	**Low temperature**

Number of connections: non-domestic	3
Number of connections: domestic	34

1920s Machine Shop Brymbo Enterprise Centre
School New-build housing in the New High St area

Total load (not including diversity factor)	471 kW
Total annual heat supply	847 MWh
Total annual electrical input	251 MWh

→

Annual electricity consumption	
Network pumping	9 MWh
Heat pumps	242 MWh
Total annual electrical input	251 MWh

Linear Heat Density	1.1 MWh/m
Network heat losses	-

Capital costs		
Ground heat collector • Drilling of ~50 boreholes • Installation of heat collector probes + grouting • Interconnecting trenching + pipework • Manifold chambers	£330,000	Borehole depth: 100 – 200 metres
Heat Network • Trenching • Pipework, including fittings	£77,100	~750 metres trenching ~1,500 metres PVC pipe, dia. 40 – 125mm
Heat Pumps	£277,000	
Brymbo Enterprise Centre internal heating system upgrade and energy efficiency works	£50,000	Budget figure - may be less than this or zero
Balance of plant	£60,000	Including ground loop fill
Installation and commissioning	£70,000	
Site costs and preliminaries	£81,100	
Contingency	£88,900	
TOTAL	**£1,034,100**	

ANNUAL BENEFITS AND COSTS	**Subsidy/grant scenario**		
	No subsidy/support	**Subsidy equal to RHI**	**50% capital grant**
Revenues and avoided costs			
Heat sales	£30,208	£30,208	£30,208
Saving from avoided electrical heating	£16,327	£16,327	£16,327
Subsidy income	-	£72,879	-
Operating costs			
Electricity costs (with 100% grid import)	£33,938	£33,938	£33,938
Fuel costs	-	-	-
Replacement of short-life equipment	-	-	-
Other O&M costs	£17,000	£17,000	£17,000

Net revenues	**-£4,403**	**£68,476**	**-£4,403**
Simple payback [years]	n/a	**15.1**	n/a
Carbon savings [tonnes CO_2e per year]	**128.3**	**128.3**	**128.3**

5.5.1. DISCUSSION OF VIABILITY

The preferred network and energy supply combination achieves a simple payback of 15.1 years when a subsidy equivalent to the RHI is received. Without any output-based subsidy, the scheme's operating costs exceed the revenues from heat sales to third parties and savings on the heritage building's heating costs. This means that unless some of the capital cost can be grant-funded and an RHI-style subsidy is available, the scheme is unlikely to be attractive to individual community investors. Neither will it be possible to generate funds for community benefit, or to deliver overall energy cost savings for the heritage hub, without meeting those two preconditions.

The reasons for the poor financial performance of this combination include:

- Fairly high capital costs (£2,200/kW), resulting from the high cost of ground heat collector installation (given the likely challenging drilling conditions posed by layers of slag and/or sloping ground), the cost of 37 individual heat pumps and the poor Linear Heat Density;
- Low revenues from heat sales (the heat tariff for the third-party customers is constrained by the requirement to compete with the low cost of heating with natural gas);
- High administration costs for metering and billing 36 customers.

If the latter constraint can be removed – if new-build connections are willing to pay a higher price for heat than they would be able to achieve with natural gas – then the viability of the development could be better than presented here.

5.5.2. INTEGRATION WITH SOLAR PV GENERATION

If the surplus generation from the planned Wonder Bank solar farm was able to be used by the network (specifically, by the heat pumps in the Machine Shop and the Enterprise Centre and the network distribution pumps), 41 MWh of grid imports could be avoided, reducing electricity costs by £3,379/year. If it is assumed that the cost of the heritage hub private wire electricity connection (£120,000) is borne by the solar farm project, but the cost of the Enterprise Centre connection (£50,000) is borne by the heat network project, the integration would have the following impact on net revenues, payback and carbon emissions:

	Subsidy/grant scenario		
	No subsidy/support	**Subsidy equal to RHI**	**50% capital grant**
Net revenues	-£1,024	£71,856	-£1,024
Simple payback [years]	n/a	15.1	n/a
Carbon savings [tonnes CO_2e per year]	136.6	136.6	136.6

If it can be achieved within the cost estimated, the integration of the solar farm and Shared Ground Loop heat network has no impact on the network's viability, and the development is still dependent on an output-based subsidy to deliver positive returns. Integrating solar PV improves the carbon savings achieved by the network.

Installing additional private wire connections to the other heat users (school and housing) is not expected to be cost-effective.

5.5.3. ALTERNATIVE ENERGY SUPPLY COMBINATIONS

The alternative heat pump-based scheme, using minewater as the heat source, achieves a similar payback when RHI-equivalent subsidies are received. However, its high operating and equipment replacement costs leave it considerably worse off if no output-based subsidies are available.

A biomass boiler-driven heat network could be installed at the lowest capital cost. RHI-equivalent subsidies are lower for biomass schemes, resulting in lower net revenues.

