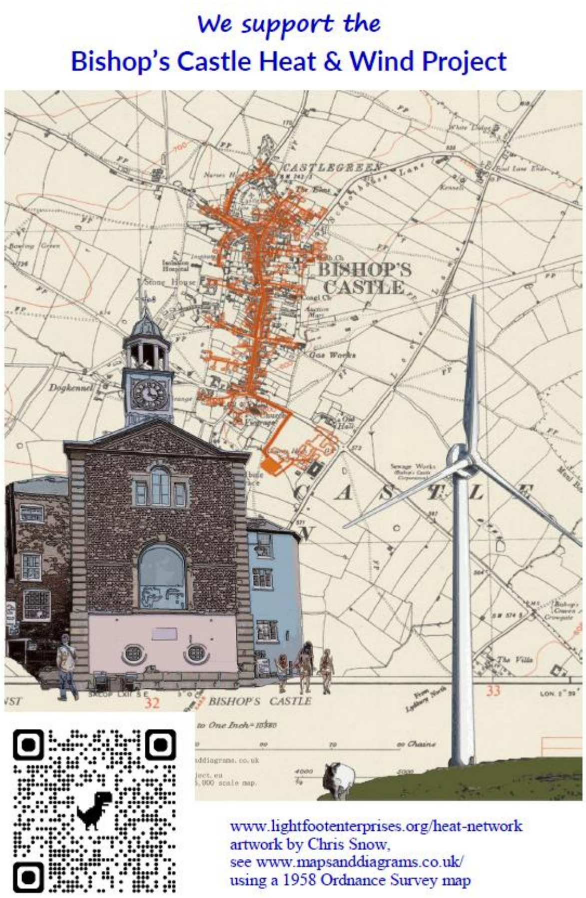
Bishop's Castle Heat Network Stage 2 Feasibility Study



A Report on behalf of

Shropshire and Telford Community Energy (STCE), Lightfoot Enterprises

& Bishop's Castle Climate Action Group

Funded by the Community Energy Fund

& a Power to Change Next Generation grant (both through STCE)

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1.1. Scheme Summary

This study is the result of four years' work by Sharenergy and Carbon Alternatives on behalf of Shropshire & Telford Community Energy (STCE) and Lightfoot Enterprises, a local environmental charity.

Bishop's Castle is a town with 828 households, a leisure centre, two schools, several pubs and other small businesses. The town is off the gas grid so most of the heating is by high carbon emitting fuels such as oil and LPG. The centre of the town is made up of older properties, many of which are listed, with solid walls and general poor energy performance. There is very little room for individual heat pumps for these properties.

The original 2021 proposal was to site air source heat pumps adjacent to the SpArC leisure centre supplying high temperature heat (circa 70 degrees) to SpArC, the Community College, the Castle Hotel and around 100 houses in the centre of the town. In this scheme there would be oil boilers to provide top up to the heat pumps in the coldest weather and back up in case of any heat pump down time. Around 80% of the heat should be supplied by the heat pumps. The electricity would mostly be provided by a 900kW wind turbine and 500 kW of photovoltaic cells (PV). 180m^3 of thermal storage would be incorporated to enable the heat pumps to generate extra heat on windy days which can be stored for when the wind does not blow. This enables a low reliance on grid electricity for the scheme which is essential for the scheme viability with the current gap between electricity and oil prices.

Significant work has been carried out during 2024 and 2025 using resources from the Community Energy Fund and the Next Generation fund. This has enabled:

- Updates to the landscape and visual impact assessment for the wind turbine
- Completion of ecology and other studies for the turbine
- Submission of a planning application for the turbine
- Case studies of 15 properties in the town
- Launching of a Customer Offer Document and Expression of Interest form
- Discussions with NGED re grid connection
- Discussions with SpArC and the Community College
- Discussions with a potential Data Centre provider
- Work on potential sites for the PV panels.
- Design work and costings for the energy centre and pipework
- Further public consultation, including two well attended public meetings, a pop up shop and two visits to town council meetings

This work has received considerable interest and support in the town. 50 properties signed an Expression of Interest form, including the Castle Hotel. SpArC and the Community College are still very interested, although Shropshire Council have received Public Sector Decarbonisation Scheme (PSDS) funding for their own heat pumps for SpArC. The wind turbine application received unanimous support from the Town Council and was not opposed by the Shropshire Hills Management Partnership[1]. Only five objections were lodged on Shropshire Council's planning portal and none of these were local to the site. Planning permission for the turbine was granted in June 2025.

However, the financial model of the heat network has been hit by a number of issues.

1. The price of oil has stagnated since the previous study in 2022, this means the price of heat in the model has had to be reduced as the system cannot be more expensive than running an oil boiler (the previous figures assumed a rise in oil prices).
2. The cost of the pipework has increased significantly.

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[1] *The Shropshire Hills Management Partnership have a policy of never support planning applications, they either object or abstain.*

3. The Green Heat Network Fund (GHNF) has effectively lowered the amount of grant on offer by reducing the maximum allowable tariff for heat delivered from 4.5p/kWh to 2.5p. The GHNF is a competitive funding scheme and larger schemes in city centres with large heat loads, short pipe runs and Council financial backing have been requesting 2.5p/kWh or less.
4. The District Network Operator (DNO) has declared that the maximum generation capacity that can be added to the grid before 2032 is 950kW. This means that the scheme could have the wind turbine or the solar panels but not both.

The addition of a data centre to the scheme was considered, this could have made the scheme viable, but it was discovered that the local network is not strong enough for a data centre operator to be interested.

These factors acting together mean that at this stage the original scheme does not appear to be viable. Because of this a planned application to the Green Heat Network Fund in April 2025 was not submitted and the decision was taken in September 2025 to progress the wind turbine project as a standalone scheme without the heat network. However, delivering renewable heat remains a long-term ambition of the group.

It is possible that if oil prices rise significantly and/or better grant support becomes available then the original scheme could be revived, but in the meantime four other options have been considered (along with some combinations of these). All include installing the 900kW wind turbine.

1. Heating the College only, private wire to SpArC which has fitted its own heat pumps.
2. No heat provided, private wire to SpArC and the College.
3. No heat provided, private wire to SpArC only.
4. No heat provided, private wire to SpArC and the College, assuming both of which have fitted heat pumps.
5. Delivering electricity to multiple customers in the town whilst encouraging those customers to fit heat pumps.

A further option of Heating SpArC and the College only, with private wire to SpArC is no longer relevant as SpArC has funding for its own heat pumps. Option 1 has been discounted as the heat network would be too reliant on one customer. Selling electricity directly to the grid without utilising any of the above options would not be viable.

A combination of Options 3 and 5 appears the most likely at this stage. The SpArC decarbonisation project team have expressed an interest in the site being connected to the wind turbine. Sharenergy have produced a separate report on Option 5 as part of their Energy Redress Fund Community Heat Development Unit project. One advantage of Option 5 is it would be open to many households in the wider town and surrounding area that the heat network would not have reached. However, it is less useful for those town centre properties where space for fitting heat pumps is limited and fitting individual heat pumps will be more disruptive internally than connecting to a heat network.

Option 5 relies on a change to the grid codes and regulations (Modification P441) under which small exempt suppliers will not pay various charges such as the Feed in Tariff and use of system charges. P441 is currently the subject of a Government consultation, so it is currently unclear exactly how this will work or how the electricity supply companies will make use of the new system. Sharenergy are currently exploring the implications of this code change further.

Whilst a heat network is not considered viable for Bishop's Castle currently this report covers the work carried out in detail for future reference as circumstances may well change.

1.2. Previous Studies and Grants

The original scheme was proposed by Sharenergy in 2021, and funding was obtained by STCE from Power to Change's Next Generation scheme. This funding enabled initial feasibility work to be carried out on the heat network and a wind constraints study and a draft Landscape and Visual Impact Assessment (LVIA) to be produced.

The wind constraints study provided two potential wind turbine sites; these were included along with the LVIA as part of a pre-application submission to Shropshire Council in late 2022. The pre-application response suggested that the turbine application would have a greater chance of success if the scheme was included in the Bishop's Castle Place Plan - this was achieved early in 2024.

The inclusion of the scheme in the local Place Plan enabled further Next Generation funding to be released and an application to the Government's Community Energy Fund for a further £100k was successful in spring of 2024.

1.3. Community Consultation

An initial survey in 2021 was distributed to all the households in the town; this showed significant support for the overall project, including the wind turbine. There were a few objectors to one of the turbine sites, however that site has since been discounted. A well-attended public meeting and a stall in the High Street were held that summer which confirmed strong support.

The Town Council were contacted in the Summer of 2021 with a request to include the scheme in the Bishop's Castle Neighbourhood Plan. Whilst the Town Council were generally supportive it was not felt possible to include the scheme in the Neighbourhood Plan.

A further public meeting was held in spring of 2023 to report on the work done to date, including the results of the initial heat network feasibility study and to present the draft LVIA report. This meeting was televised for Channel 4's The Great Climate Fight series and was again well attended with strong support shown.

The Town Council were approached again in late 2023 with a request for the scheme to be included in the local Place Plan (as suggested by Shropshire Council Planning Department). The Town Council voted unanimously to back this request, and the Place Plan insertion was verified by Shropshire Council early in 2024.

In the summer of 2024, 15 case studies were carried out in the town to show how individual properties could be connected to the network. There was strong interest in taking part in these studies, and indeed the original proposal of 5 or 6 studies was extended to 15 due to the demand. Demand was particularly strong at the top of the town.

During 2024 discussions were also held with SpArC and the Community College, both of which showed strong interest in the scheme, along with Shropshire Council and NGED (the local District Network Operator).

A third public meeting was held in September 2024 along with a Saturday stall in the High St. The meeting was again well attended with strong support for the scheme. In January 2025 a pop-up shop was open for 6 days. None of these events revealed any opposition to the current wind turbine site.

A customer offer letter and Expression of Interest form were circulated alongside the September meeting. 50 forms have been returned to date.

In September 2025 a further public meeting was held and the Town Council were visited, at both of these meetings the plan to progress with the wind turbine as a stand-alone project was accepted.

1.4. Energy Centre Location and Heat Network Routing

The Community College and SpArC are situated in the SE corner of the town, fairly close to the proposed wind turbine sites and with land available nearby that could be used for PV panels. This would therefore be a good location for an Energy Centre, where the heat pumps and thermal storage would be located, though other locations are possible. If the Energy Centre was located near SpArC then any surplus electricity from the wind turbine and PV could have been sold to SpArC alongside the heat. This power sale has been assumed in the economic evaluation.

Bishop's Castle does not provide any particular challenges with heat network routing, apart from the slope and some tighter streets at the top of the town. From an Energy Centre located in the SE corner it is technically possible to supply as much of the town as is required.

Any heat network installation would have to be carefully managed to ensure high safety levels with minimal interference to existing infrastructure.

1.5. Business Case

Of the three main scenarios (detailed in section 9.2), only the one with the data centre added has a reasonable IRR (internal rate of return), even with Green Heat Network Fund support, but that scenario has been discounted due to issues with the internet connection.[2]

None of the alternative options would qualify for the Green Heat Network Fund which will make getting development funding more difficult, but the capital costs are much lower and the hurdle of gaining GHNF approval is removed.

1.6. Governance

Five possible models have been considered for ownership of the wind turbine and heat network[3]. The proposed governance model is to set up a Special Purpose Vehicle either as a subsidiary of Shropshire and Telford Community Energy (STCE) or as a separate entity. The advantage of using STCE rather than a new society is that they have access to wider resources and expertise and are in a position to manage the commercialisation stage, including being registered for VAT and having audited accounts.

1.7. Conclusions & Next Steps

Bishop's Castle appears to be an ideal place for a heat network. The town has no mains gas and in the town centre there are limited opportunities for the deployment of individual heat pumps or for whole house retrofit.

The proposed combination of air source heat pumps, back up oil boilers and thermal storage with electricity supplied by a wind turbine and solar panels would offer huge carbon savings of up to 1,134 tonnes/annum with price protection for residents and organisations in Bishop's Castle. However, a heat network that includes a large section of the centre of the town does not appear to be viable at the moment even with the wind turbine. We believe that this is in part due to the limited experience in the UK of installing heat network pipework to existing individual homes.

Local support for the scheme has been strong and there is considerable disappointment that the larger heat network is not currently viable. There are however alternative options that can be explored, albeit all of these are more restricted in scope.

What happens next depends on two main factors:

- Whether an off taker can be found for the electricity generated by the wind turbine.
- Whether the P441 Code modifications make a significant difference to the ability of the scheme to supply electricity to customers though the local grid.

Further work will need to consider:

- Whether electricity could be supplied to both the College and SpArC or only to one of these.
- Whether supplying electricity to individual customers can be used to help and encourage them to fit individual heat pumps.

Further development funds will be needed to explore these options fully. Approaches have been made to several funders.

Maintaining the public and council support for the scheme will be vital. The changes to the proposal have been well received so far, further consultation on the proposals should be carried out at regular intervals to keep residents and the Town Council informed of developments.

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[2] *For the assumptions behind these calculations see Section 9.*

[3] *See section 12*

Figure1 Bishop's Castle Heat & Wind consultation October 2021

2. Project Background

2.1. Bishop's Castle

Bishop's Castle is a small town in South Shropshire. There are 828 households, a community college, a primary school, the Sports and Arts Centre (SpArC) with swimming pool and gym, a library/resource centre (Enterprise House), two estates of small industrial units and Ransfords sawmill, Stone House Care Home, a small cottage hospital and a doctor's surgery, several pubs, the Castle Hotel and the Three Tuns brewery. There is also a parish church (St John's) and a parish hall (Church Barn). There is no mains gas supply in the area, so most heating is from oil or LPG boilers. Around 100 of the houses have heat pumps, including 12 Housing Association properties on shared ground loops. A Care Home and the Hospital are heated by a biomass boiler. Ransfords have a biomass boiler which is mostly used for drying treated timber. A previous proposal for community owned biomass heating for the Community College and SpArC unfortunately did not proceed.

The core of the town is made up of older properties with solid stone walls and limited space for fitting heat pumps. There is an estate of eco-houses in the north-west corner, known as 'The Wintles', but most of these houses have LPG boilers running off a shared tank.

Household heating accounts for around 25% of the total household CO_2 emissions of Bishop's Castle *(from the Impact tool see figure 2*) with carbon emissions per person significantly above the national average.

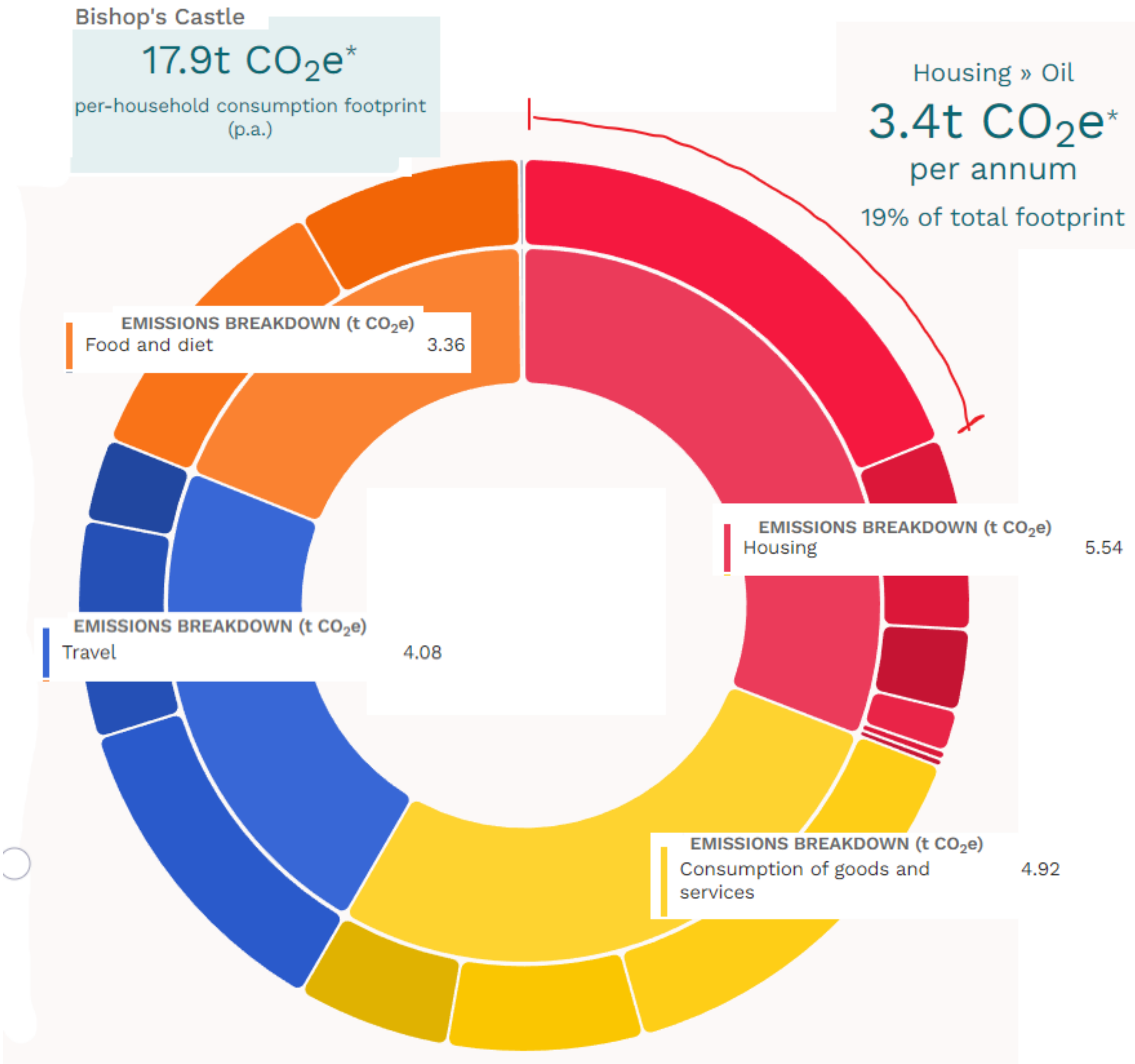

Figure 2 Bishop's Castle carbon emissions from the Impact tool [4]

There is a Conservation Area covering the centre of the town which would make it difficult to fit individual heat pumps and external wall insulation and restricts glazing options.

The Government has indicated that, in order to meet carbon targets, at some point replacement oil boilers will no longer be available.

Whilst there is scope for some energy improvements to the older properties in Bishop's Castle the opportunities are fairly limited, and without undertaking deep whole-house retrofit, the fuel savings are unlikely to be more than around 20%. Ideally, if this scheme progresses, energy surveys would be provided to all interested households, with assistance to undertake energy improvement measures.

There is a 40m height difference from the bottom of the town by the church and the castle at the top which may affect the design of a heat network.

[4] https://impact-tool.org.uk/

2.2. Initial Work

The project started after Sharenergy carried out a feasibility study of possible community energy schemes across Shropshire and Telford for Shropshire and Telford Community Energy (STCE)[5] in early 2021 which identified a heat network powered by a wind turbine as a potential solution to the problem of high costs and carbon emissions from heating in Bishop's Castle. STCE then commissioned Sharenergy and Carbon Alternatives to carry out this study, commissioned Sharenergy and Locogen to develop proposals for the wind turbine and the Energy Workshop to submit a wind turbine pre-planning application.[6]

Sharenergy are community energy specialists, working with a range of projects and societies across the UK. They carried out a study of a possible shared loop ground source system for a housing estate (the Wintles) in Bishop's Castle in 2020 and worked on a heat network feasibility study in Brassington (Derbyshire) with Carbon Alternatives in 2022. Carbon Alternatives are heat network specialists, they have worked on a variety of schemes, including studying the feasibility of ambient temperature heat networks. Locogen are experienced in wind turbine studies and planning applications for renewables.

The wind constraints study provided two potential wind turbine sites; these were included along with the LVIA as part of a pre-application submission to Shropshire Council in late 2022. The pre-app response suggested that the turbine application would have a greater chance of success if the scheme was included in the Bishop's Castle Place Plan; this was achieved early in 2024.

The inclusion of the scheme in the local Place Plan enabled further Next Generation funding to be released and an application to the Government's Community Energy Fund for a further £100k was successful in spring of 2024. That funding enabled the work reported here to be undertaken, along with ecology and other studies for the wind turbine application and finalisation of the LVIA.

2.3. Why Fit a Heat Network? *(see section 7 for more detail)*

As the centre of Bishop's Castle is tightly developed with older buildings that are difficult to insulate and very little room for heat pumps, the options for decarbonising the heat supply are limited. A heat network could supply low carbon heat and allow people to replace their oil boilers and oil tanks. The existence of two anchor loads at the bottom of the town - the SpArC leisure centre and the Community College - is a significant factor, and there has also been considerable interest from larger heat loads at the top of the town, including the Castle Hotel.

The original proposal was to site air source heat pumps adjacent to the SpArC leisure centre supplying high temperature heat (circa 70 degrees) to SpArC, the Community College, the Castle Hotel and around 100 houses in the centre of the town. There would be oil boilers to provide top-up to the heat pumps in the coldest weather and backup in case of any heat pump down time. Around 80% of the heat should be supplied by the heat pumps. The electricity would mostly be provided by a 900kW wind turbine and 500 kW of photovoltaic cells (PV). 180m^3 of thermal storage would be incorporated to enable the heat pumps to generate extra heat on windy days, which can be stored for when the wind does not blow. This would reduce the use of grid electricity for the scheme, which is essential for the scheme viability with the current gap between electricity and oil prices.

3. Recent Work

Significant work has been carried out during 2024 and early 2025 using resources from the Community Energy Fund and the Next Generation fund. This has enabled:

- An update to the landscape and visual impact assessment for the wind turbine.
- Completion of ecology and other studies for the turbine.
- Submission of a planning application for the turbine.
- Case studies of 15 properties in the town.
- Launching of a Customer Offer Document and Expression of Interest form.
- Discussions with NGED re grid connection.

[5] www.stcenergy.org.uk
[6] *See appendices*

- Discussions with SpArC and the Community College.
- Discussions with a potential Data Centre provider.
- Work on potential sites for the PV panels.
- Design work and costings for the energy centre and pipework.
- Further public consultation.

Revision work on the financial model has revealed how significant certain changes to the finances have been and so additional work has been undertaken to investigate alternative options.

4. Community Engagement

A survey was distributed to all Bishop's Castle households in Sept/Oct 2021. Stalls were held in the High St and at the Friday market, and a public meeting at the Three Tuns pub held on 16th September 2021 was attended by 60 people. See appendix 4 for the poster for this event.

122 survey responses were received and there was strong support for both the heat network and the wind turbine, with 90% scoring 7, 8 or 9 out of 9 in support of the heat network and 87% showing strong support for the wind turbine.

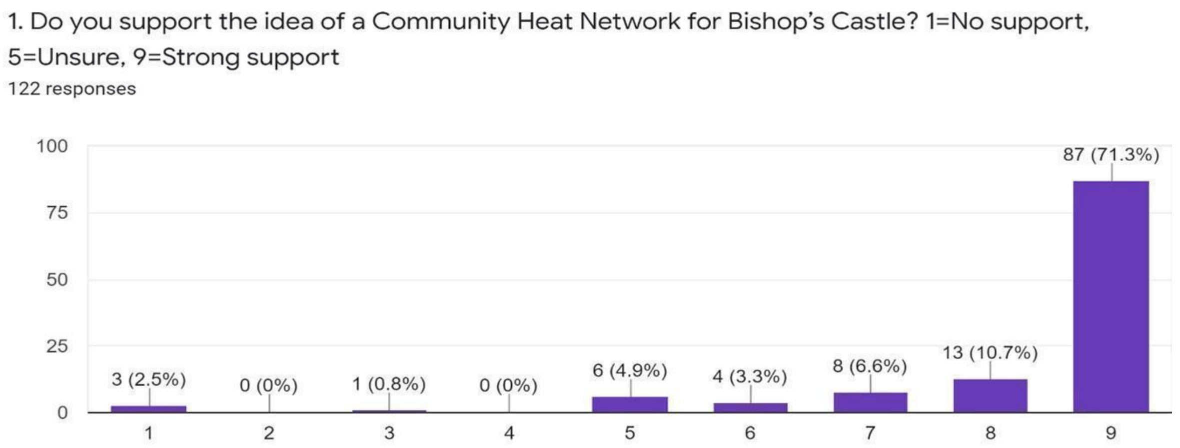

Figure 3 Survey response 2021 Q2

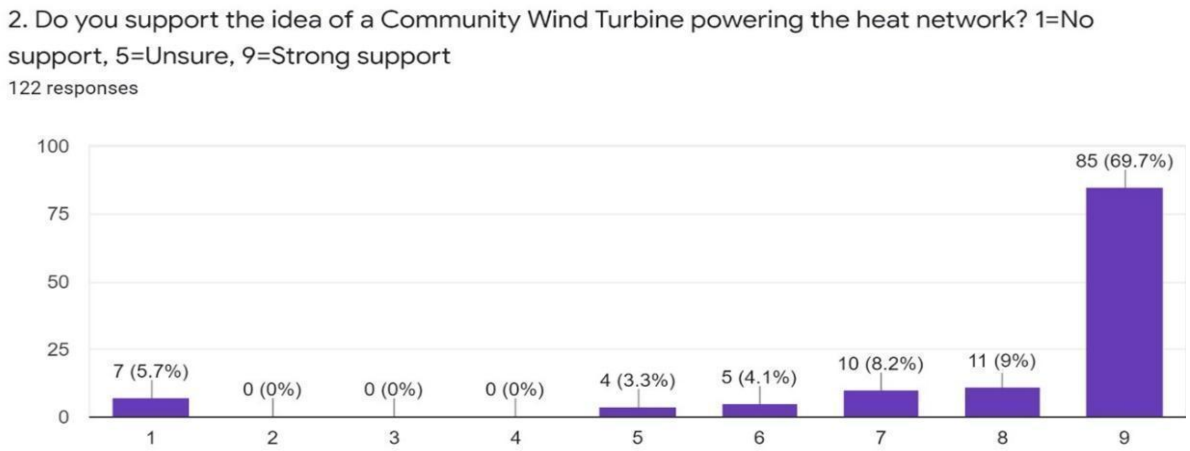

Figure 4 Survey response 2021 Q2

There were only three objections to the heat network and seven objections to the wind turbine. At this stage there were two potential sites for the wind turbine. One of these sites was eliminated as part of the pre-planning process, many of the early wind turbine objections related to this eliminated site.

Bishop's Castle Town Council were fully briefed on the proposals and discussions were held with the aim of getting the proposals included as a policy in the emerging Neighbourhood Plan. Whilst a relevant policy was not included this was due to reasons of timing and resources. In late 2023 the Town Council gave unanimous support for including the scheme in the Local Place Plan (as suggested by Shropshire Council Planning Department) and Shropshire Council verified this inclusion early in 2024.

A second public meeting was held in April 2023, including presentation of the results of the initial heat network feasibility study and presentation of the draft LVIA report. This meeting was televised for Channel 4's Climate Fight series and was again well attended with strong support shown.

In the summer of 2024 15 case studies were carried out in the town to show how individual properties could be connected to the network. There was strong interest in taking part in these studies; indeed, the original proposal of 5 or 6 studies was extended to 15 due to the demand. Demand was particularly strong at the top of the town.

During 2024 discussions were also held with SpArC and the Community College, both of which showed strong interest in the scheme, along with Shropshire Council and NGED (the local District Network Operator).

A third public meeting was held in September 2024. This was again well attended with strong support for the scheme. A stall was also held in the High St; neither event revealed any opposition to the current wind turbine site. A display of the heat network and wind turbine proposals was included in Lightfoot's pop-up shop in the High Street from 13th-18th January 2025. Again, there was considerable support shown for the proposals with no apparent concerns about the wind turbine.

A customer offer letter and Expression of Interest form were circulated alongside the September meeting. 50 forms were returned.

The wind turbine planning application of January 2025 received the unanimous support of the Town Council and the Shropshire Hills Management Partnership did not object[7]. There were no objections from anyone living in the immediate area and only five objections were received in total. Planning permission was granted in June 2025.

5. Community Benefits

If the combined heat and wind scheme were to progress the community would benefit through:

- The ability to remove oil tanks and boilers.
- Improved air quality.
- Protection from energy price spikes.
- Assistance with fitting energy efficiency measures.
- The opportunity to invest in the Community Benefit Society (CBS).
- Reduced dependency on imported oil and LPG.
- Support for local businesses and organisations.
- A convenient alternative to oil boilers when these become unavailable.
- Reduced carbon emissions.
- Community control of the heat network and wind turbine allowing increased use of wind turbine electricity and expansion of the heat network should these be to the community's benefit.

Whilst the price of heat delivered would need to compete with the price of oil heating in order to attract funding and customers, it is not envisaged that significant discounts will be available initially. However, the scheme would be able to offer significant protection against future price shocks.

[7] *The Shropshire Hills Management Partnership never support planning applications, they only ever object or abstain.*

Other Community Energy schemes that benefitted from the Feed-in-Tariff have provided significant Community Benefit Funds (CBF) for schemes such as improving village halls, providing play equipment, setting up community orchards or providing energy efficiency assistance. Such CBFs are no longer to be expected from Community Energy schemes, certainly not in the early years. The finances of this scheme are fairly marginal and any surpluses in early years would be best spent on repaying some of the capital invested to reduce the burden of interest payments. Any further economic surpluses from the operation of the scheme would be best used to lower heat charges or invested to increase CO2 savings and/or improve energy efficiency. In this way the community will benefit directly from any surpluses generated.

6. Technology

This work was commissioned with the aim of further investigating the feasibility of a heat network for Bishop's Castle. Other renewable energy options have not been investigated, other than looking into the possibility of renewable energy sources to power the proposed heat pumps. Options to use biomass or ground source heat pumps as the heat source and using ambient loop system were discounted as a result of the initial feasibility work. Another option to utilise spare biomass heat capacity from Ransfords sawmill was discounted as this spare capacity is no longer available. The sewage works and a new data centre were both considered as warmer heat sources for the heat pumps, but these were not viable and so the lower efficiency ASHP was the selected option.

6.1. Air Source Heat Pumps

Air source heat pumps (ASHPs) take heat from the atmosphere, which is an unlimited resource as long as the cooled air can flow away from the heat pump. ASHPs have, in the past, had lower efficiencies than ground source heat pumps (GSHP) but the gap has narrowed as the design and specification of ASHPs has improved. ASHP systems have a much lower capital cost than ground source systems and, when included in a centralised heat network, are easier to power by a renewable energy source than ambient loop systems. ASHPs can also be combined with thermal storage allowing the system to use electricity when it's cheapest, either from a renewable source or when grid prices are lower (e.g. overnight). Whilst heat pumps are most efficient running at lower flow temperatures it is possible to run a higher flow temperature when required and hence remove the need for upgrading the radiators in every house on the system.

6.2. Renewable Electricity Source

The recommended air source heat pump system could be powered solely by grid electricity, but this is expensive, and the viability of the scheme suffers because of this. The sources of renewable electricity considered were wind and photovoltaics. Photovoltaic (PV) systems would need considerable land take to provide a significant proportion of the energy required and PV is not a good seasonal match with the energy demands of a heat network, with the PV peak summer period aligning with the lowest demand period for the heat network. Wind generated energy gives a much better fit with a heat network. Providing lower-cost electricity through local renewable generation improved the viability considerably in the earlier model, especially as the thermal store allows maximum use of the renewable power. Supplementing the suggested 900 kW wind turbine with PV panels would improve the viability further. A comparison of the estimated amount of locally generated electricity consumed by the ASHPs or exported to the grid is presented in Table 1.

A wind constraints study was carried out by Locogen in 2021[8] and two sites were identified, both to the east of the town. A 900 kW turbine on one of these sites received planning permission in June 2025.

Two sites for a solar array have been investigated, one south of the town and one just east of the A488. The eastern site is preferred as it is flatter land with less visual intrusion from a distance. A fairly small array by modern standards has been suggested. Most new commercial solar farms are now 20 to 50 MW, 40 to 100 times bigger than the proposed 500kW. However, it appears that issues with maintaining fault levels

[8] See appendix 2.

on the local grid mean that we can only install a maximum of 900kW of generation capacity until 2032 so the PV panels will not be possible initially.

	ASHP 785kW **Wind turbine 900kW**	**785 kW ASHP Wind turbine 900kW** **& 500kW PV**
% heat from ASHP	81%	83%
% of renewable electricity exported	51%	54%

Table 1 impacts of renewable electricity generation on large scale heat network

Figure 5 Wind turbine site

Figure 6 Illustrative space requirement for 500 kW of PV

6.3. Recommended Heat Source

The recommendation is for an air source heat pump of around 780 kW. This could provide over 80% of the total heat required each year. This proportion includes the use of a 180 m^3 thermal store as it greatly increases the hours that the heat pump can supply all the heat required. This thermal store could hold up to 5,200 kWh of heat. Oil boilers will be needed both as a backup and to allow for the occasions when the heat pump and thermal store are not sufficient to supply all the energy required. It is estimated that the oil boilers would supply under 20% of the total energy requirement. If a larger heat pump was installed it would be significantly more expensive and it would be underutilised most of the time. Additional heat pumps could be installed in the future if the scheme is extended or increased carbon saving were sought. The top-up/backup boilers could be electric instead of oil which would provide additional carbon savings, but the running costs would increase substantially.

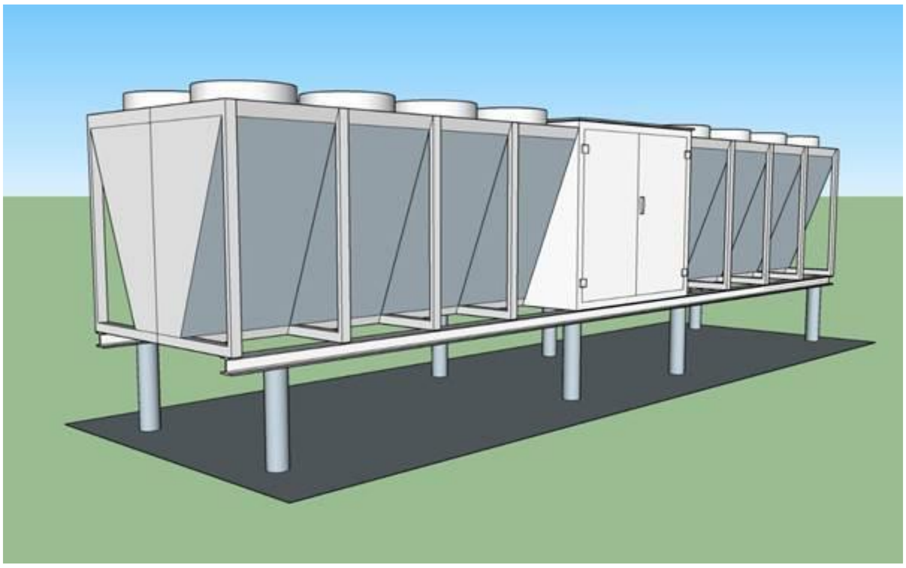

Figure 7 Indicative 827kW ASHP from Solid Energy, 11.6m long, 2.3m wide, 3.5m high.

For the large-scale heat network, it is recommended that two back up oil boilers are fitted, at least one of which should be a condensing boiler; the second one might be non-condensing if this is significantly cheaper as it will only rarely be used.