	PREFERRED OPTION: Boreholes + Shared Ground Loop, Decentralised	Minewater, Decentralised	Biomass boiler, Centralised
Capital cost	£1,034,100	£927,200	£619,900
Electricity and fuel costs	£33,938	£40,386	£36,409
With no subsidy/support			
Net revenues	-£4,403	-£20,476	-£4,874
Simple payback [years]	n/a	n/a	n/a
With subsidy equal to RHI			
Net revenues (with subsidy equal to RHI)	£68,476	£52,404	£21,474
Simple payback [years]	15.1	17.7	28.9
With 50% capital grant			
Net revenues	-£4,403	-£20,476	-£4,874
Simple payback [years]	n/a	n/a	n/a
Carbon savings [tonnes CO_2e per year]	**128.3**	**118.8**	**155.3**

5.6. STANDALONE RENEWABLE HEAT SYSTEMS

An alternative way for the community organisation to achieve its objectives may be to invest in standalone renewable heat systems rather than a network. The financial viability of standalone systems is different for domestic and non-domestic heat users and depends on what the 'business as usual' energy source would be. This section presents two alternative standalone systems for three different users: the Machine Shop, the new primary school and a typical new-build house.

The assumed biomass price (4.0 p/kWh) is higher than for the network development options.

5.6.1. MACHINE SHOP STANDALONE SYSTEM

Assuming (in line with the calculations presented previously) that the default heating energy source for the Machine Shop would be electricity, both a biomass boiler and an air source heat pump system would offer attractive paybacks on the capital cost of the system even if no subsidies were available. With an RHI-equivalent output-based payment, or with a 50% capital grant, the paybacks are even better.

With the air source heat pump's power provided from the grid, the capital costs and net revenues are very similar for both technologies. However, if the ASHP were to be connected to surplus solar PV generation from the Wonder Bank installation, around 17 MWh of surplus power could be used, and net revenues increased by £1,400 per year above the figures in the table.

We assume that the installation of a ground source heat pump for the Machine Shop will not be feasible.

Heat source	Biomass boiler		Capital cost	£70,000

ANNUAL BENEFITS AND COSTS	Subsidy/grant scenario		
	No subsidy/support	**Subsidy equal to RHI**	**50% capital grant**
Revenues and avoided costs			
Heat sales	-	-	-
Saving from avoided electrical heating	£16,327	£16,327	£16,327
Subsidy income	-	£3,761	-
Operating costs			
Electricity costs (with 100% grid import)	-	-	-
Fuel costs	£6,283	£6,283	£6,283
Replacement of short-life equipment	-	-	-
Other O&M costs	£1,000	£1,000	£1,000
Net revenues	**£9,044**	**£12,806**	**£9,044**
Simple payback [years]	**7.7**	**5.5**	**3.9**

Heat source	Air source heat pump		Capital cost	£70,000[13]

ANNUAL BENEFITS AND COSTS	Subsidy/grant scenario		
	No subsidy/support	**Subsidy equal to RHI**	**50% capital grant**
Revenues and avoided costs			
Heat sales	-	-	-
Saving from avoided electrical heating	£16,327	£16,327	£16,327
Subsidy income	-	£3,326	-
Operating costs			
Electricity costs (with 100% grid import)	£5,831	£5,831	£5,831
Fuel costs	-	-	-
Replacement of short-life equipment	-	-	-
Other O&M costs	£600	£600	£600
Net revenues	**£9,896**	**£13,222**	**£9,896**
Simple payback [years]	**7.1**	**5.3**	**3.5**

5.6.2. NEW PRIMARY SCHOOL STANDALONE SYSTEM

Assuming (in line with the calculations presented previously) that the default heating energy source for the new primary school would be natural gas, the financial case for investment is weak when output-based subsidies are available and non-existent where they are not. The relatively more generous RHI payments for ground source heat pumps mean that the simple payback for a ground source scheme is much better than that of a biomass boiler scheme.

[13] Both biomass boilers and air source heat pumps have installed costs of around £1000/kW at this scale.

Heat source	Ground source heat pump	Capital cost	£270,000

ANNUAL BENEFITS AND COSTS	Subsidy/grant scenario		
	No subsidy/support	Subsidy equal to RHI	50% capital grant
Revenues and avoided costs			
Heat sales	£8,342	£8,342	£8,342
Saving from avoided electrical heating	-	-	-
Subsidy income	-	£21,546	-
Operating costs			
Electricity costs (with 100% grid import)	£10,726	£10,726	£10,726
Fuel costs	-	-	-
Replacement of short-life equipment	-	-	-
Other O&M costs	£1,500	£1,500	£1,500
Net revenues	**-£3,884**	**£17,663**	**-£3,884**
Simple payback [years]	**n/a**	**15.4**	**n/a**

Heat source	Biomass boiler	Capital cost	£155,000

ANNUAL BENEFITS AND COSTS	Subsidy/grant scenario		
	No subsidy/support	Subsidy equal to RHI	50% capital grant
Revenues and avoided costs			
Heat sales	£8,342	£8,342	£8,342
Saving from avoided electrical heating	-	-	-
Subsidy income	-	£8,648	-
Operating costs			
Electricity costs (with 100% grid import)	-	-	-
Fuel costs	£14,446	£14,446	£14,446
Replacement of short-life equipment	-	-	-
Other O&M costs	£2,000	£2,000	£2,000
Net revenues	**-£8,103**	**£545**	**-£8,103**
Simple payback [years]	**n/a**	**>100**	**n/a**

5.6.3. TYPICAL NEW-BUILD HOUSE

The two standalone energy supply options that are most likely to be appropriate for new-build housing are air source heat pumps and ground source heat pumps. Unlike the non-domestic scheme which pays installations over a 20-year period, the domestic RHI pays the owners of eligible installations for a period of only 7 years (although the payment tariffs are higher).