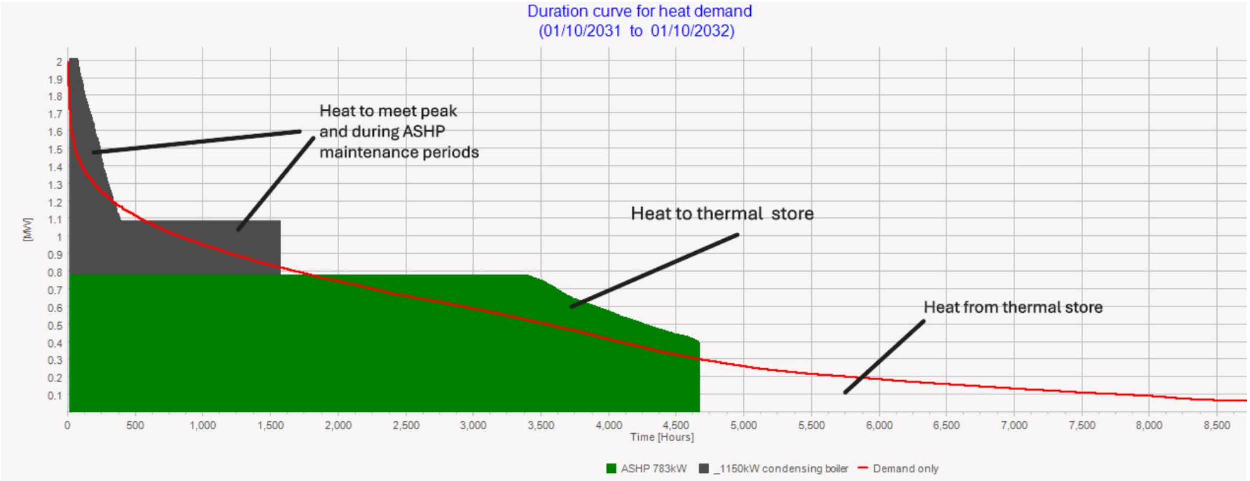

Figure 8 Heat demand supplied by heat pump, thermal store and back up boiler.
The areas above the red line show heat stored in the thermal store, the uncoloured area under the red line shows energy taken from the thermal store.
This figure does not allow for additional use of the oil boilers as a back-up in case of any maintenance issues with the heat pump.

7. The Heat Demands and the Opportunity

Understanding the heat demands is key to assessing the economic viability of a heat network; the higher the heat load in an area the more viable the heat network becomes. Understanding what existing heat sources the heat network would replace is essential to assess the current heating costs and determine the tariff required for the heat network to be competitive. Knowing which heating fuels are replaced also allows the environmental benefits to be assessed.

Bishop's Castle is a small town in South Shropshire with just under 1,900 residents in the Parish as a whole in 2014. There were 828 households and 898 dwellings[9]. Only limited new construction has taken place in the last eight years. 62% of households are owner-occupiers, 17% social renters and 21% private renters. 18% of householders are single person pensioners. There is a community college, a primary school, a Sports and Arts Centre (SpArC) with swimming pool and gym, a library/resource centre (Enterprise House), a Town Hall, two estates of small industrial units and Ransfords sawmill. There is a care home, a small cottage hospital and a doctor's surgery, several pubs, a hotel and a brewery, a parish church and parish hall. There is no mains gas supply in the area, so most heating is from oil or LPG boilers.

Within the area highlighted in Figure 9 there are:

Residential properties 898 of which 507 have an EPC

Commercial properties 185, of which 29 have non-domestic EPCs or a Display Energy Certificate (DEC - these only apply to larger buildings used by the public)

EPCs are Energy Performance Certificates which give details of heating system, levels of insulation and an estimate of the heat use. An EPC is required when a property is sold, rented out or has energy efficiency work undertaken that attracts a government grant.

'A' rated properties are the cheapest to run per square metre for heat, hot water and lighting, 'G' rated properties are the most expensive to run.

[9] *https://www.shropshire.gov.uk/media/3420/bishops-castle-parish-profile-2014-1.pdf*

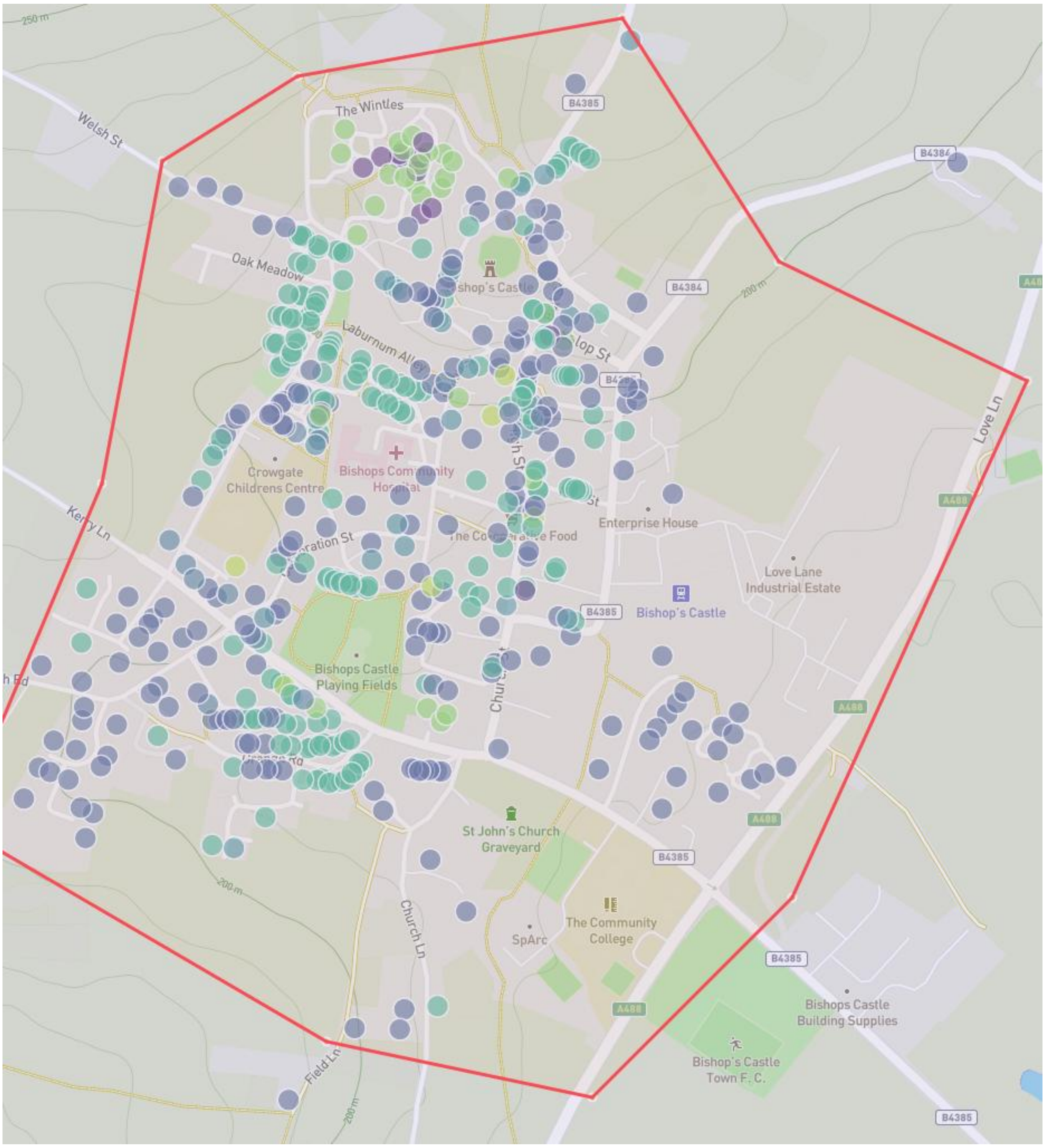

Figure 9 EPCs for Bishops Castle

The average home heat demand for the available EPCs in Bishops Castle is 15,300kWh of heat per year.

Prior to the energy price increases resulting from the Russian invasion of Ukraine the average gas use per house in England was around 14,000kWh (gas heats the vast majority of homes in UK and so gas consumption is a good representation of the average heat use). 14,000kWh of gas equates to around 11,200kWh of heat use. That Bishop's Castle has higher heat demand is probably due to there being a higher proportion of older housing than is the case across the UK and that EPCs overestimate actual heat use for the houses with the lowest energy ratings.

Older buildings will tend to be less well insulated and need more heat to stay warm. Older, typically pre-1930s buildings, will have solid walls rather than cavity walls. Solid walls lose more heat and cost more to add insulation to. For these reasons connecting solid wall buildings to a heat network brings increased economic and environmental benefits. Decarbonising through the supply of low carbon heat, helps avoid the need to insulate the solid wall. The least intrusive solid wall insulation option is external wall insulation, but this then covers the attractive stone facades that give towns such as Bishop's Castle much of their character. This is part of what the Bishop's Castle Conservation Area seeks to maintain. See Figure 10.

The EPC software assumes average occupancy for a property; if an occupier works from home or is housebound they are likely to use more heat than the EPC suggests.

There are also ways in which residents could be encouraged to make more use of heat from the network: by replacing electric showers with mixer showers; by using secondary heating (wood stoves and electric fires) less; and use of hot fill appliances. All of these would lower household energy costs and reduce pollution.

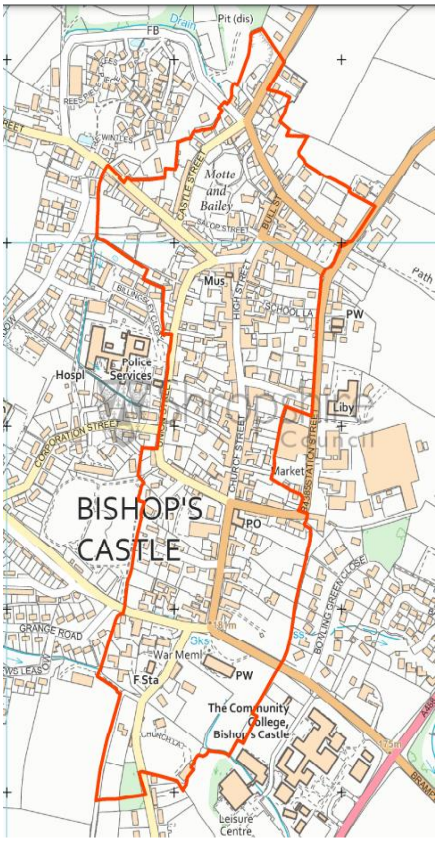

Figure 10 Bishop's Castle Conservation Area

7.1. Energy Performance Certificates Details (EPCs)

Of the 507 domestic EPCs on the register 122 (24%) are C-rated or better, 180 (36%) are D, and 205 (40%) are E, F or G-rated. However, there are nearly 400 properties without EPCs. These are likely to be at the lower end of the ratings so the total number of E, F or G-rated properties is likely to be significantly worse than this.

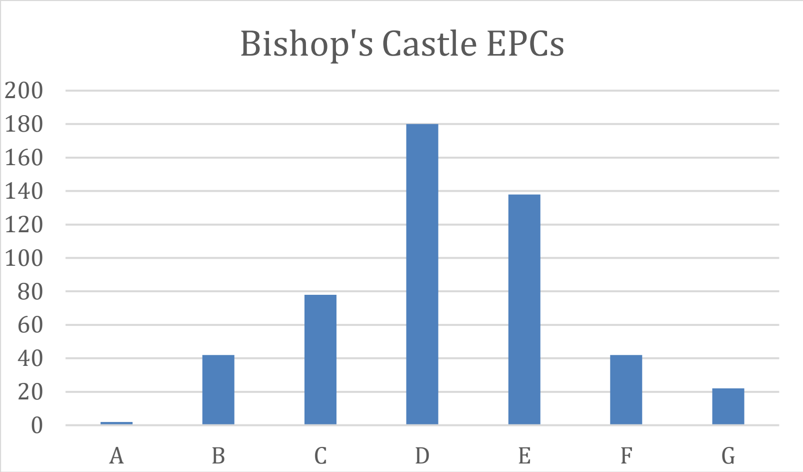

Figure.11 Bishop's Castle EPC ratings

Significant non-domestic heat loads

	Heat demand MWh/a	Number	Heat source	Data source
Enterprise House	48	1	Mostly AC unit + small oil boiler	DEC
Castle Hotel	289	1	Oil	Discussion with owner
SpArC	451	1	Oil	DEC
College	205	1	Oil	DEC
The Old School House	170	1	Oil	Discussion with owner
Other larger non-domestic/retail pub/hotel	620	18	Unknown - assume mostly oil	THERMOS and EPCs
Total	1,543	23		

Table 2 Non-domestic heat loads

In response to the very high cost of heating fuels the fuel use at both SpArC and the Community College has reduced since the first study. This decrease can be seen in the Display Energy Certificates with a 50% reduction at the College.

Heat loads assessed but not included:

- Enterprise House – this building is mostly heated via air conditioning units which are in effect air source heating (or cooling) pumps and so are already fairly low carbon. To replace the heating from these units, it would be necessary to install radiators, increasing the cost of utilising the heat network.
- Doctor's Surgery – This is a fairly modern building with relatively short operating hours per week. As a result, oil usage is fairly low, making it economically unviable to extend the heat network to this building.
- Stone House Care Home and the community hospital – These facilities are heated by a biomass boiler installed in 2015. The system is financially supported by the Renewable Heat Incentive (RHI) that makes payments for 20 years providing the boiler keeps operating. Therefore, this heat load is unlikely to want to connect to the heat network before 2035 at which time the heat network could offer a good source of low carbon heat.

7.2. Existing Domestic Heating Systems

The available EPC data for all of Bishops Castle has been analysed to provide Table 3.

	No of dwellings	% of stock	Average KWh/property	CO_2 per property kg/yr	CO_2 /kWh
GSHP	49	7.9%	10,000	613	0.061
ASHP	49	7.9%	10,200	670	0.066
LPG	36	5.8%	13,400	3,374	0.252
Oil	292	46.8%	18,400	5,801	0.315
Wood	8	1.3%	16,900	341	0.020
Coal/Smokeless fuel	7	1.1%	18,600	8,996	0.484
Electric	183	29.3%	13,400	2,466	0.184
Average				3840	0.27

Table 3 Current heating mix based on the EPCs for Bishop's Castle, with the electricity carbon factors given as an average expected over the next 20 years.

The 16% of houses already using heat pumps include several Housing Association properties connected to ground source shared loop systems – namely, 16 properties on Billingsley Close, 11 at Clive House, and 5 at Kerry Green. The air source heat pumps are concentrated in Grange Road (18 properties), 8 in Clove Piece, 4 in the Leys and 24 (recently built) in Oak Meadow. This information is not necessarily complete. EPCs are required when property is sold, let or to claim grants and are completed before the grant funded measure, such as the heat pump, is undertaken. Of the 675 EPCs issued, around 100 were carried out with the intention of applying for grant funding that could support the installation of a heat pump. As can be seen from Figure 12 most of the heat pumps are installed in the newer houses and Housing Association properties west of the town centre. This demonstrates that these types of houses are suitable for the installation of heat pumps.

Properties that already have heat pumps are assumed not to connect as they are already decarbonised and the investment in the heat pump is likely to be quite recent so there is no need to replace in short to medium term.

Cost of connection – the heat network would heat properties via radiators or wet underfloor heating system, so houses with these need few internal changes. Properties with electric storage heaters, wood burning stove and open fires would need radiators to be installed to use heat from the heat network.

Benefits of connection – no more oil and LPG deliveries and reduction in smells is seen by many as significant benefits. For properties currently using solid fuels the heat from the network has the advantage of being fully automatic with no active input required to maintain a warm house and hot water. For properties currently using electric heaters the heat network would offer significant savings.

Environmental benefits – the carbon savings arising from connection to the heat network are dependent on the current heating fuel. There will be significant improvements in the urban air quality if less wood, smokeless fuel and coal are burnt and for houses using these fuels there are likely to be significant improvements in the internal air quality if these fuels are used less. Reduced use of oil and LPG will also bring smaller improvements in air quality. Removal of oil tanks and deliveries will remove the risk of fuel leaks into the environment.

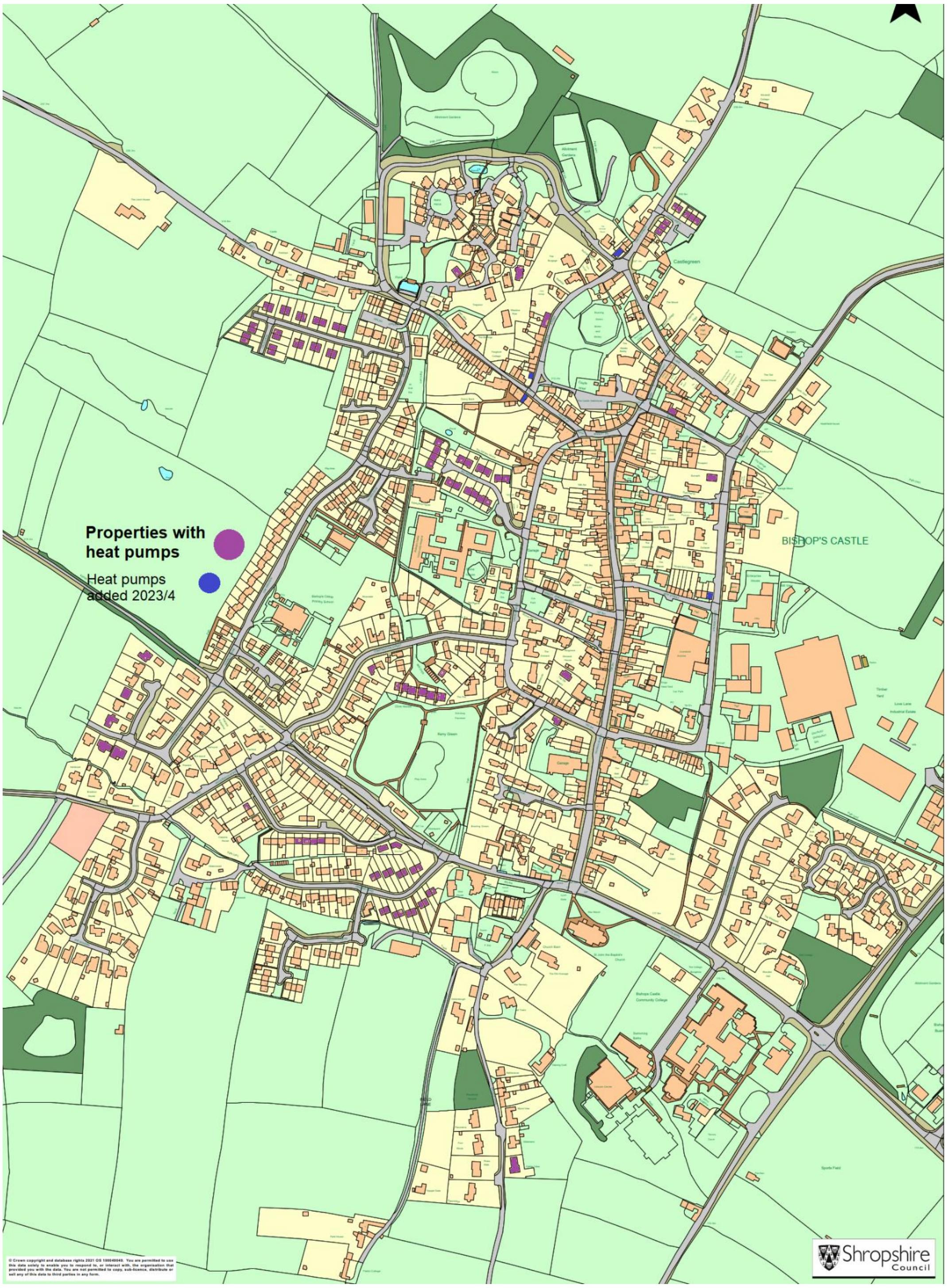

Figure 12 Map of existing heat pumps in Bishops Castle from EPC data (there may be more where a heat pump has been fitted but the EPC has not been updated)

7.3. Air quality improvements

As part of the recent studies a pollution monitor that measures the particulates in the air was installed in Bishop's Castle. Off-gas-grid areas such as Bishop's Castle, continue to use a wider range of heating fuels compared to areas with mains gas. Some of these fuels and the appliances they are used in generate a range of pollutants that are detrimental to urban air quality. The other main source of urban pollutants has been road vehicles, but these emissions have reduced significantly over recent years. Air quality has been improving over recent decades as heating has moved from coal, oil boilers have become cleaner and there have been large reductions from road vehicles. Now wood, coal, smokeless fuel and older oil boilers are the main sources of particulate pollution. Table 5 below indicates how much worse coal is in comparison with oil and LPG for all pollutant types. Recent research has been highlighting that the health impacts of particulates is greater than has been previously acknowledged. Particulates are abbreviated to PM_{10}, the 10 being the particle size being measured. The smaller the particle size the greater the concern. $PM_{2.5}$ is the measurement that is the default display on the Purple Air website[10]. Particulates are probably the local air quality pollutant that is of greatest concern to health.

The monitoring of particles in Bishop's Castle shows that whilst generally the air quality is satisfactory or acceptable there are times when it is poor. The installed PurpleAir monitor can be seen on-line at www.purpleair.com and reports the particulate pollution levels using the US EPA Air Quality Index (AQI). This is an air quality index created by the United States Environmental Protection Agency, and its goal is to convey health-based air quality information to the public.

(green)	**1 - 50**	Air quality is satisfactory, and air pollution poses little or no risk.
(yellow)	**51 - 100**	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
(orange)	**101 - 150**	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
(red)	**151 - 200**	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
(purple)	**201 - 300**	Health alert: The risk of health effects is increased for everyone.
(maroon)	**301 and higher**	Health warning of emergency conditions: everyone is more likely to be affected.

Figure 13 air quality index explanation

The air quality index measured in Bishops Castle between 26 September 2024 and 8 April 2025 (no data 24 November to 10 December) was:

Air quality index	**hours**
Below 50	3,474
51-100	721
101-150	31
151-200	5

Table 4 Measured air quality index in Bishops Castle

[10] https://www2.purpleair.com/

The lifecycle GHG emissions for traditional fossil fuels, as shown in Table 5, are taken from table 19 of the supplementary guidance to the HMT Green Book, which are the same as the Government emission conversion factors for greenhouse gas company reporting.

Emissions grams per GJ	**Coal**	**Smokeless fuel**	**Wood**	**Oil**	**LPG**	**Natural gas**
Benzene	22	7	58	0.05	0.3	0.2
CO	4,600	4,600	2,900	54	24	23
NOx	118	127	63	48	48	18
NMVOC	490	150	390	1	4	2
SO2	810	490	10	8	0.3	0.3b
PM_{10}	307	55	455	2	1	1
CO2 (g/kWh heat)	350	350	15	268	214	184

Table 5 Pollutants from different heating fuels[11]

The precise numbers and pollutant type as shown in Table 5 are not too important, the main purpose of presenting them here is to show how much worse wood, coal, and 'smokeless' fuels are than oil and LPG. Each coal fire or wood burning stove has an impact equivalent to hundreds of oil or LPG boilers for most of the pollutant types.

Natural gas figures are also included, as it is the UK's primary heating fuel and, while much cleaner than coal and wood, it is also significantly cleaner than oil. The pollution impacts of gas set the general national discussion on air quality impacts from heating, as gas is the most common fuel. The perceived cleanliness of gas has resulted in little attention being paid to the air quality impacts of heating. Table 5 simplifies the actual situation as the appliance the fuel is burnt in has a large impact on the actual emissions in use. Table 6 indicates the range of particulate emissions from wood burning in different appliances.

Wood burning emissions	**Range of $PM_{2.5}$ grams/GJ**	**Notes**
Open fireplace	440-1760	
Conventional stove	370-1480	
High-efficiency stoves	285-740	
Advanced/ecolabelled stoves & boilers <50 kWth	19-233	
Wood/woodchip boilers < 50 kWth	235-940	Data from 2003-2008 so probable improvement since then,
Pellet stoves and boilers <50 kWth	30-120	

Table 6 impact of appliance type on particle emissions from wood burning.

[11] *Evidence Gathering for Off-Gas Grid Bioliquid Heating Options Final Report Prepared for BEIS, BEIS Research Paper no: 2019/020*

The emission limit for boilers receiving the RHI is 30g/GJ, so the wood pellet boiler at the community hospital will be much cleaner than most other wood burning appliances in Bishop's Castle.

Table 6 is data from testing, most typically under optimum combustion conditions. It is highly likely that actual emissions will be higher, for example, damp wood will significantly increase emissions. More processed fuels such as wood chip and especially wood pellet will have lower emissions and lower variability as the fuel is more consistent in size, moisture and quality, all of which allow the boilers to be designed to achieve much greater control of the combustion process to enable optimum combustion conditions.

In summary, combustion is a very variable process leading to wide range of emission levels. Woodchip and pellet boilers are cleaner; woodburning stoves that are 'Clean Air Act Approved' or the newer 'Eco design' certified will be less polluting, but still many times worse than oil or LPG for all but CO_2.

There is a similar, but much smaller variation in emissions outputs from oil and LPG boilers since over time, regulation has resulted in lower NOx outputs from boilers and for oil boilers a reduction in particulates. Older oil boilers can be problematic as they have very long lives and so may not get replaced, despite newer boilers being significantly more efficient and cleaner burning.

The Heat Network would enable the removal of wood and coal burning and older oil boilers in many houses which would bring improved local air quality to Bishop's Castle in the winter months. This should benefit the health all of residents of Bishop's Castle and especially those who stop using wood and coal as often air quality in homes with stoves and open fireplaces can be far worse than the external air quality.

8. Assessing the Large-Scale Heat Network

THERMOS software[12] has been used to assess the optimum size for the heat network. It is challenging to develop an economically viable heat network and so the buildings that the heat network is designed to serve must be the ones that deliver the best economic result. THERMOS is a modelling tool designed for this purpose. THERMOS works by estimating each building's heat demand from the area of each building (from the map) and the height of each building from LIDAR data (a dataset of measurements from a satellite).

Where better data is available, such as from EPCs, this has been used to override the THERMOS heat demand estimate. Work undertaken by Carbon Alternatives for DESNZ has assessed the accuracy of the THERMOS estimates and, perhaps unsurprisingly, found that it tends to underestimate the heat load of the oldest houses while overestimating the heat load of newer, more thermally efficient houses. Conversely, analysis carried out by Sharenergy shows that a house with an E, F or G EPC rating is unlikely to use as much heat as the EPC estimates, as residents typically tolerate lower internal temperatures than the EPC assumes in order to keep the heating costs affordable. These insights have been incorporated into the changes made to the THERMOS heat demand estimates where applicable.

The earlier study used the OpenStreetMap (OSM) as the base map. In OSM buildings are typically drawn on to the map by volunteers drawing shapes around the buildings as seen in on-line aerial photos; this is not that accurate and makes the identification of the number of buildings in a terrace difficult. For this study the Ordinance Survey base map has been used. On the OS map the building sizes are more accurate as is the division of larger buildings into individual residences.

THERMOS has been set to not connect to houses that already have heat pumps.

[12] www. THERMOS-project.eu

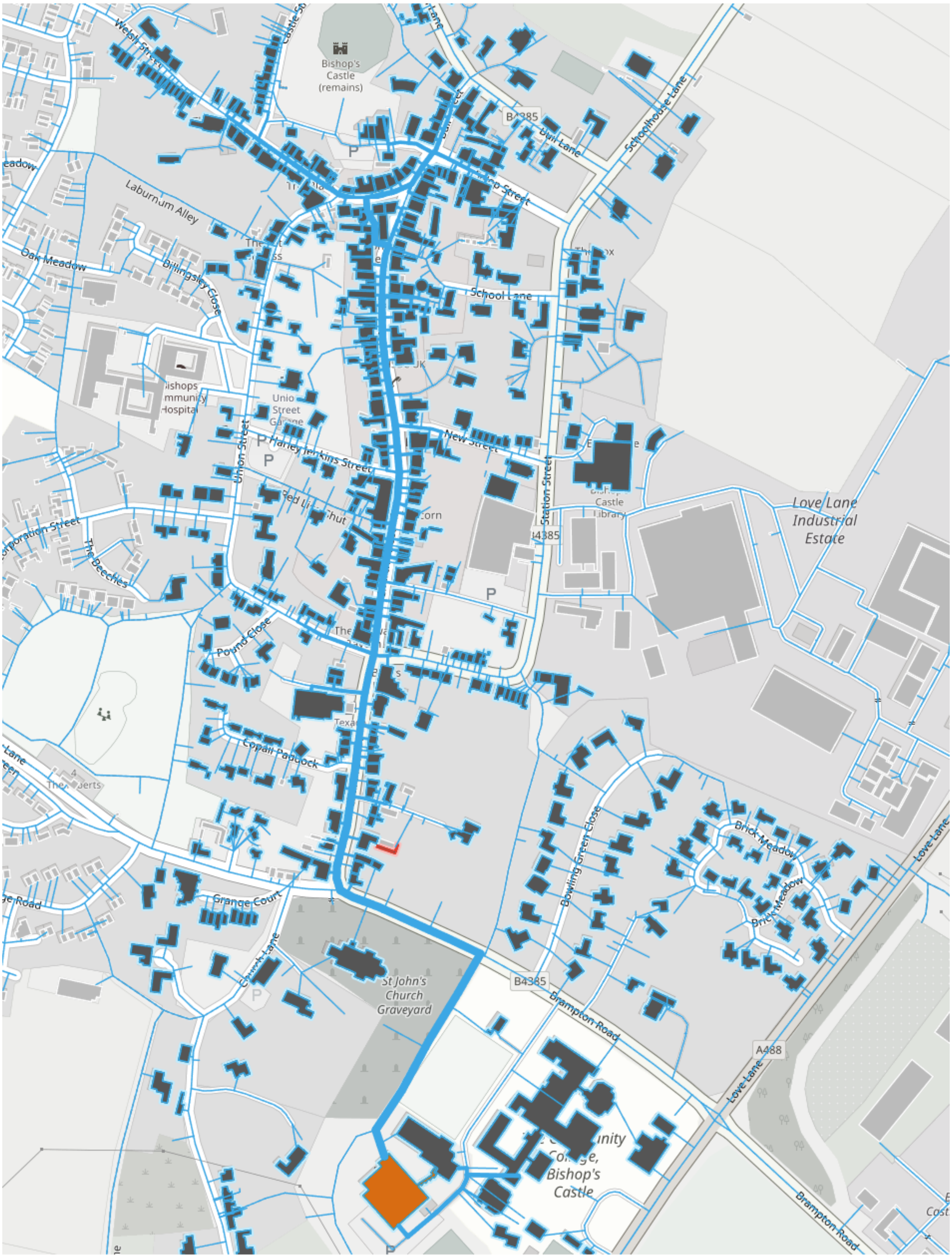

Figure 14 Buildings and paths considered by THERMOS for connection (SpArC is orange building at the bottom of the map)

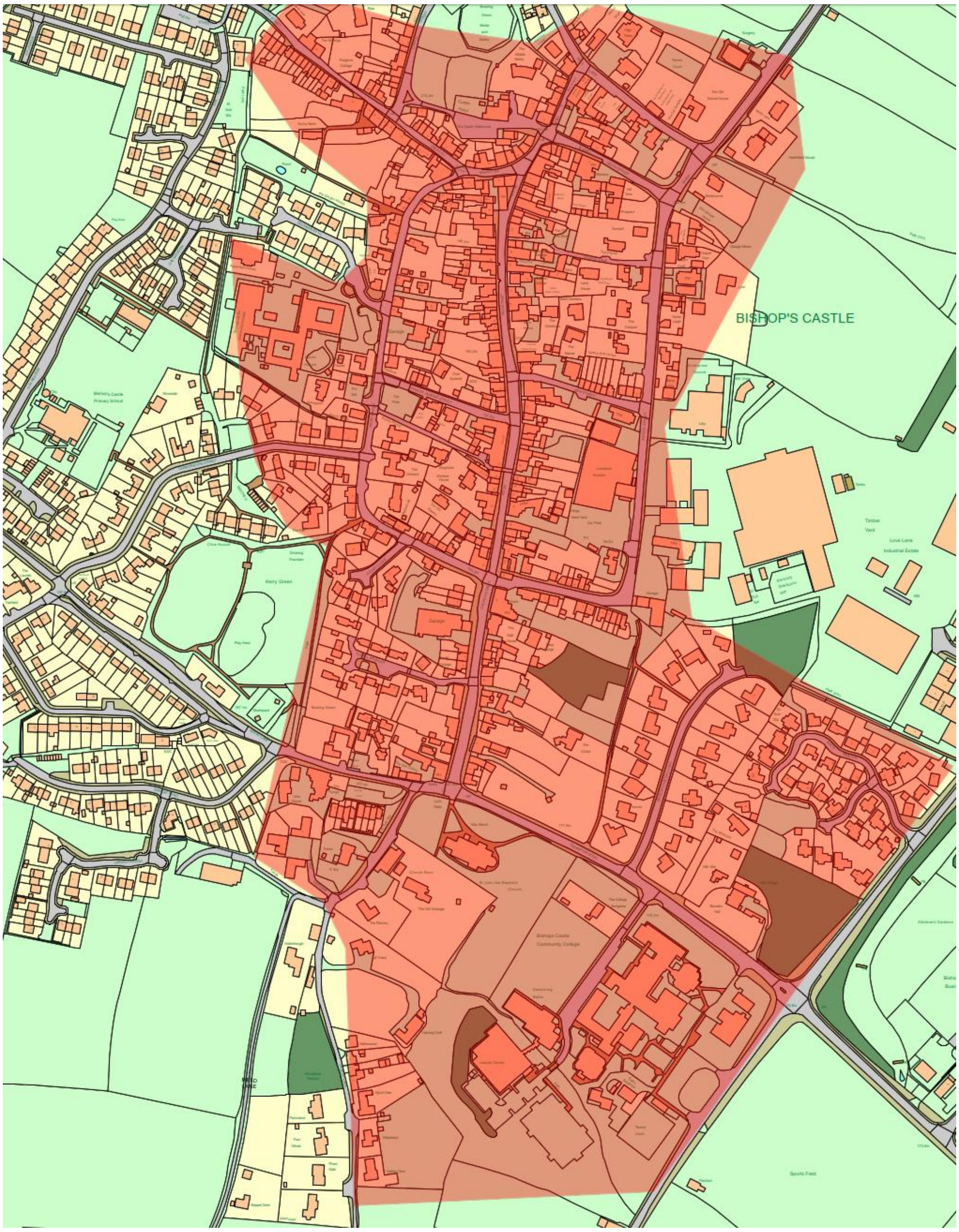

Fig 15 Proposed Network Area

THERMOS takes significant computing power to run, so the number of buildings it has been set to assess has been limited. The scope of this limitation is informed by previous modelling, and has primarily excluded newer, more widely spaced houses. These areas typically require more pipework per property - so capital cost per house increases - and have lower heat demand, resulting in reduced revenue potential. Additionally, the presence of already installed heat pumps creates areas with no relevant heat load e.g. on Corporation St, Billingsley Close and Grange Road.

With the annual heat demand estimates THERMOS assesses the economics of each building that could connect to the network. It considers how much revenue each extra connection would generate in heat sales and standing charges and how much capital would need to be spent to make the extra connection. THERMOS estimates possible pipe routes and assesses the length and size of the pipe needed to connect the loads. From this information THERMOS estimates the capital costs. THERMOS has preset costs for heat network pipework though we have overridden these in our financial model. The energy centre location has been set in THERMOS to be at SpArC.

The individual building heat load, low prevalence of heat pumps and the higher density of the heat load along Church St/High St have led the THERMOS assessment to focus the heat network on these streets.

The proposed network, as assessed as economically viable by THERMOS using mostly default assumptions for heat network pipe capital costs and a fixed heat generation cost is shown in Figure 16.