With the heat sales price fixed at 6.0 p/kWh (competitive with the cost of heating with natural gas), neither type of heat pump system generates net revenues without the receipt of an RHI-style subsidy. Even with this subsidy, neither scheme can pay off the initial capital investment within the 7 years during which revenues are generated.

6. FINANCIAL ANALYSIS

6.1. INTRODUCTION

Two development options have been identified that could achieve simple paybacks of around 15 years if output-based subsidies equivalent to the current terms of the Renewable Heat Incentive are available. Bearing this caveat in mind, this section lays out 20-year cash flow projections for one of the two frontrunner development options, a ground source heat network supplying 6 non-domestic loads (Development Option B). The cashflow projections consider two alternative finance scenarios: one in which the majority of the scheme's capital cost is met through a concessional (low interest) loan with commercial repayment terms, and the other in which community energy bonds are issued. Further indicators of financial viability are developed for this example.

The conclusions that can be drawn from the scheme presented are broadly applicable to the other frontrunner development option (the ground source heat network supplying 3 non-domestic and 34 domestic loads in and around New High Street, Development Option D).

6.1.1. ASSUMPTIONS

- Heat sales income and electricity costs (both incurred and avoided) are assumed to increase by 4% p.a.
- Subsidy income and OPEX are assumed to increase by 2.5% p.a.
- The discount rate is assumed to be 3.5% p.a.
- The replacement cost for the heat pumps and ancillary equipment (such as buffer tanks) is assumed to be £120,000. The average lifespan of this equipment is in excess of 20 years, so provision is made for payments into an equipment replacement fund to be built up from Year 11 to Year 20 at a rate of £12,000 per year.
- The concessional loan is assumed to have a 15-year term, with an interest rate of 4% p.a. and payments made from Year 1 onwards.
- The community energy bonds are issued for a 15-year term, paying investors interest only at rate of 5% p.a. until Year 15 when the capital is repaid – this is typical for community energy projects currently in development.

Note that for neither of the finance cases is the cost of securing and administering finance accounted for (e.g. loan arrangement fees or administration costs for community bond issue).

6.2. CONCESSIONAL LOAN & GRANT BLEND

The project is not able to afford debt repayments on the assumed terms if 100% of the capital cost is financed with a loan. The maximum amount of loan that can be afforded is around £600,000, meaning that a grant must be sought to cover the remaining £245,000 capital cost.

The loan terms and interest rate assumed are very favourable in comparison to commercial loans. However, were a lower interest rate (<4%), longer term (> 15 years) or an enabling feature such as an interest-free period available, it is possible that the amount of grant required could be lower.

The 20-year Net Present Value of the development is £306,000. The nominal Internal Rate of Return is 5%.

The majority of the cash flow that could be used for community benefit comes in years 16 – 20, once the loan is repaid but while subsidy payments are still ongoing.

Table 4: 20-year cashflow projection for Development Option B financed by £600,000 loan and £245,000 grant (continued overleaf)

Year of Project	0	1	2	3	4	5	6	7	8	9	10
Income											
Loan capital	600000										
Grant received	244713										
Heat sales		19227	19996	20796	21628	22493	23392	24328	25301	26313	27366
RHI-equivalent subsidy		59029	60505	62018	63568	65157	66786	68456	70167	71922	73720
Total Income	**844713**	**78256**	**80501**	**82814**	**85196**	**87650**	**90179**	**92784**	**95469**	**98235**	**101086**
Expenditure											
Capital expenditure	-844713										
Electricity costs		-30743	-31973	-33252	-34582	-35965	-37404	-38900	-40456	-42074	-43757
OPEX		-8000	-8200	-8405	-8615	-8831	-9051	-9278	-9509	-9747	-9991
Reinvestment fund		0	0	0	0	0	0	0	0	0	0
Total Expenditure	**-844713**	**-38743**	**-40173**	**-41657**	**-43197**	**-44796**	**-46455**	**-48177**	**-49965**	**-51821**	**-53748**
Avoided Costs											
Capital expenditure		0	0	0	0	0	0	0	0	0	0
Saving from avoided electrical heating		16327	16980	17659	18366	19100	19864	20659	21485	22345	23238
OPEX		0	0	0	0	0	0	0	0	0	0
Total Avoided Costs	**0**	**16327**	**16980**	**17659**	**18366**	**19100**	**19864**	**20659**	**21485**	**22345**	**23238**
Pre-finance Surplus	**0**	**55840**	**57308**	**58816**	**60365**	**61955**	**63588**	**65266**	**66989**	**68758**	**70576**
Debt Service											
Loan repayments		-53965	-53965	-53965	-53965	-53965	-53965	-53965	-53965	-53965	-53965
Total Debt Service Expenditure	**0**	**-53965**	**-53965**	**-53965**	**-53965**	**-53965**	**-53965**	**-53965**	**-53965**	**-53965**	**-53965**
Cash Flow		**1876**	**3344**	**4851**	**6400**	**7990**	**9623**	**11301**	**13024**	**14794**	**16611**
Cumulative Cash Flow	**0**	**1876**	**5219**	**10071**	**16471**	**24461**	**34084**	**45385**	**58409**	**73203**	**89814**
Discounted Cash Flow	**0**	**1812**	**3121**	**4376**	**5577**	**6728**	**7829**	**8882**	**9891**	**10855**	**11776**
Cumulative Discounted Cash Flow	**0**	**1812**	**4933**	**9309**	**14886**	**21614**	**29443**	**38325**	**48215**	**59070**	**70846**

Table 4 continued: 20-year cashflow projection for Development Option B financed by £600,000 loan and £245,000 grant

Year of Project	11	12	13	14	15	16	17	18	19	20
Income										
Loan capital										
Grant received										
Heat sales	28461	29599	30783	32014	33295	34627	36012	37452	38950	40508
RHI-equivalent subsidy	75563	77452	79388	81373	83407	85492	87630	89820	92066	94367
Total Income	**104023**	**107051**	**110171**	**113387**	**116702**	**120119**	**123641**	**127272**	**131016**	**134876**
Expenditure										
Capital expenditure										
Electricity costs	-45507	-47328	-49221	-51189	-53237	-55367	-57581	-59884	-62280	-64771
OPEX	-10241	-10497	-10759	-11028	-11304	-11586	-11876	-12173	-12477	-12789
Reinvestment fund	-12000	-12000	-12000	-12000	-12000	-12000	-12000	-12000	-12000	-12000
Total Expenditure	**-67748**	**-69824**	**-71980**	**-74218**	**-76541**	**-78953**	**-81457**	**-84057**	**-86757**	**-89560**
Avoided Costs										
Capital expenditure	0	0	0	0	0	0	0	0	0	0
Saving from avoided electrical heating	24168	25135	26140	27186	28273	29404	30580	31803	33075	34398
OPEX	0	0	0	0	0	0	0	0	0	0
Total Avoided Costs	**24168**	**25135**	**26140**	**27186**	**28273**	**29404**	**30580**	**31803**	**33075**	**34398**
Pre-finance Surplus	**60443**	**62361**	**64331**	**66355**	**68434**	**70570**	**72764**	**75018**	**77334**	**79714**
Debt Service										
Loan repayments	-53965	-53965	-53965	-53965	-53965					
Total Debt Service Expenditure	**-53965**	**-53965**	**-53965**	**-53965**	**-53965**	**0**	**0**	**0**	**0**	**0**
Cash Flow	**6478**	**8396**	**10366**	**12390**	**14469**	**70570**	**72764**	**75018**	**77334**	**79714**
Cumulative Cash Flow	**96292**	**104689**	**115055**	**127445**	**141914**	**212484**	**285248**	**360266**	**437600**	**517314**
Discounted Cash Flow	**4437**	**5557**	**6628**	**7654**	**8637**	**40698**	**40544**	**40387**	**40226**	**40061**
Cumulative Discounted Cash Flow	**75283**	**80840**	**87468**	**95123**	**103759**	**144457**	**185002**	**225388**	**265614**	**305676**

6.3. COMMUNITY ENERGY BOND ISSUE & GRANT BLEND

Table 5: 20-year cashflow projection for Development Option B financed by £500,000 community energy bond issue and £345,000 grant (continued overleaf)

Year of Project	0	1	2	3	4	5	6	7	8	9	10
Income											
Capital from community bond issue	500000										
Grant received	344713										
Heat sales		19227	19996	20796	21628	22493	23392	24328	25301	26313	27366
RHI-equivalent subsidy		59029	60505	62018	63568	65157	66786	68456	70167	71922	73720
Total Income	**844713**	**78256**	**80501**	**82814**	**85196**	**87650**	**90179**	**92784**	**95469**	**98235**	**101086**
Expenditure											
Capital expenditure	-844713										
Electricity costs		-30743	-31973	-33252	-34582	-35965	-37404	-38900	-40456	-42074	-43757
OPEX		-8000	-8200	-8405	-8615	-8831	-9051	-9278	-9509	-9747	-9991
Reinvestment fund		0	0	0	0	0	0	0	0	0	0
Total Expenditure	**-844713**	**-38743**	**-40173**	**-41657**	**-43197**	**-44796**	**-46455**	**-48177**	**-49965**	**-51821**	**-53748**
Avoided Costs											
Capital expenditure		0	0	0	0	0	0	0	0	0	0
Saving from avoided electrical heating		16327	16980	17659	18366	19100	19864	20659	21485	22345	23238
OPEX		0	0	0	0	0	0	0	0	0	0
Total Avoided Costs	**0**	**16327**	**16980**	**17659**	**18366**	**19100**	**19864**	**20659**	**21485**	**22345**	**23238**
Pre-finance Surplus	**0**	**55840**	**57308**	**58816**	**60365**	**61955**	**63588**	**65266**	**66989**	**68758**	**70576**
Debt Service											
Community bond interest payments		-25000	-25625	-26266	-26922	-27595	-28285	-28992	-29717	-30460	-31222
Community bond principal repayment		0	0	0	0	0	0	0	0	0	0
Total Debt Service Expenditure	**0**	**-25000**	**-25625**	**-26266**	**-26922**	**-27595**	**-28285**	**-28992**	**-29717**	**-30460**	**-31222**
Cash Flow		**30840**	**31683**	**32550**	**33442**	**34360**	**35303**	**36273**	**37271**	**38298**	**39354**
Cumulative Cash Flow	**0**	**30840**	**62524**	**95074**	**128516**	**162876**	**198179**	**234452**	**271723**	**310022**	**349376**
Discounted Cash Flow	**0**	**29797**	**29577**	**29359**	**29143**	**28930**	**28719**	**28510**	**28304**	**28101**	**27899**
Cumulative Discounted Cash Flow	**0**	**29797**	**59374**	**88733**	**117876**	**146805**	**175524**	**204035**	**232339**	**260440**	**288339**