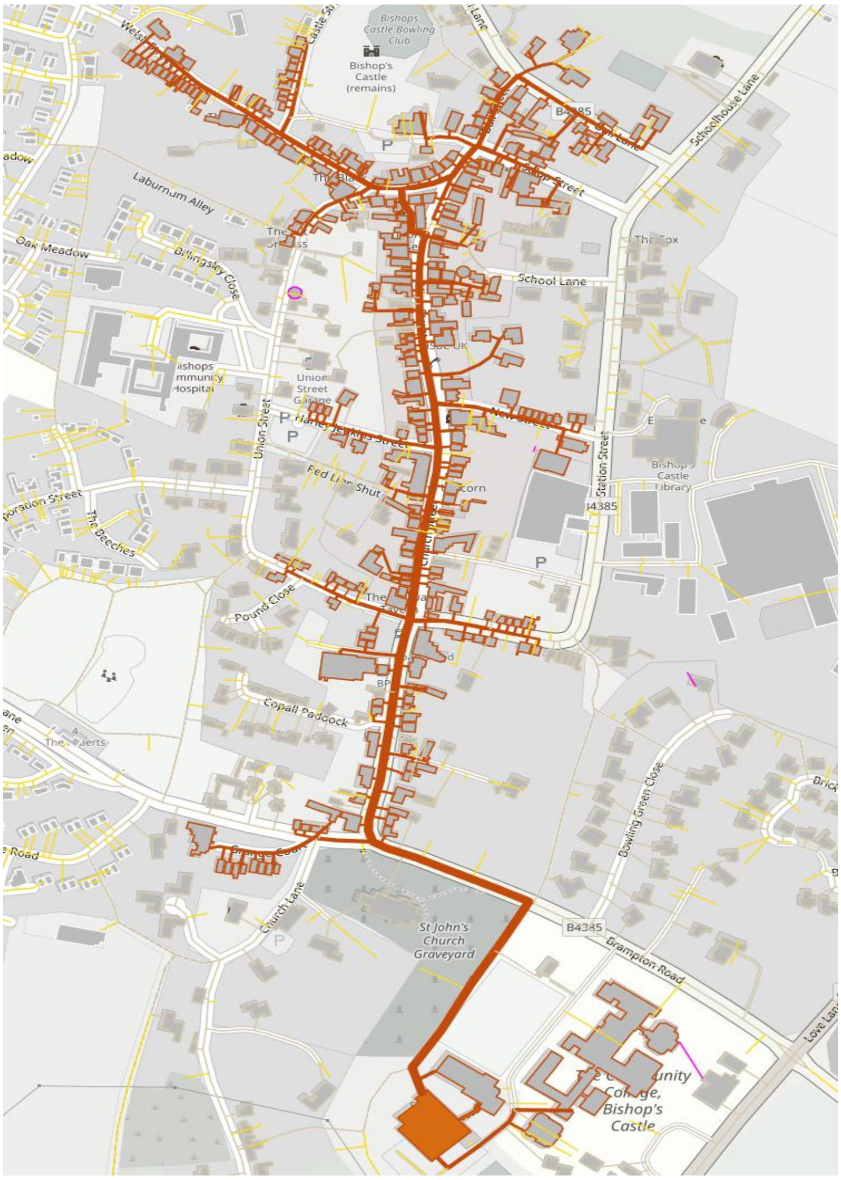

Figure 16 Proposed large-scale heat network (SpArC is the orange shape at the bottom of the map)

To explore what network is viable the economic parameters in THERMOS can be changed. In this modelling the cost of heat generation has been varied to find how the optimum network grows and shrinks as fundamental economics of heat networks vary. Changing the heat generation cost also mimics the other issues that change the fundamental heat network economics e.g. higher or lower capital costs, lower or higher heat selling prices. If the heat were a little cheaper (or other factors changed to improve the underlying economics of the heat network) the optimum economic network would grow to that shown in Figure 17.

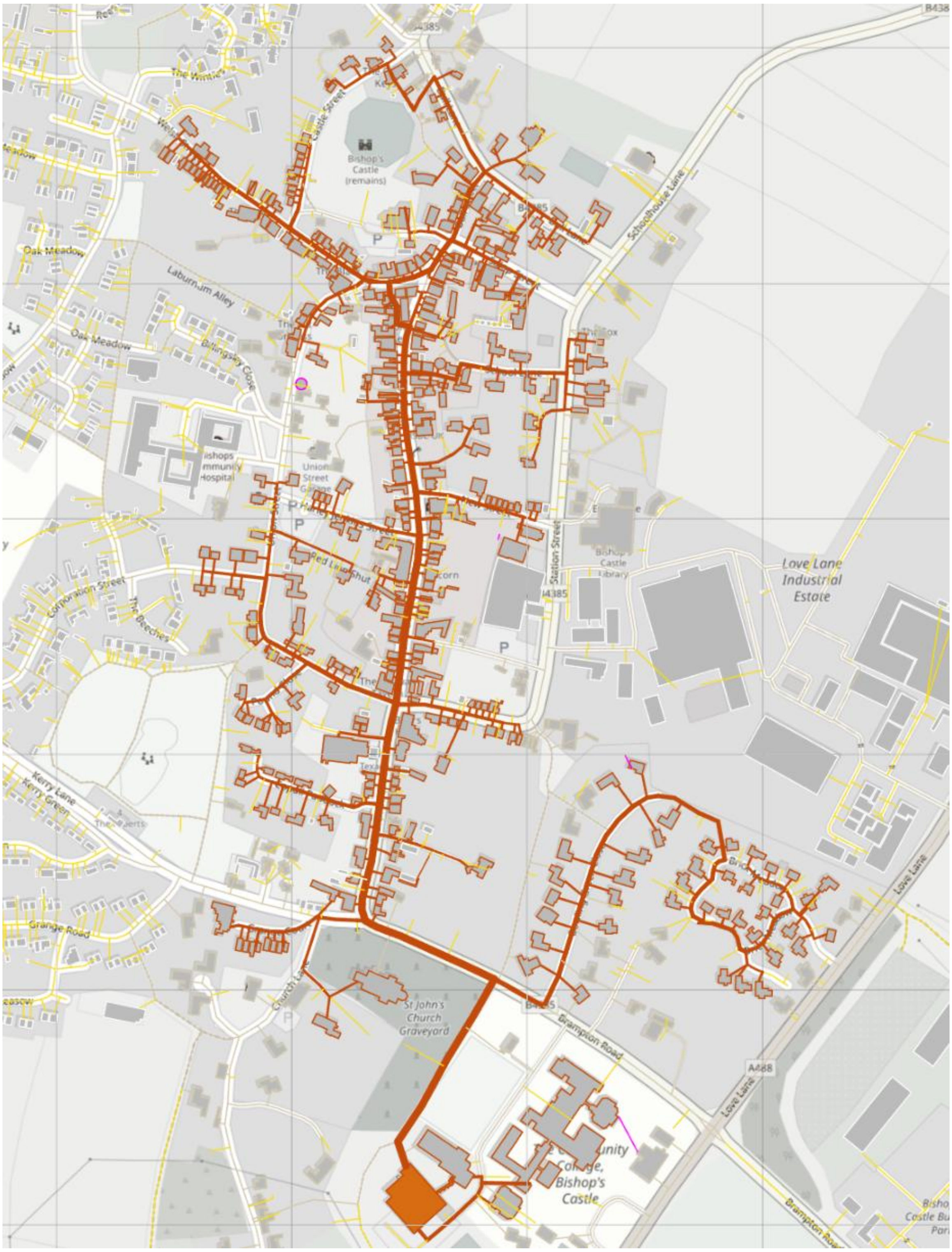

Figure 17 Optimum heat network if heat generation cost 15% lower than for proposed network

It is suggested that the pipes installed for the initial network should be sized to accommodate the loads of this larger network.

A smaller network could be more economic, as shown in Figure 18, but this would supply less of the Bishop's Castle heat demand and the economics are not a true representation of reality as the energy centre costs do not fall linearly with heat output – something the THERMOS assessment does not fully evaluate.

In essence, these THERMOS outputs show which properties to connect in order to achieve the best economic returns for that amount of heat delivered, demonstrating where the initial network should focus and where the greatest economic expansion is. Knowing where future expansion is most likely allows the pipework installed for the initial network to be sized to allow for network growth in the most economically advantageous areas.

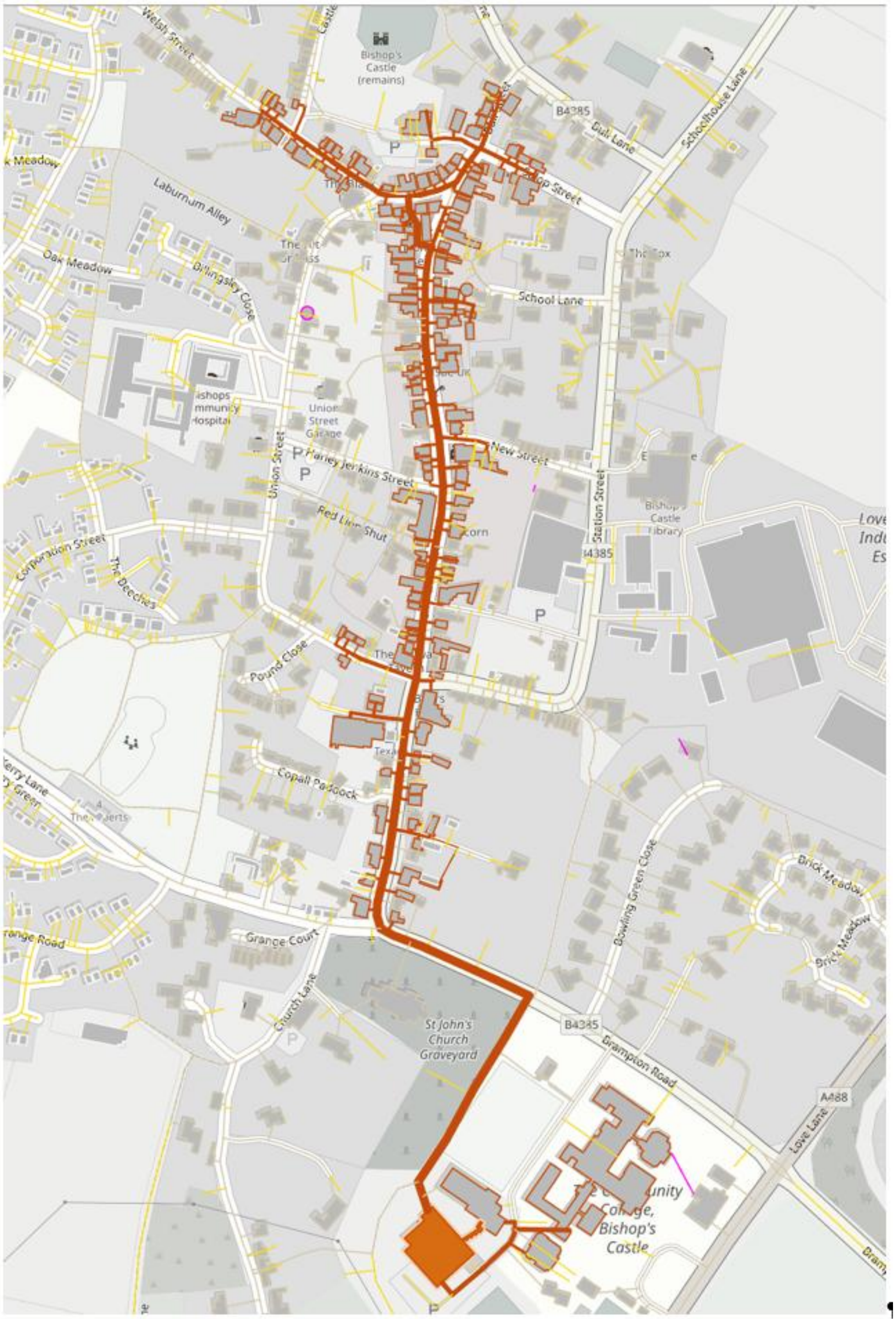

Figure 18 Heat network if heat generation cost is 10% higher than for proposed network

The average heat demand of the houses connected to the proposed network is 18.1MWh/yr and the average of the houses in the wider assessed area is 14.2MWh/yr.

As shown in Figures 19, 20 and 21 the housing supplied by the proposed heat network has lower EPC ratings, a higher proportion of solid walls and is older on average than the rest of Bishop's Castle. These older houses tend to be of attractive stone construction for which wall insulation would result in loss of the traditional character of the houses and the area. With significant improvement in fabric insulation being difficult, provision of a low carbon heat source is an effective route to decarbonisation.

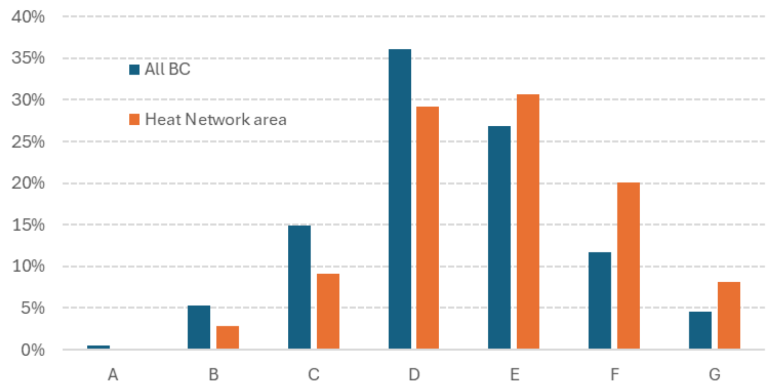

Figure 19 EPC rating of Bishop's Castle dwellings and those on proposed heat network

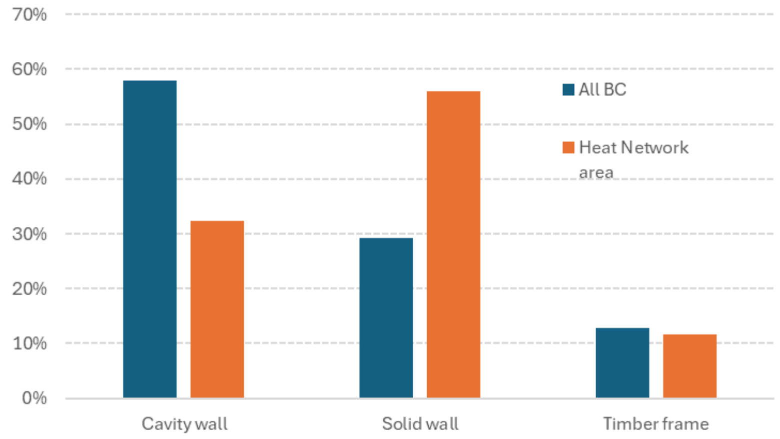

Figure 20 Wall construction

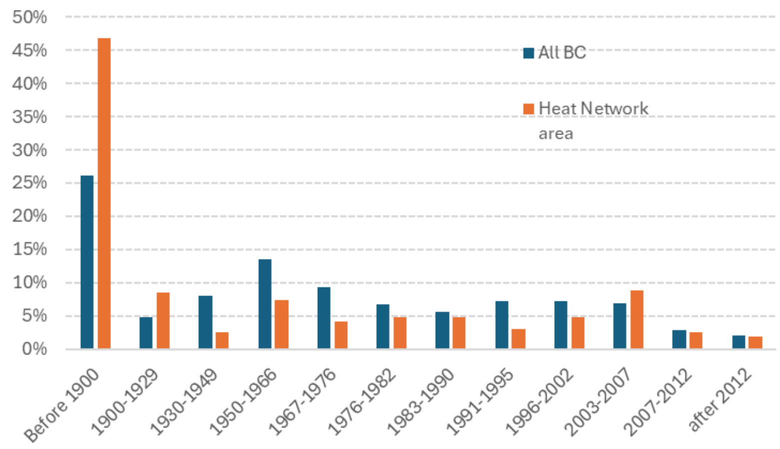

Figure 21 Age of houses

8.1. Technical Constraints on the Heat Network

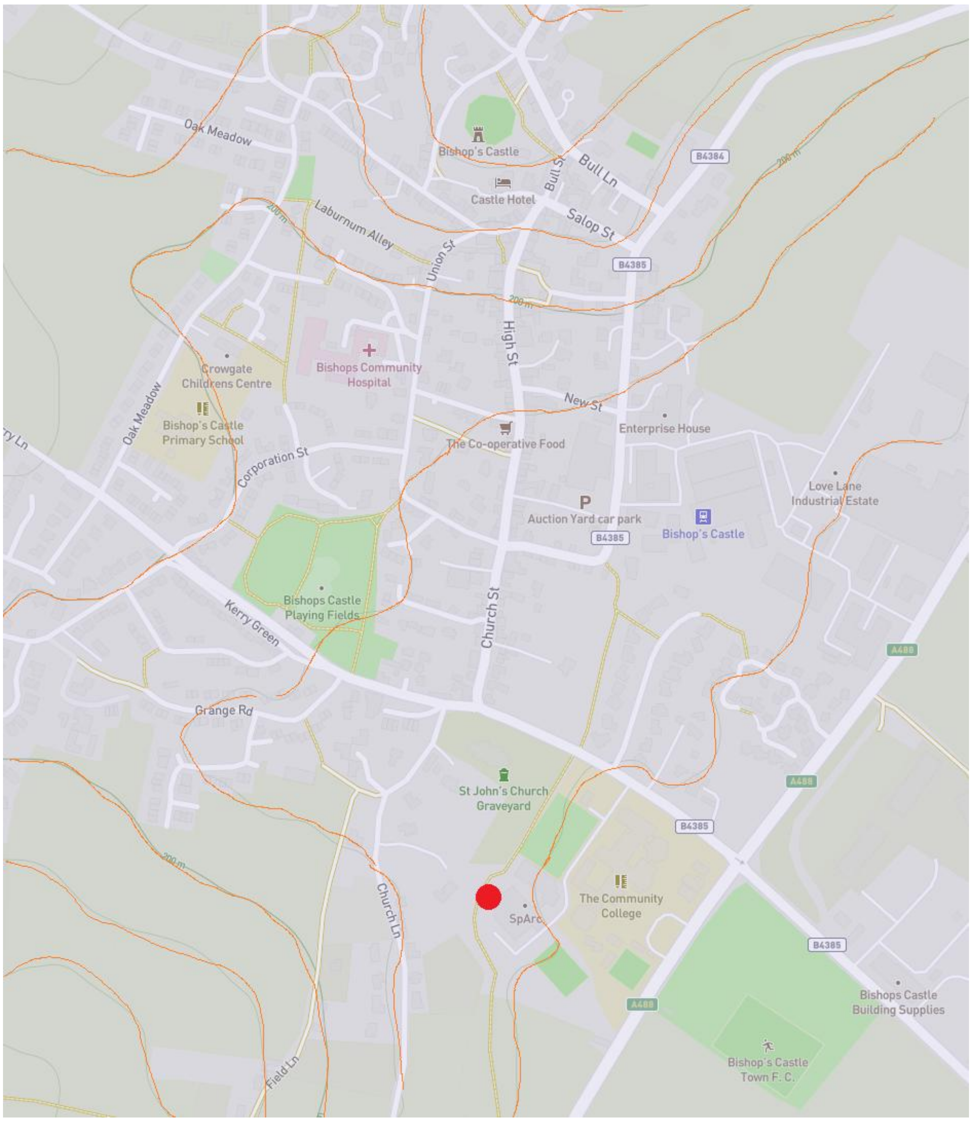

Figure 22 Map with contours at 10m meter interval emphasised (red spot is the proposed energy centre)

Bishop's Castle is on a hill which results in higher pressures in the heat network pipework lower down the hill compared to the pipework at the top of the hill. For every 10 metres of height difference the static pressure increases by 1 bar. Typical commercial heating and hot water equipment is rated at 6 bar. At the highest point in the heat network there needs to be a minimum pressure of 1 bar. At the energy centre, likely to be at SpArC which happens to be at the lowest point of the network, there will be pumps which will add around 1-1.5 bar to the pressure in the flow pipe.