Table 5 continued: 20-year cashflow projection for Development Option B financed by £500,000 community energy bond issue and £345,000 grant

Year of Project	11	12	13	14	15	16	17	18	19	20
Income										
Capital from community bond issue										
Grant received										
Heat sales	28461	29599	30783	32014	33295	34627	36012	37452	38950	40508
RHI-equivalent subsidy	75563	77452	79388	81373	83407	85492	87630	89820	92066	94367
Total Income	**104023**	**107051**	**110171**	**113387**	**116702**	**120119**	**123641**	**127272**	**131016**	**134876**
Expenditure										
Capital expenditure										
Electricity costs	-45507	-47328	-49221	-51189	-53237	-55367	-57581	-59884	-62280	-64771
OPEX	-10241	-10497	-10759	-11028	-11304	-11586	-11876	-12173	-12477	-12789
Reinvestment fund	-12000	-12000	-12000	-12000	-12000	-12000	-12000	-12000	-12000	-12000
Total Expenditure	**-67748**	**-69824**	**-71980**	**-74218**	**-76541**	**-78953**	**-81457**	**-84057**	**-86757**	**-89560**
Avoided Costs										
Capital expenditure	0	0	0	0	0	0	0	0	0	0
Saving from avoided electrical heating	24168	25135	26140	27186	28273	29404	30580	31803	33075	34398
OPEX	0	0	0	0	0	0	0	0	0	0
Total Avoided Costs	**24168**	**25135**	**26140**	**27186**	**28273**	**29404**	**30580**	**31803**	**33075**	**34398**
Pre-finance Surplus	**60443**	**62361**	**64331**	**66355**	**68434**	**70570**	**72764**	**75018**	**77334**	**79714**
Debt Service										
Community bond interest payments	-32002	-32802	-33622	-34463	-35324	0	0	0	0	0
Community bond principal repayment	0	0	0	0	-500000	0	0	0	0	0
Total Debt Service Expenditure	**-32002**	**-32802**	**-33622**	**-34463**	**-535324**	**0**	**0**	**0**	**0**	**0**
Cash Flow	**28441**	**29559**	**30709**	**31892**	**-466890**	**70570**	**72764**	**75018**	**77334**	**79714**
Cumulative Cash Flow	**377817**	**407376**	**438085**	**469977**	**3086**	**73656**	**146420**	**221438**	**298772**	**378486**
Discounted Cash Flow	**19481**	**19562**	**19635**	**19702**	**-278683**	**40698**	**40544**	**40387**	**40226**	**40061**
Cumulative Discounted Cash Flow	**307819**	**327381**	**347016**	**366719**	**88036**	**128734**	**169278**	**209665**	**249891**	**289952**

The project is not able to afford to repay investors' capital on the timescale that has been assumed if 100% of the capital cost is financed with a community energy bond issue. The maximum value of bonds that can be issued is around £500,000, meaning that a grant must be sought to cover the remaining £345,000 capital cost.

The interest rate (5%) and timescale for capital repayment (15 years) are fairly typical for community energy bonds currently being issued. However, some projects do raise finance with lower interest rates (normally at least 4%) and/or longer repayment timescales (up to 20 years). If these terms were achievable for the Brymbo Heat Network, it is possible that the amount of grant required could be lower.

The 20-year Net Present Value of the development is £290,000. The nominal Internal Rate of Return is 5%.

The majority of the cash flow that could be used for community benefit comes in years 16 – 20, once the bond capital has been repaid but while subsidy payments are still ongoing.

7. DELIVERY MODELS

7.1. INTRODUCTION

Different models and structures are currently used in the electricity and heat supply market in the UK. This chapter explores potential delivery models, potential ownership and corporate structuring options, and provides recommendations within the Brymbo context and in line with the aims and interests of the Brymbo Heritage Trust and community stakeholders.

7.2. METERING AND TARIFF OPTIONS

7.2.1. METERING

Heat metering and billing regulations have been introduced to implement the requirements of the European Energy Efficiency Directive in the UK. All new heat networks are required to install meters and controls so that customers can manage their heating. There are also requirements to provide customers with transparent billing information.

The heat network is fundamentally different to the gas or electricity markets, in that as a local network (rather than a national grid), there is only one 'supplier'. Appropriate governance structures need to be put in place for all heat customers to provide safeguards that the heat tariff is equivalent to, if not discounted against, other forms of energy supply.

Voluntary guidance on heat networks is contained in the November 2015 *Heat Networks: Code of Practice for the UK*, prepared jointly by the Association for Decentralised Energy (ADE) and the Chartered Institution of Building Services Engineers (CIBSE). Amongst the areas covered is heat metering, to inform choices on how to select metering, prepayment and billing systems that are accurate and cost effective.

7.2.2. TARIFFS

The heat sales revenue was modelled on the basis of a heat tariff with a flat rate of 3.0 p/kWh for non-domestic customers and 6.0 p/kWh for domestic customers, with both rates selected to be competitive with heating from natural gas (including, for domestic customers, the cost of installation, maintenance and replacement of a conventional gas heating system). In practice, heat tariffs normally comprise of fixed (standing charge) and variable (unit price) components. At a later stage in the development of the heat network, these fixed and variable elements can be specified in order to meet specific aims, which may include customer equity, fuel poverty reduction and comparability with gas prices in addition to ensuring the financial viability of the development.

7.3. ENERGY SERVICES COMPANY (ESCO)

Brymbo Heritage Trust, whether in its currently constituted form, or through the establishment of a new delivery vehicle for the supply of energy services, will become involved in energy services as part of its aspirations for the generation of electricity and - should the heat network go ahead to construction - heat. Because of the sheer diversity of activities undertaken and services offered by an ESCo, finding a meaningful definition of what an ESCo actually is can be difficult. A definition commonly adopted in the UK, including by the energy regulator, Ofgem, is derived from the EU's 2006/32/EC Energy Service Directive: "*an entity that provides a commitment to deliver the benefits of energy to a specified level of performance and reliability*." Figure 3 shows an overview of the energy services domain in which ESCos can operate.

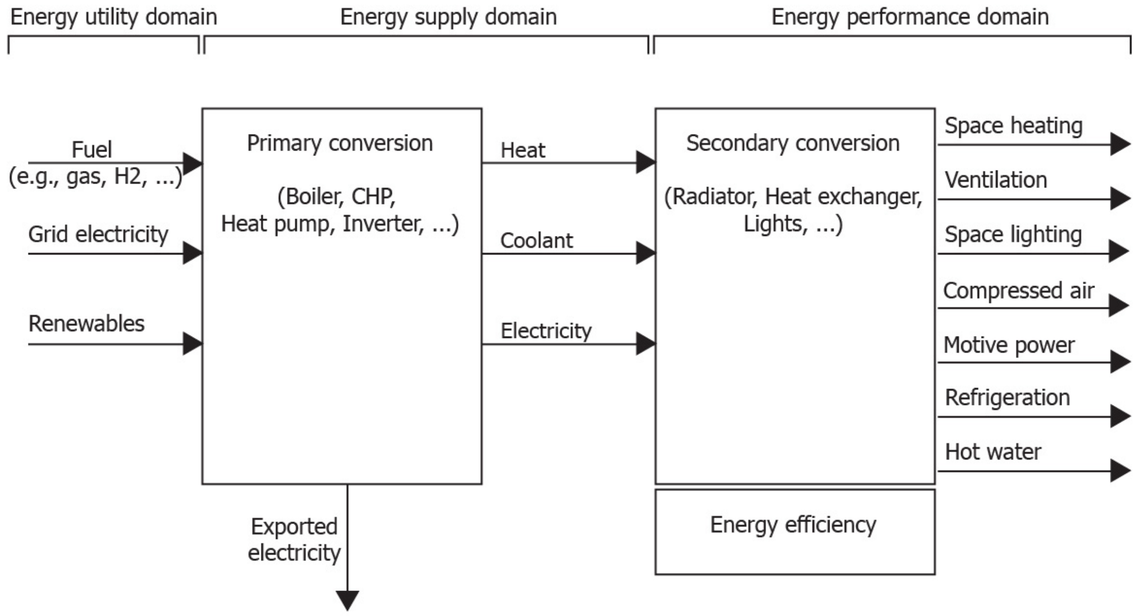

Figure 3: Stylised overview of energy services

There are two features that further specify the role of ESCos beyond the very general definition mentioned above:

1. ESCos have the aim of improving and/or providing energy cost savings, which may include the provision of lower-cost energy services but can also refer to providing energy efficiency and/or higher quality energy services.
2. ESCos generally take on some or all of the risk associated with the delivery of energy service(s).

In the context of the Brymbo Heat Network, the ESCo would be operating in the energy utility and energy supply domains, although the development of the scheme could also directly deliver energy efficiency improvements for the Enterprise Centre (included in the capital cost) and would be an indirect driver of energy efficiency for the new and restored buildings.