The contour just above the Castle Hotel is 40m (4 bar) above the energy centre location; adding 1 bar static pressure and 1.5-2 bar for the pump results in a pressure of 7 bar. 8 bar rated equipment has only a very small cost premium and so this is suggested, but it is also recommended not to extend the network further up Castle Street or Bull Lane than is shown in Figure 17, to ensure the maximum network pressure remains under 8 bar with a comfortable margin.

The underground heat network pipework and its installation is the largest cost element in the heat network project, and such work typically has a high risk of being more complex than anticipated and hence more expensive. The risks are due to it being common to find unexpected other utilities in the ground when trenches for the pipes are being dug. Working around unexpected issues increases the complexity of a project and can be expensive if work has to be stopped whilst a solution is found. Due to these risks, it is rare to find a contractor who will offer a fixed price for installing heat network pipework; if they do a very large risk margin will be built into the price.

To try and minimise these uncertainties, a study has been undertaken to assess the number of buried utilities and other potential hazards along the possible routes for the heat network pipework. This enables a better understanding of the possible risks to installing the pipework and gives scope to change the pipe routes to avoid the areas that are most challenging to install pipework into or change the routing so that only smaller pipework runs through problematic areas. Smaller pipework can be more flexible which makes it easier to install around other buried utilities.

The study of heat network pipe routes reviewed:

- Buried electrical cables.
- Water and sewage pipes.
- Buried telecoms cable.
- Available archaeology information.

This information was shared with the contractor pricing the heat network installation.

Figure 23 presents high-level survey findings on which routes pose greater challenges for installing heat network pipework.

Figure 23 Indication of which routes are more challenging to install heat network pipework - red most difficult.

The most challenging finding from the assessment of pipe routes is the difficulty at the southern end of Church Street, where in addition to the usual utilities there is a culverted stream. This is additionally problematic as some of the larger diameter pipes would ideally run along this section of road.

Permissions to install heat network pipe in the road are needed, as heat network companies, unlike the conventional utilities such as water and gas, currently don't have rights to dig up the road. Heat networks regulations due to come into force in early 2026 will extend those rights to heat networks, however it is acknowledged that there will be a large administrative burden to get this accreditation and as such it will only be suitable for the larger heat networks. Options suitable for smaller organisations are being considered. Part of the regulations for Heat Network Zoning addresses these issues and so there is an expectation that getting the permissions will be easier as the detail of the Zoning regulations developed and put into law. This is not an insurmountable hurdle especially as Shropshire Council is supportive of the scheme.

8.2. Pipework Costs

3D Technical Design were commissioned to review all the available utilities maps, archaeological records, review from google street view and video showing the manholes and other features which help assess the locations of existing utilities. With this information alternative pipe routes can be investigated.

Steel pipe expands and contract as the network changes temperature and the pipe design need bends or doglegs to accommodate these changes in length without putting excessive stress on the pipe and pipe branches. Plastic pipe is more flexible than steel for the smaller pipe sizes and there is less expansion, but the plastic pipe can be more expensive than steel and has a significantly lower lifetime at higher temperatures and pressures than steel pipes provide. With Bishops Castle being on a hill the static water pressure in the pipe at the bottom of the hill is close to the limits for most plastic pipes.

The network expanse was assessed using THERMOS with its in-built heat network pipe prices reduced to take account of the contribution from the GHNF. This allowed Thermos to assess the economically viable network size with the benefit of GHNF. Thermos also estimates the required pipe sizes.

3D TD were then asked to assess the installation challenges and risks for the area identified by Thermos for the larger heat network. 3D TD also provided estimates of the range of costs for the DH pipe installation. The outputs of both THERMOS and 3D TD were then given to Vital Energi to price for the heat mains installation. Vital Energi are one of the UK largest heat network design and build contractors.

The Vital Energi costs received were considerably higher than the THERMOS estimates. Reheat were then contacted to question the basis of the significantly lower pipe costs they used in the recent CARES heat network feasibility studies they have been undertaking across Scotland. Reheat indicated that they are confident of the prices they have used as they are based on contractor costs. On this basis Reheat were then engaged to assess the heat network pipe costs for Bishop's Castle.

The final connections, for the pipe from the heat network pipe in the street into each house, are even harder to price. The industry has very limited experience of retrofitting heat networks to existing individual houses and there was a general reluctance to provide costs for this.

The range of costs provided are very wide:

	Thermos	Reheat	Vital Energi	3D TD
Heat main average £/m	1073	930	1891	1726
Final house connection £/m	545	498	1925	875

Note, The Thermos price is the full Thermos price (not the lowered prices used in the network size assessment which factored in the benefits of GHNF).

The different quotes can be difficult to directly compare as there are many different costs that can be included / excluded e.g. design, contingency, project management. The pipe sizes vary a little too between the quotes but from table 7 it can be seen that the type of dig has more effect on price than the pipe size.

Estimated Pipe Installation
Cost Summary - 2024 Pricing

2024

	2024 Estimated Excavation and Installation Rates, adjusted with average construction output index											
Assumed Depths	**Pipe size**	*** Typical £/m for budget purposes**	**Highways - Main Dual Carriage**	**Highways - "A" Road**	**Highways - Minor Main Road**	*** Highways - Residential Road**	**Highways - Footpath/Verge**	**Non Highways - Road**	**Non Highways - Footpath/Verge**	**Soft Excavation**	**Low Rate**	**High Rate**
1.2 m	DN40	£ 1,094	£ 3,268	£ 2,043	£ 1,736	£ 1,094	£ 1,094	£ 985	£ 875	£ 875	£ 875	£ 2,043
1.2 m	DN65	£ 1,094	£ 3,268	£ 2,043	£ 1,736	£ 1,094	£ 1,094	£ 985	£ 875	£ 875	£ 875	£ 2,043
1.2 m	DN80	£ 1,094	£ 3,268	£ 2,043	£ 1,736	£ 1,094	£ 1,094	£ 985	£ 875	£ 875	£ 875	£ 2,043
1.5 m	DN100	£ 1,094	£ 3,268	£ 2,043	£ 1,736	£ 1,094	£ 1,094	£ 985	£ 875	£ 875	£ 875	£ 2,043
1.5 m	DN125	£ 1,313	£ 3,735	£ 2,334	£ 1,984	£ 1,313	£ 1,313	£ 1,182	£ 1,050	£ 1,021	£ 1,021	£ 2,334
1.5 m	DN150	£ 1,641	£ 4,377	£ 2,736	£ 2,325	£ 1,641	£ 1,641	£ 1,477	£ 1,313	£ 1,131	£ 1,131	£ 2,736
1.5 m	DN200	£ 1,970	£ 5,252	£ 3,283	£ 2,790	£ 1,970	£ 1,970	£ 1,773	£ 1,576	£ 1,386	£ 1,386	£ 3,283
1.5 m	DN250	£ 2,189	£ 5,836	£ 3,648	£ 3,100	£ 2,189	£ 2,189	£ 1,970	£ 1,751	£ 1,605	£ 1,605	£ 3,648

Table 7

Reheats costs were used for the financial model, but the scheme was still very marginal financially with insufficient headroom to cover the risks involved when laying pipes in congested streets.

However, as more heat network pipework is installed costs should fall as there is more experience and a wider and more competitive contractor pool. The use of plastic pipe requires significantly less skill which opens up the opportunity for more local contractors to train up to undertake the installation, with only minimal lengths of steel pipe being installed by more experienced contractors. Ideally some innovation type funding will be sought to identify ways to reduce costs and to work with contractors to better understand where processes could be simplified.

8.3. Heat Network Pipework

Pre-insulated pipes where insulation is bonded to either plastic or steel pipe are both commonly used in heat networks. The differences between the pipes are:

Feature	**Preinsulated Plastic Pipes**	**Preinsulated Steel Pipes**
Material	Plastic (HDPE, PE-X)	Steel with corrosion-resistant coatings
Pressure and temperature rating	Much shorter life at higher temperatures and pressures	Higher temperatures and pressures do not affect pipe life
Ease of installation	More flexible, easier to install in complex areas	Rigid, can be more difficult to install
Corrosion Resistance	High, no corrosion concerns	Requires additional corrosion protection (e.g., coatings)
Jointing	Typically uses mechanical joints that need lower skill levels to use	Pipe is welded, needing highly skilled welders
Thermal Insulation	Good, with polyurethane foam insulation	Good, with polyurethane foam insulation
Leak detection	No	Yes
Cost	Pipe cost typically higher than steel but installation costs lower. So site specific as to whether steel or plastic is cheaper	

Table 8 Comparison of the properties of pre-insulated plastic and steel pipes

In addition to the plastic or steel options the other common option is 'Aluflex' a plastic pipe with an aluminium layer in the plastic pipe construction. This is more expensive but allows higher temperatures and pressure with a long operating life.

Pipework configuration

There are 2 options of how the heat network flow and return pipes are insulated.

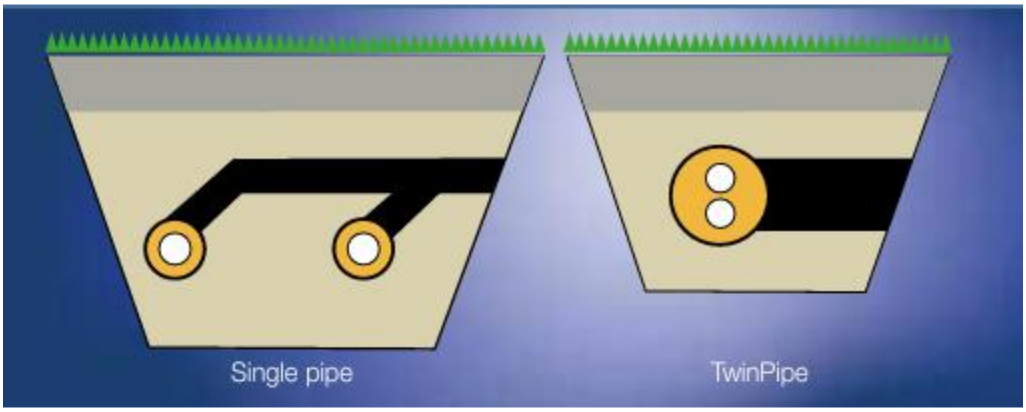

Figure 24 Single and twin pipe compared

Twin pipe loses around 40% less heat than a pair of single pipes and needs a narrower trench, which reduces installation costs. As the pipe sizes get larger the pipe become increasingly less flexible, and the welding of larger steel twin pipe is more challenging. The final variable is the thickness of the pipe insulation. The larger steel pipe manufacturers typically offer 3 levels of insulation, Series 1 to 3 with Series 3 having the highest insulation values but costing more and having a larger overall pipe diameter.

The pipe selection for Bishop's Castle would use:

- Pairs of single steel pipes for the larger pipes nearer the energy centre. This is easier to install than twin pipe since the overall outer diameter of twin pipe, containing two 150mm diameter pipes, is 500mm which is hard to manoeuvre and install,
- Steel twin pipe as the pipe size drops below around 60mm diameter for the inner pipe. At this size the challenges of installing twin pipe are fewer and the pipe can be curved a little to ease real world installation where absolutely straight pipe runs are very hard to achieve.
- Below around 50mm use plastic/Aluflex twin pipe (depending upon the static pressure at that point in the network). House connections, typically using 20 or 25mm pipe, can be made in unjointed lengths of plastic twin pipe between the heat main running up the road and entry into the house. If tappings are preinstalled on the heat main for each house this will lower the required skill level to install individual house connections. The aim would be to enable a locally based contractor to undertake these final house connections.

The optimum insulation level is an economic balance between higher capital cost for more insulation against lower operating costs as less heat is lost. With much of the electricity for the heat pump coming from the wind turbine the financial and environmental cost of the heat is lower than in many heat networks, but raising the capital is challenging so it is likely that Series 2 levels of insulation would be the economic optimum.

Pipework installation

More than half of the cost of the installation of heat network pipework is the digging and reinstatement of the trenches for the pipes. Trenches can be 'hard dig' or 'soft dig'. Hard dig is where the pipe is installed in a surfaced road or pavement and soft dig where the pipe is installed in a verge or field. Soft dig can be 20-40% cheaper as digging and reinstatement of a grass surface is much easier than for a tarmac road surface. Not digging in the road also lowers costs as there is no need for traffic management. Unfortunately, most of the trenching in Bishop's Castle would be hard dig.

8.4. Connections into the Properties

To connect each property to the heat network, pipes will need to be installed between the heat network pipe running along the road and the heating system in the house. These pipes will need to be buried where they pass through the front garden, where there is one, and an appropriate place found to enter the house. For houses with a basement this is much easier, and the pipes would enter the basement at the most convenient point and then run across the basement to the nearest point to the current boiler.

The village of Swaffham Prior, near Cambridge, is the best UK example of the retrofitting a heat network to existing low rise housing. The photos below show the connection of the heat network to a house.

Figure 25 Photos of house connection in Swaffham Prior

The actual connection between the heat network and the property is via a Heat Interface Unit (HIU, also known as a Hydraulic Interface Unit) which would be installed. The HIU is usually located where the boiler is currently installed, as this is where there should be space and should be the simplest location to connect to the heating and hot water systems.

However, if the boiler is currently outside or in an unheated shed etc, the HIU would be better located somewhere inside, away from any risk of freezing. Unlike a boiler an HIU has no ventilation or flue requirement, is quiet and doesn't smell so it is much more pleasant to have inside the house and there are fewer restrictions as to where it can be located. An ideal location is in a basement as it will be easy to connect to the heat network pipes in the road/pavement outside. Of the 15 properties we have studied more than half have either a basement or boiler room to the side of the property where we could easily make our connection.

The HIU is about the size of a gas combination boiler and is wall mounted, and needs a mains electricity supply to power the circulation pump for the property's heating system and the HIU controls. They typically have a white metal cover or a grey polystyrene cover (tougher than standard polystyrene).

The HIU will contain a heat meter which calculates the heat taken from the heat network. The heat meter will be read automatically, and the data collected will allow bills to be generated and also help diagnose system and HIU faults.

8.5. Hot water supply using the HIU

To supply hot tap water the HIU can either:

1. Supply heat to an existing hot water cylinder in the same way as the current boiler.
2. Generate hot water instantaneously as and when a hot tap is turned on, so no hot water cylinder is needed.

The instantaneous option means any header tank in the loft would need to be removed. The hot water would then be supplied at the cold-water mains pressure – which should give an improved shower. The removal of header tanks from attics has several small benefits: less scope for contamination of domestic hot water (DHW), fewer pipes to freeze, more space in attic, can fully insulate ceiling (typically the area under a header tank is not insulated to help prevent the tank freezing in cold weather).

The instantaneous hot water option may fill a bath slightly slower than is the case with a hot water cylinder, but hot water is unlimited as there is no delay whilst an empty hot water tank heats up again.

For houses with larger hot water demands, higher output HIUs can be installed to provide for higher required flow rates e.g. if there are multiple bath/shower rooms.

Ideally an instantaneous hot water HIU would be located fairly near the most frequently used taps so that the hot water gets to the taps quickly.

Each HIU has a 'keep warm' function that ensures that the HIU quickly generates hot water when a tap is turned on. Collectively, all the HIUs 'keeping warm' results in a small continuous flow through the heat network, so the whole system stays warm.

The official requirement is that DHW cylinders are heated to 60°C as this removes risks from Legionella bacteria which in rare instances has made people very ill. To get a DHW cylinder to 60°C the heating coil needs to be over 60°C. Scaling of hot surfaces occurs at temperatures of over 50°C, so a heating coil at over 60°C will result in lots of scale on the coil, reducing the heat output and slowing the heating of the DHW, and the higher temperature coming back from the coil to the heat network increases the heat network heat loss and lowers the heat pump efficiency. The HIUs that heat DHW instantaneously heat the DHW only to 50°C and so avoid the scaling issues. The 50°C is safe as there are no volumes of stored DHW for the Legionella to grow in. The heat network will operate more efficiently and at lower cost when the instantaneous hot water HIUs are used, as the water return to the heat network is much cooler; this will therefore be the preferred approach.

Space heating from the HIU

The HIU would supply hot water to the existing radiators at similar temperatures to the existing systems on the coldest days. When the weather is warmer the temperature supplied to the radiators will be lower, but still sufficient to ensure rooms warm up to the chosen temperature. The maximum temperature anticipated will be around 75°C.

The HIU contains a heat exchanger so the water in the radiators is not the same water as is in the heat network. The heat network will operate at higher pressure for the houses at the bottom of the hill and the plate heat exchanger means the radiators can continue to operate at the pressure they currently operate at. If any radiators spring a leak only the water in the home's radiators can leak out.