The contract with each customer – the Heat Supply Agreement - would be an example of an 'Energy Supply Contract'.

7.4. OWNERSHIP & FINANCING

The ownership and financing structure options for the ESCo model range from developments that are wholly-owned and operated by the community, to joint ventures between community and private sector, to developments in which a private sector partner assumes full responsibility. The marginal financial viability of the Brymbo Heat Network is likely to mean that community ownership and operation is the only option.

Because risk generally goes hand in hand with control, the achievement of the non-financial aims of the Brymbo Heat Network may also dictate a high degree of community ownership and operation. DECC's Investor guide to

Heat Networks[14] includes the following graphic illustrating the relationship between control and risk. For 'public sector' read 'community'.

Figure 4: Relationship of control to risk for heat network ownership and operation[15]

Decision-making must balance the prospective aims and outcomes of the ESCo against an 'acceptable level' of risk. The risks are dependent on a large number of factors, not least the capacity and willingness of the community to take on risk and assume control of the project, or the availability of suitable and experienced partners to deliver some or all of the project successfully.

With the expected development of the Wonder Bank solar farm, Brymbo Heritage Trust is already venturing into the ownership of local energy assets, although the degree to which its role can be described as that of an 'ESCo' depends on which local electricity users (if any) are connected and what service guarantees are provided. However, because the solar farm is expected to be largely grant-funded, the trade-off between risk and control is less relevant for the solar project than for the heat network.

7.5. CORPORATE STRUCTURING OPTIONS

Choosing the most appropriate commercial structure will depend largely on the favoured supply and ownership model.

A Limited by Shares structure is most suited to models that require upfront external investment and subsequent returns on that investment and where there is more than one investor who may want flexibility around their involvement and exit strategy. One of the key features of this approach is that it seeks to pay profits and any liability is limited to the amount invested. The benefits of Limited by Shares model are that it is straightforward to

14 DECC (2015). Investing in the UK's Heat Infrastructure: Heat Networks.

15 DECC, public sector information licensed under Open Government Licence v3.0
www.nationalarchives.gov.uk/doc/open-government-licence/

establish, allows different ownership percentages, provides clarity over control, and influences issues and enables dividends to be paid and investment to be traded. The major downside is that a limited by shares structure would be liable for corporation tax. A standard set up for a community project is to have the company set up as a fully owned subsidiary, with any profits gifted to a parent charity.

Limited by Guarantee structures are most suited to not-for-private-profit distributing enterprises which are required to either own assets, enter into contracts or employ staff. The key features of this model are that there are no shares, surpluses are recycled back into the business and liabilities are limited to £1 guarantee on insolvency. Limited by Guarantee structures allows for application for charitable status, which comes with benefits such as corporation tax relief and business rates relief. Restricted financing options for this structure and limited flexibility in exit strategies can make this option unviable in certain circumstances. Limited by guarantee companies are often used as the parent companies in community energy projects, which deploy trading subsidiaries to own and operate the system, taking responsibility for operational activities (including maintenance, metering and billing) and gifting their operational surpluses to the parent company or charitable organisation.

7.6. POTENTIAL JOB CREATION AND UPSKILLING

The addition of the heat network to BHT's energy services activities will bring the opportunity for additional new job creation and the upskilling of individual capabilities. The further development and operation of the solar farm project will require commercial, technical and administrative functions – although the level of effort required once the scheme is operational will be considerably less than a full-time role[16]. It is estimated that the operation of the heat network would create between 0.1 and 0.5 FTE jobs in Brymbo, with the schemes with a large number of customers (i.e. developments serving domestic customers) and those with more regular technical operation tasks (e.g. biomass boilers) creating more jobs.

Some of these jobs will require new expertise, and training for BHT employees or local volunteers may be integrated into the package of works that is procured. The development process can be leveraged to upskill individuals from the Brymbo area, thus contributing to establishing a more diversified workforce.

It is necessary to note that significant further input will be required to progress this opportunity from this feasibility stage to an operational heat network, particularly when considered in the context of the concurrent (but further progressed) solar farm development. Consideration should be given to establishing dedicated and funded personnel resource within BHT or a stakeholder organisation to support the ongoing delivery of the project.

[16] It should be noted that the OPEX costs allowed for 'Administration & contingency' by the solar farm feasibility study - £310 per year for a 288 kWp scheme – probably do not account for the full cost of staff time that will be required and are therefore not directly comparable with the O&M costs presented in this study.

8. NEXT STEPS

8.1. RECOMMENDATIONS

The feasibility work conducted indicates significant challenges to the delivery of a viable heat network for Brymbo. No development options have been identified that are financially viable without some form of subsidy based on renewable heat output. If a future output-based subsidy providing a level of income equivalent to the RHI is available, and the right blend of concessional loans, community energy bonds and grant funding can be secured, viable development options do exist. However, the mechanism through which the UK government will support renewable heat post-2021 is highly uncertain.

It is recommended that stakeholders wait for information on post-RHI support for renewable heat before further work is undertaken to develop heat network opportunities, although work to identify and line up grant funding opportunities could be undertaken. Once an announcement has been made, the financial case should be reconsidered for the frontrunner development options identified by this study.