The HIU contains a pressure vessel which means a header tank in the attic for the heating system is not required and could be removed.

The HIU contains the pump that circulates the heated water to the radiators. This pump will be of the most modern energy efficient design, allowing the current heating circulation pump to be removed, likely resulting in an electricity saving worth around £40/year.

As part of the connection to the heat network new thermostatic radiator valves (TRVs) may be fitted to each radiator; the type installed would help ensure each radiator gets the flow it needs to provide the heat output required.

Properties without radiators

Radiators would need to be installed in those properties that do not already have them. This will be an extra cost to be funded. For electrically heated houses, the current heating costs are likely to be significantly higher than for oil heating; the cost of the radiator installation could potentially be covered by a higher monthly standing charge while still keeping the heating costs via the heat network below the current heating costs.

For other properties without radiators, if extra grant funding cannot be found it may be necessary to charge an up-front installation cost or agree a higher monthly standing charge.

Fig 26 HIU with and without cover.

8.6. Energy Centre

The energy centre will house all the equipment required to provide a reliable heat source for the heat network. This comprises:

- Air source heat pumps.
- Back up boilers.
- Network circulation pumps.
- Thermal storage.

- Controls.
- Water treatment systems.
- Possibly an electricity transformer for power from wind turbine to heat pump.

The key items of the above list are described below. The pumps are needed to deliver the hot water flow to each customer. The pumps will be sized to operate over the wide range of flowrates seen over a year, from very small flows in the summer to the peak winter flows. The pumps will have redundancy so that the peak flows can be met even if there is a failure of one of the pumps.

Water treatment systems keep the water within the heat network very clean and devoid of oxygen. The cleanliness prevents clogging of equipment on the heat network, and zero oxygen means no corrosion of the steel heat network pipes. The water treatment equipment would include a water softener so that any water that is added to the heat network does not over time scale up the system, which in the long run would reduce the efficiency, reliability and life of the pipework and equipment. In the UK water treatment is mostly done with chemicals; in countries with more established heat networks the focus is much more on removing dirt, scale, and air in the water leading to much cleaner systems - when chemical treatments are needed, much lower volumes of chemicals are required, which is better environmentally.

8.7. Back-up Plant

It is proposed that oil back-up boilers are used to provide for peak loads and to cover if the heat pump fails. Oil boilers clearly have a much higher CO_2 footprint than the heat pump, but they have low capital cost and are very reliable. Based on the analysis, because of the thermal store the 750kW heat pump can provide 80% of the heat required despite the peak load being estimated at around 4MW.

The proposed back-up oil boilers include one condensing boiler with low NOx, high turndown, variable speed burners, and 2 larger non-condensing boilers with simpler high/low fire burners that are not low NOx. The condensing boiler and burner is more efficient and produces lower NOx pollution but is significantly more expensive than the non-condensing boilers.

Operationally the condensing boiler would provide over 90% of the heat required from the boilers; the other boilers would run only very occasionally but provide the security of supply in the event of heat pump and/or condensing boiler failure. Reliability of the heat supply is paramount.

The boilers would require a flue approximately 15m tall. The ridge height of SpArC is approximately 11m high so the flue would terminate 4m above the ridge.

If the lowest CO_2 option is favoured, a larger heat pump would be required, with associated higher capital costs. Alternatively, direct electric heating could be used instead of the oil boilers, which would have very high operating costs. The substitution of the oil boilers for a lower carbon option later on in the project would be relatively easy. The oil boiler could use biodiesel instead of conventional oil, but this would take the biodiesel away from other demands such as HGVs, train and aviation where there are much more limited decarbonisation options.

Often there can be opportunity to use some existing boilers installed in buildings that are to be connected to a heat network to provide some of the back-up heat. There is a degree of control and commercial complexity to enable this to be possible and the boilers need to be quite large to be worth pursuing this option. The boilers of potential interest are at SpArC and the College as these are close to the proposed energy centre location.

The boilers installed are:

College

- 2 x Harrier 220 kW, each estimated at 15 years old
- 1 x Harrier for hot water for taps and showers, max 100kW, estimated at 15 years old
- 1 x Harrier for Block A max 100kW, estimated at 15 years old

Canteen

- Clyde Combustion 111kW, over 20 years old

SpArC

- Theatre side 3 x ACV 107kW, installed 2005
- Pool side 1 x Buderus GE515 350kW, installed 1997

All of these boilers are old and relatively small in comparison to the required capacity of around 4MW to meet the anticipated peak demand. As a result, it is not worth putting a large effort into utilising these boilers.

The spaces these boilers are in, especially the main college boiler house, could be a useful space to consider using. Such a space could probably fit sufficient boilers to back-up the entire heat network and would make the required new energy centre smaller. Use of the College boiler house would also make use of the existing oil tank capacity and possibly the existing flue.

8.8. Thermal Storage

Thermal storage, most commonly a large tank of hot water, is key to maximising the economic and environmental benefits of heat networks and renewable heat sources as it allows:

- Increased utilisation of renewable heating plant due to the store taking heat when the demand is below the output of the plant and supplying it back when the demand is higher than the maximum output of the renewable heating plant.
- Heat pumps to operate at times of lowest electricity cost rather than only at times when the heat is needed, so the heat pump would run every night when electricity is cheapest, filling the thermal store with heat that will be used the following day.
- If the power was supplied from the wind turbine, a large thermal store can be used to provide heat during times of no wind. Storing the heat in a thermal store is up to 100 times cheaper than storing the electricity the heat pump needs in an electrical battery, and it is more efficient.
- The heat pump operations can be minimised at times of the highest electricity prices.
- At a more practical level, the thermal store helps to keep the heat pump running for long periods; turning large heat pumps on/off repeatedly is poor for their reliability and hence maintenance providers usually have contractual requirements to limit the number of times a large heat pump starts up each day.

Thermal stores need to be two to three times taller than they are wide to ensure they stratify i.e. the hotter water settles at the top and the cooler water at the bottom of the store. The proposed energy centre location, at SpArC, will have a roof height of 10.5m and this results in the maximum thermal store size being 10m tall and 5m in diameter, which results in store volume of around 180m^3. The techno-economic modelling in *energyPRO*[13] has been undertaken with a thermal store of 180m^3 of water. An economic optimisation has been undertaken that indicates that the economic returns for a store larger than this are reduced, but there is a good economic case for making the store larger than 150m^3 , with the extra capital costs of the larger store paying back in 5-10 years of reduced operating costs and higher (unvalued) CO_2 savings. The thermal store could be located externally, but it then becomes another consideration for planning, and the construction cost will be higher and possibly the heat losses too. Generally, it is simpler if the thermal store can be located in the same building as the heat pumps and back-up boilers and so the recommendation is to maximise the size of the store that can fit into the energy centre building.

[13] https://www.emd-international.com/energypro

Figure 27 Example of thermal store of a size similar to that proposed – but the recommendation is for the store to be within the energy centre

8.9. Energy Centre Location

The recommended energy centre location is unchanged from that suggested in the earlier feasibility study. This location is an extension to the northwest of the SpArC theatre building. The benefits of this location are:

- The existing building is high enabling a single tall thermal store to fit within the building, a mezzanine floor to accommodate some of the plant hence reducing the building footprint and the height of the building reduces the visual impact of the flue needed for the oil boilers.
- The location is fairly out of sight which reduces the scope for objections.
- The construction can replicate the current SpArC construction which is fairly low cost.
- The location is a little over 40m from the nearest house and is behind trees; the distance and the trees will limit the risk of noise from the energy centre causing disturbance.
- There is open space not far away that is suitable for the heat pump air coolers.
- The site is owned by Shropshire Council who are supportive of the heat network, which should ease the negotiations for the use of the site and annual rental.
- The site is located next to the largest heat load, the Community College, which reduces the heat network pipe sizes that would be needed compared to if these loads were distant from the energy centre.
- The access is good for larger oil delivery tankers to deliver oil in greater bulk reducing cost and number of lorry movements.
- The location is on the edge of the town nearest to the wind turbine location which reduces the length of the electrical connection to the wind turbine. There are also potential PV sites nearby.

However, as SpArC are fitting their own heat pumps if the heat network were to go ahead it is likely that the energy centre location would need to be reassessed.

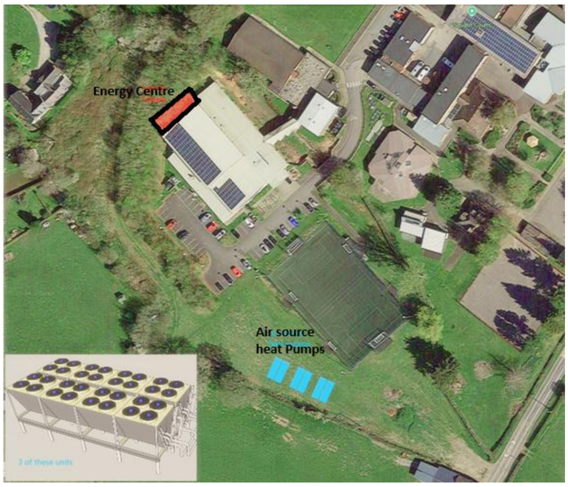

Figure 28 Proposed energy centre location

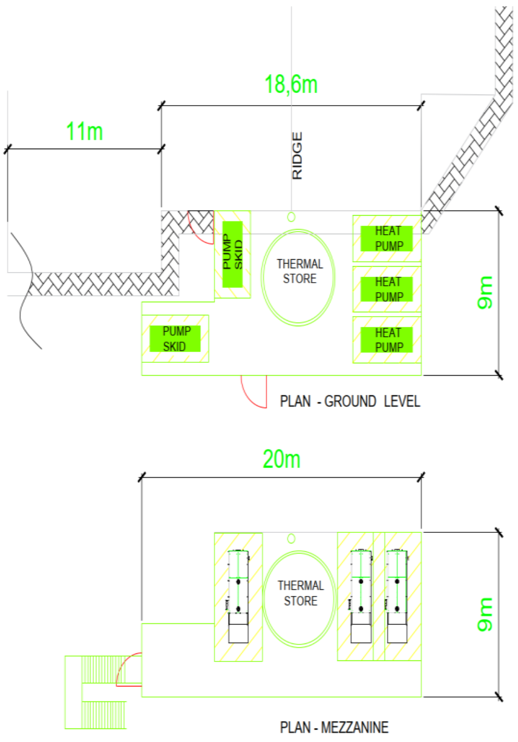

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Figure 29 Indicative energy centre layout

8.10. Electrical Connection to the Grid

Discussions have been held with National Grid Electricity Distribution (NGED), the District Network Operator (DNO), re connecting the renewable assets and energy centre to the grid. NGED's proposal is to put a new buried 33kV line back to the ring main unit (RMU) at the fire station with a secondary connection to the top of Church St. This work will cost in the order of £300k, this has been built into the business case. The maximum generation capacity that can be added at the moment is 950kW so we cannot fit both the wind turbine and the PV. Discussions are being held with the SpArC project managers to ensure that their new grid connection would be suitable for taking the wind turbine export.

8.11. Data centre option

Data centres generate large quantities of heat from the computer servers that are the operational elements of a data centre. A data centre operator, Deep Green[14], is offering this waste heat to communities at zero cost if the community hosts the data centre building. The waste heat on offer is available every hour of the year and is much warmer (40°C) than ambient air, so the electricity needed by a heat pump to generate the temperatures needed for the heat network is greatly reduced.

Benefits of using a data centre as the heat source for the heat pump:

- Lower cost of heat.
- Lower capital cost of heat pump.
- No air condenser units needed.
- All wind and PV generated electricity not used by the heat pump could be consumed by the data centre, so increasing the income from the renewable electricity generation.

[14] https://deepgreen.energy

The main challenge is to find a site for the data centre. A data centre that has a constant surplus waste heat of 1000kW has a footprint of 300m^2 and is 11m high. For comparison 300m^2 is 1/5 of the footprint of the whole SpArC theatre build, which is about 11m tall along the ridge.

An alternative data centre delivering 800kW of heat has a footprint of 500m^2 but is only 6m high. This lower building may be more acceptable despite the larger footprint.

There is probably insufficient space for this near SpArC/College but there may be on the Business Park 450m away. Inquiries were made of Shropshire Council who own the site, and some space could be available.

The data centres are modular in part, so could to some extent grow with the heat demand.

Other requirements are the power supply to the data centre. A data centre with 1MW of surplus heat would need a 3.5MW electricity supply. The grid in Bishop's Castle is currently constrained but significant reinforcement is planned for 2028, at which point there is less likely to be an issue with sufficient grid capacity.

Deep Green are seeking renewable energy for their data centres and would be keen to buy any surplus power from the wind turbine and solar PV. Use of heat from a datacentre would make the large-scale heat network viable, however it appears that the fibre connection in Bishop's Castle does not meet their requirements, so this option is not recommended for further assessment.

9. Large Scale Heat Network Financial Projections

9.1. Assumptions Made

At the time of writing this report, there continues to be considerable flux in energy prices. Since the earlier study oil prices and electricity export values have dropped but electricity import costs do not seem to have fallen as much. This makes the economic case more challenging.

Cost of heat from oil boiler	8.75	p/kWh	70 p/litre allowing for efficiency of the boiler
Heat network price of heat	8.75	p/kWh	
Electricity price from grid, day	26	p/kWh	
Electric from grid night	21	p/kWh	
Electricity export day	11	p/kWh	
Electricity export night	9	p/kWh	
Sale price private wire electricity - day	23.4	p/kWh	10% discount over imported electricity
Sale price private wire electricity - night	18.9	p/kWh	10% discount over imported electricity
Standing charge	£360	£/year	Per property
Connection Charge	Free		For those properties joining when the heat network is installed.
Heat pump availability	95%		Allowance of 1.5 days per month downtime for maintenance, faults and repairs
Inflation rate	2.5%/a		Across the board

Share & Loan Interest paid	5.0%/a		

Table 9 Assumptions made

'Private wire' electricity sales

As can be seen from Table 9 there is a very large difference between the value of exported electricity versus the cost of imported electricity. This reflects the many costs within the electricity supply system. Private wire is the supply of electricity directly from generation to demand without passing through any of the wider electrical network. This allows a much higher sale value for the electricity to be achieved. Private wire supplies to both SpArC and the Community College have been considered as they are large electrical demands and are close to the energy centre that will be supplied from the wind turbine and solar PV. The closer the loads are, the shorter the new cables to supply the loads directly from the energy centre will be. The cable cost should be reduced as the cables can be installed in a widened trench that the heat network pipework is laid in. Generally, the regulator Ofgem is not supportive of private wire supplies to domestic properties, and there are technical issues with this, and hence a wider private wire electricity supply has not been considered. Modifications to the electricity supply codes may alter this.

The modelling assumes that the private wire customers would receive a 10% discount on their electricity costs, to ensure that it is attractive to these customers to agree to a long-term purchase agreement. The model assumes that the cost to SpArC and the College is 10% lower than the import tariff assumed for the energy centre plant. The collective electricity standing charges will probably be lower for a single connection serving the generation and private wire loads if the SpArC and the College remain on the public electricity network so there may be some additional cost saving.

Heat charges

The charges for heat from the heat network will comprise of a unit charge p/kWh of heat, as measured by the heat meter in the HIU and a monthly standing charge.

The pence/kWh charge has to be less than the cost of heat from an oil boiler.

The £360 standing charge is based on the heat network enabling individual properties to avoid the cost of:

Boiler servicing £80/yr[15]

Boiler repairs averaging £50/yr

Oil boiler replacement £2,700 every 15 years[16] (£180/yr)

Oil tank replacement £1,750 every 35 years (£50/yr) (the tank costs £1, 300 + fitting and removal of the old tank)

The standing charge would include the maintenance and replacement every 20 years of the HIU that connects the heat network to the existing heating and hot water system. The standing charge ensures that even very low energy users are still paying something for being connected to the network.

The heat sales cost of 8.75p/kWh matches the cost of heating from oil at a price of 70p/litre, which is based on a boiler with 80% efficiency. The proposed standing charge may be seen as being high as it is not common to consider the maintenance, servicing and replacement costs averaged to a yearly basis.

Oil boilers don't necessarily need replacing every 15 years, but older boilers are significantly less efficient and more polluting than newer boilers. However, a property that currently uses 2000 litres of oil per year could be saving up to 400 litres/year with a new boiler (around £350), so the payback on a new boiler would be around 7.5 years or less if oil prices rise over time.

LPG tends to be a little more expensive than oil, so the heat network connection would be better value for LPG users. For electrically heated properties the £400 standing charge is much higher than the costs for owning and maintaining electrical heating systems, but 8.75p/kWh is much cheaper than their current unit

[15] https://www.myjobquote.co.uk/costs/cost-to-get-your-boiler-serviced

[16] https://www.myjobquote.co.uk/costs/cost-of-installing-an-oil-boiler

costs. For electrically heated properties the cost of installation of radiators would need to be funded either by the owner or through other means as the GHNF would not cover this work.

Larger connections would have higher standing charges reflecting higher costs to connect the heat network and the higher costs of maintaining the current plant.

The heat supply from the heat network needs to be cheaper than the current cost of heating a building if the heat network is to be attractive to potential customers. The economics of the heat network rely on Government grants. A condition of the grant is that the heat price to customers is at least a little lower than the current heating costs. The Government's calculation of the heating cost includes the full lifecycle cost e.g. including maintenance and periodic boiler renewal.

The heat charges would be expected to rise with inflation and would not follow the peaks and the troughs of the oil price – as the cost of oil used is only a very small proportion of the annual running costs. The heat price is well protected against rises and falls in electricity prices due to the amount of electricity self-supplied. If electricity prices rise, the import costs will rise but so will the value of the electricity exported.

Build out of network.

The heat network will take time to build, and it's hoped that over time more customers will want to connect. It is assumed that not all the buildings will connect, but getting a high proportion is key to the economic viability. For the financial modelling, it was assumed that SpArC, College, Castle Hotel and The Old School House connect in the first year, with the subsequent connection of the 13 other non-domestic and 145 residential properties shown in Figure 30. The assumption is that up to 80% of the domestic buildings and 70% of the non-domestic buildings adjacent to the heat network pipe routes will have connected by year 5.