Meanwhile, the design process for the restoration of the 1920s machine shop should consider renewable heat options for the building's space heating and hot water supply, even if this rules out the building's participation in a future heat network (at least for the first phase). Whether or not the installation could be completed and accreditation achieved ahead of the closure of the RHI scheme (March 2021), a biomass boiler or an air source heat pump installation could offer substantial savings over electric heating or the installation of a new gas supply and gas-fired heating system. Professional installers of such systems will be able to provide budget quotes and preliminary design outlines to enable robust assessment of the different options versus conventional, non-renewable heat. If the result of further work was that renewable heat technologies were not found to be viable as part of the renovation project, the conventional heating system installed should be designed to be suitable for future connection to a heat network or a standalone renewable heat system (i.e. capable of heating the building when the temperature of the heating circuit is 50-55°C). Thermal efficiency of the building fabric should be maximised to the greatest extent possible within technical and budget constraints.

Similarly, where the decision is made not to install renewable heat technologies in the first instance, it is recommended that the developers of new-build housing, commercial properties and public facilities 'futureproof' their buildings by installing heating systems that are compatible with heat networks or standalone renewable heat supplies. This would mean that the pathway for the first (and potentially subsequent) phases of heat network development on the former Steelworks site is significantly eased, both in terms of cost and in terms of customer acceptability (disruption during works and the impact on home layout and décor are among the most common reasons for building owners to decline the offer of a heat network connection or renewable heat supply).

Although neither of the frontrunner development options identified by this study are based on minewater heat, in some cases the financial performance of the minewater options are not substantially worse than the other energy supply options and may be within the margin of error that applies to the capital and operating cost estimates made. The 'Power from the Deep' project seeks to develop the minewater heat opportunity at Brymbo, initially through the drilling of a new borehole which will allow pumping tests and temperature measurements to be made and the minewater heat capacity better understood. If it was found that the minewater heat resource was larger than today's estimates, there may be opportunities to improve the financial and carbon-reduction performance of Development Options B, C and D by adding connections to housing that is sufficiently near to the connections specified in this study (i.e. that improve the Linear Heat Density). Therefore, it may be appropriate to carry out a rapid reassessment of development options once the 'Power from the Deep' investigations are concluded. Another factor may be that it may be easier to secure the grant funding necessary, for a novel demonstration technology such as minewater heat over other more established renewable alternatives.

8.2. DELIVERY RISKS

Table 6 outlines the delivery risks identified at this stage.

Table 6: Summary of key risks for heat network project (as at completion of feasibility study)

Risk	Risk = Probability x Impact	Manage-ability	Mitigating Actions	Risk After Mitigation
Post-RHI support for renewable heat does not lead to a viable financial case	High	Poor	None – although BHT could add to lobbying efforts being made by industry organisations[17] to pressure BEIS for clarity on the post-RHI framework and for the framework to provide the support that is needed to enable prompt decarbonisation of heat.	High
Potential heat customers do not connect to network: • Property developers opt to install conventional heating systems rather than take up network connection offer. • Existing heat users (e.g. Enterprise Centre) decline offer of network connection. • Proposed new buildings are aborted or are not completed in time, so heat sales are lower than predicted.	High	Medium	Engagement with management of existing buildings and with property developers to persuade them of the benefits of opting for network connections. Revise assessments as new information becomes available regarding the planned property developments.	Medium
Important parameters vary from the assumptions made at feasibility stage, impacting the assessment of viability	Medium	Medium	The best available site-specific measurements/data, information from other similar projects and rules of thumb have been used to assess viability at feasibility level. Review of outputs by renewable energy specialists (REMARC Cymru) will validate the quality of assumptions made.	Medium
Landowner wayleaves are: • Not provided at nil cost to the development… and/or • Incur legal costs to finalise due to negotiations… …adversely affecting the financial modelling assumptions.	Medium	Medium	Discussions with BDL on gifting land for renewable development extend to cover the access requirements for ancillary infrastructure such as pipework and/or private wire routes.	Medium

[17] https://www.biomassheatworks.co.uk/; https://www.gshp.org.uk/; https://www.heatpumps.org.uk/

Risk	Risk = Probability x Impact	Manage-ability	Mitigating Actions	Risk After Mitigation
Insufficient capacity within BHT/partner organisations to carry out the reassessments recommended by this study, or to progress funding opportunities should a viable project emerge.	Medium	Medium	If not already in place, funding could be sought for paid resource to continue to act in role of 'client' to the solar farm/minewater heat/heat network projects: • Liaising with BDL and property developers; • Reviewing and approving work of consultants; • Developing appropriate governance structures; • Developing funding opportunities; • Community and stakeholder communications.	Low
Planning/(natural) heritage/ environmental constraints prohibit network installation	Low	Medium	Review of planning and environmental baseline suggests no particular problems should be anticipated. Pre-application engagement with planners would validate this.	Low
Opposition from community members (e.g. to biomass installation)	Low	Good	No opposition expected. Engagement with community at an appropriate time to inform and consult.	Low

APPENDIX 1 – DRAWINGS