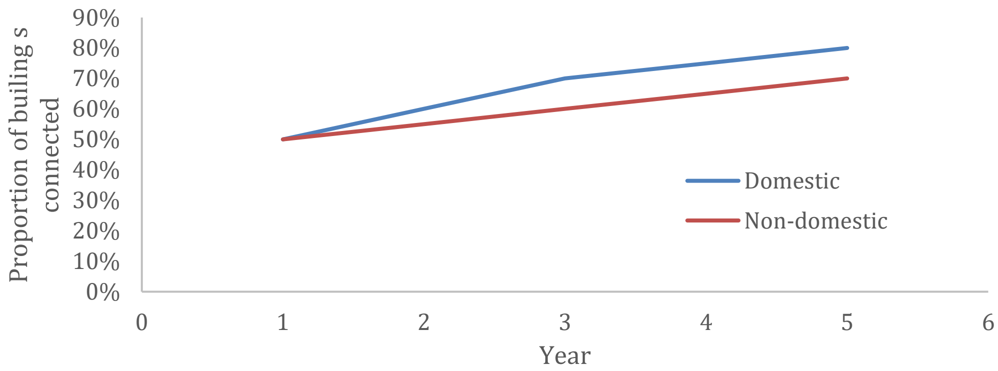

Figure 30 Properties connected over first five years

Heat network service offer

The heat network will operate at all times. The plant will be designed with duplicated systems and back-up boilers to maximise the reliability of the heat supply to customers.

The heat network operator will look after the HIU, with the servicing of the HIU and any required repairs covered by the monthly standing charge.

If these proposed charges result in the co-op's income being higher than the operating costs (including the cost of capital), then the charges could be reduced. Alternatively, the co-op may decide to use the surplus income to accelerate the repayment of debt, to improve system efficiency or to expand the heat network; such decisions would be decided by members balancing immediate benefits against potentially larger longer-term benefits later.

There will be no connection charge for those properties who join the scheme at its inception – an offer which acts as an incentive for residents to join the scheme at the beginning. Those joining later will need to pay a connection charge as extra costs will be incurred.

The *energyPRO* software has used space heating demand figures from the available EPC database. This has been reduced by 10% to allow for some thermal improvements to the properties, but a larger scale whole house retrofit programme has not been assumed. It is considered that whole house retrofit of most of the properties in Bishop's Castle would not be viable.

9.2. Economic Modelling

Oil prices are particularly difficult to estimate, and as the network heat sales price will need to be cheaper than the current oil price, may have a huge effect on the viability of the heat network. It is often possible to get cheaper oil by stocking up at the quiet times of year. However, it can also be reasonably assumed that the price of oil will rise faster than the price of general inflation, or the price of electricity, over the next five to ten years. Currently, all of the green taxes on our energy bills are on electricity tariffs, not on fossil fuels. The Government has acknowledged that to help tackle climate change this needs to be addressed. Once established the heat network would cushion its members from future oil price shocks.

The *energyPRO* modelling seeks to operate the heat pump to provide the lowest overall running cost of meeting the heat and electricity demands. The efficiency of the ASHP varies with air temperature and with output temperature. The modelling estimates the heat pump CoP to be just under 3 (equivalent to an efficiency of 295%), increasing to a CoP of just over 6 for the data centre option. The output temperature is assumed to vary such that in the summer the heat network is hot enough to provide DHW (65°C) but in the winter this can rise up to 80°C as more heat is needed and radiators need to be hotter to keep rooms warm. If, over time, heating systems can be modified to lower the required peak heat network temperatures, then the heat pump efficiency will rise.

The effective electricity cost to the heat pump varies depending upon:

- The amount of PV/wind generation available.
- The electrical load of private wire loads and the resulting amount imported to meet the private wire and heat pump loads (the most expensive element).

The *energyPRO* modelling also assumes that the renewable electricity produced will be prioritised for use by private wire loads, with the heat pumps taking anything not required and using grid electricity to fill any shortfall. As the heat pumps can be set to run when spare renewable electricity is available, utilising the thermal storage, this minimises the amount of electricity exported to the grid. If the heat pumps were to take priority, the thermal store might fill up during the day when the private wire loads are larger, and then there may be surplus electricity when the private wire loads are lower over night, but as the thermal store has been filling during the day there is less scope for heat pump operation.

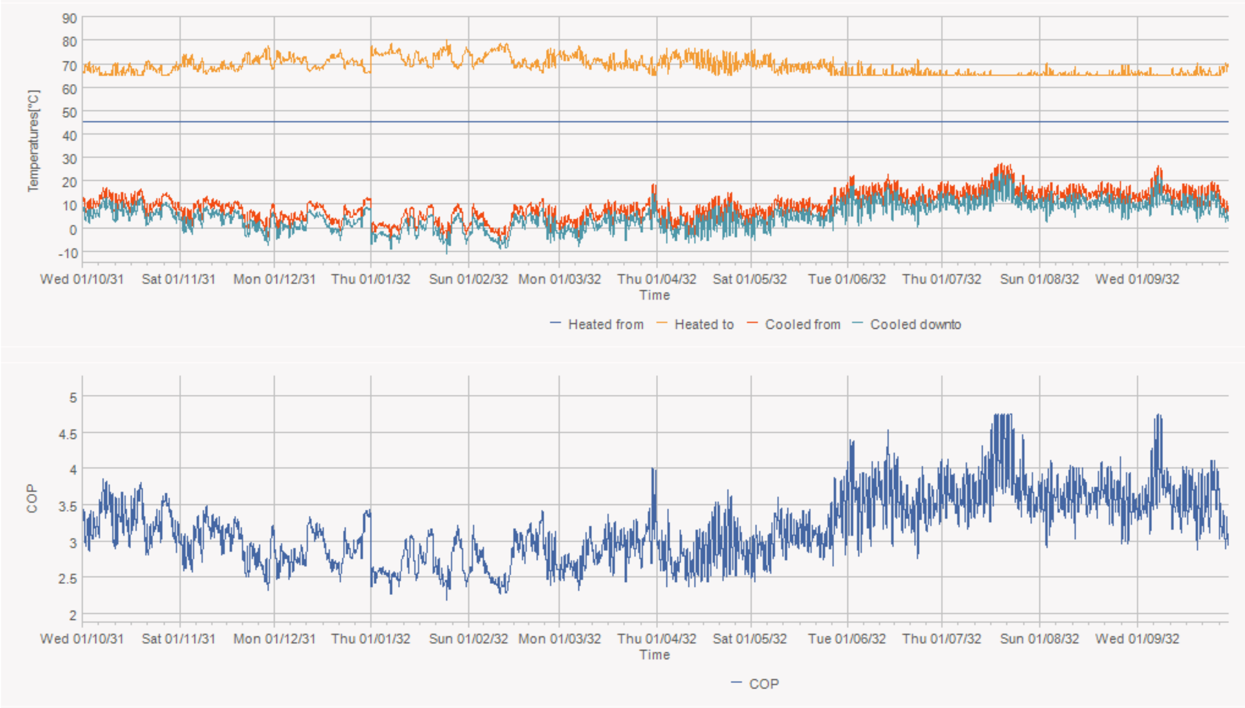

Figure 31 Heat pump Coefficient of Performance (CoP) variation with ambient and output temperatures

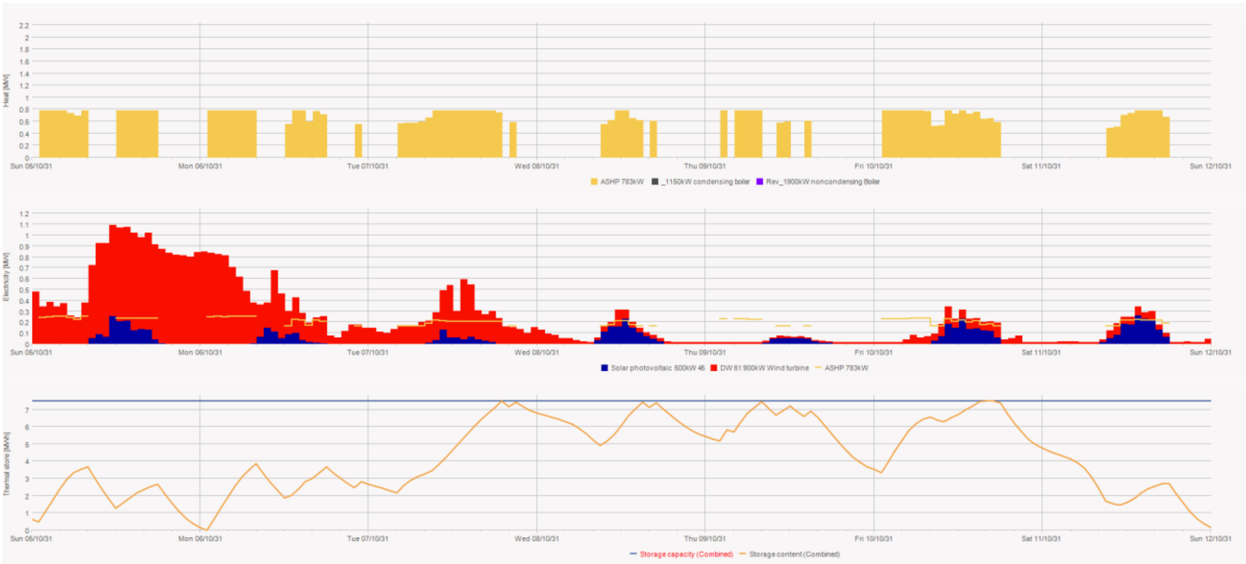

Figure 32 Plant operation for sample week, including thermal store charging/discharging

A range of scenarios of different heat loads, private wire load, plant size and renewable generation options and size were undertaken to understand the economic benefits of the options. Of these a limited number are presented here to show the impacts of the key changes to the scheme:

1. Scenario 1: 900kW Wind turbine, 500kW PV, 750kW ASHP, and private wire to SpArC. This is the base option with the other scenarios evaluating other options. Knowing the financial implications of the options gives an understanding of how much effort it is worthwhile to expend in pursuing the opportunity.
2. Scenario 2: was the same as for scenario 1 but without the PV system.
3. Scenario 3: took heat from a datacentre, which results in significantly higher efficiency operation of a lower cost heat pump. It is assumed all surplus generated power is sold to the data centre where the electricity demand will always exceed the available wind and PV generation. SpArC is not supplied with electricity in this scenario.

9.3. Available Financial Support for Heat Networks

As mentioned earlier the Government's Committee on Climate Change estimates that to achieve our required carbon reductions, heat networks will be the most economic heating option for approximately 18% of the UK heat demand. As a result, the Government has understood the need to support the development of heat networks. The high capital costs of heat networks make the economics challenging but the Government understands this and so has, for the last 10 years or so, been providing significant funding support for the construction of new networks. The Government sees the long-term value to the nation of the heat network pipework, which has a life of over 50 years. Funding has also been available for the last 10 years via the Heat Network Delivery Unit to support feasibility studies for heat networks. Until 2022 capital funding was available via the Heat Network Investment Project, which has now been replaced by the Green Heat Network Fund.

9.4. Green Heat Network Fund

The Green Heat Network Fund[17] (GHNF) can provide funding for up to 50% of the capital and later stages of development for Heat Networks. This is subject to meeting a number of criteria. These criteria are:

1. Carbon gate - Maximum 100gCO2e/kWh thermal energy delivered (lower is better).
2. Customer detriment - Domestic customers and micro-businesses must not be offered a price of heat greater than a low carbon counterfactual for new buildings and a gas/oil counterfactual for existing buildings.
3. Social IRR - Projects must demonstrate a Social IRR of 3.5% or greater over a 40-year period.
4. Minimum demand - For urban networks a minimum end customer demand of 2GWh/year (including existing customers). For rural (off gas grid) networks a minimum number of 100 dwellings connected. This is to be achieved within a 5-year window from the date of first connection.
5. Limit on award compared to eligible costs - Combined grant requested up to but not including 50% of the estimated eligible commercialisation and construction costs of the project.
6. Capped award - The total award may not exceed 4.5 pence of grant per kWh delivered over the first 15 years of operation, though recent successful GHNF bids have only been requesting 2.5p/kWh.
7. Non-heat/cooling cost inclusion. For projects including wider energy infrastructure in their application, the value of income generated/costs saved/wider subsidy obtained should be greater than or equal to the costs included.

For the proposed heat network

1) Carbon gate – PASS, the proposed network would deliver heat that has an associated CO2 emission of less than 20 gCO2e/kWh heat delivered.
2) Customer detriment – PASS, the tariffs have been set to ensure this.
3) Social IRR – PASS.
4) Minimum demand over 2GWh – PASS, the proposed scheme delivers over 4GWh of heat.
5) Limit on award – PASS as between 25% - 30%.
6) Capped award – PASS at 4.5p but only by reducing grant funding to between 25% - 30% of capital cost but FAIL as most projects being awarded GHNF funding are seeking nearer 2.5p/kWh of heat supplied, GHNF will fund projects seeking lower funding in preference to those needing more funding..
7) Non-heat/cooling cost inclusion – PASS, grant funding could cover the wind turbine and PV, but the funding is capped by item 6.

Without such funding no heat network would be viable, so all three scenarios have assumed a successful bid to the GHNF. This funding would not cover the cost of the wind turbine, the solar array, or any work required within dwellings, other than provision of a heat exchange unit. The GHNF, as currently publicly stated, runs until March 2028, with the latest round for applications having closed on 11 April 2025, but it is clear from other DESNZ actions and comments that the GHNF will have future rounds. Due to the viability issues outlined no application for this scheme has been made.

[17] https://assets.publishing.service.gov.uk/media/6798e14afe1eabe7d7a22d76/ghnf-guidance.pdf

9.5. Capital Costs

The capital costs estimated by Carbon Alternatives are significantly higher than the cost of fitting individual ASHPs if the £7.5k Boiler Upgrade scheme is allowed for, but as stated previously this is not an option for many of the Bishop's Castle properties. Individual heat pumps will also need to be replaced every 15 to 20 years, whereas a significant proportion of the cost of the heat network is in the pipes - these will last 40 years or more, so the heat network cost over a 40-year cycle may actually be similar to a scheme promoting individual heat pumps. It was hoped that the capital cost estimates for Bishop's Castle could show some learning and cost reduction from the Swaffham Prior project, but this has not been evident in the prices from the heat network contractor; the rate of inflation in the construction industry has totalled around 25% in the last 4 years. This increase in costs is probably higher in the heat network sector where the market growth has been largely fuelled by the GHNF and a relatively small existing contractor base.

The capital costs used for the DH pipes are based on the Reheat assessment which is low compared to other contractor estimates. The stated pipe price is 12% lower than that in the Reheat report as the Reheat estimate include for contingency which is added further down the capital costs table.

Capex (£'000)		**Base case heat network, Wind, PV, PW to SpArC**	**Base case but no PV**	**Heat network, Wind, PV, Data centre**
Heat pump		£1,185	£1,185	£593
Wind turbine and PV		£2,050	£1,650	£2,050
Thermal store		£200	£200	£200
EC Building and elec connection		£680	£650	£680
Back up boilers 1.9MW and oil tank		£250	£250	£250
Non-domestic sized connections		£75	£75	£75
Pumps, controls, water treatment		£250	£250	£250
Heat network pipework		£3,144	£3,144	£3,294
House sized connections, HIU, metering	157	£1,138	£1,138	£1,138
Commissioning		£100	£100	£100
Project management, design, prelims, contingency	12%	£1,089	£1,037	£1,036
Total £k		**£10,161**	**£9,680**	**£9,666**
Total eligible for GHNF		£7,865	£7,832	£7,370
Green Heat Networks Fund Grant		£2,753	£2,749	£2,004
GHNF to get 4.5 p/kWh		35.0%	35.1%	27.2%
Investment needed £k		**£7,408**	**£6,931**	**£7,662**

Table 10 Capital costs

In addition, substantial replacement (Repex) costs have been allowed for in year 20 of £3.2m to £3.8m (current costs).

Capital cost increase since earlier report. The following costs have increased:

- Heat pump £450k increase based on supplier quotes
- Energy centre and electrical connection £300k based on DNO quote and more detailed assessment of energy centre design
- Heat network pipe costs and house connection £600k but as noted believe these costs are ambitious

9.6. Ongoing Costs

We have allowed for the costs for billing customers, administration of the society running the scheme, insurance, maintenance etc, plus allowances for replacement of the major equipment after 20 to 30 years. The pipework is expected to be good for at least 40 years without major maintenance work.

The assessed operating costs are:

	£k/year
Heat pump maintenance	4
Energy centre and heat network maintenance	15
HIU maintenance and repair @ £80 per customer/yr	13
Heat meter reading and billing @£95 per customer/yr	15.4
Wind turbine maintenance	25
Community heat and power company management and accounts	3.5
Community heat and power company financial admin	4
Insurance	5
PV Operations & Maintenance	5
PV land rent	5
Wind turbine land rent	10
Total maintenance and annual operational costs	**105**

Table 11 Ongoing costs

Business Rates

Currently heat networks are subject to business rates, for which there have been ongoing temporary exemptions. Other utility infrastructure e.g. DNO wires and water company pipes are not subject to business rates and Government is supportive of also exempting heat networks from business rates, but this is taking time. From another angle, charities are not subject to business rates, and it could be requested that not-for-profit Co-ops/CBSs are similarly treated. It has been assumed that no business rates payments will be due.

9.7. Rates of Return

Carbon Alternatives have calculated the Internal Rate of Return (IRR) for the three large scale heat network scenarios. The project IRR gives a good indication of whether a project can repay capital borrowing and is likely to be able to pay interest on loans or shares but does not include a calculation of when the capital will be repaid or how much interest shareholders will receive.

Ideally community energy projects should have a positive rate of return over the cost of borrowing over a maximum of 20 years, however it is recognised that heat networks are a longer-term investment with the pipework being in place for 40 years or more, so a 30-year positive IRR might be acceptable. The capital costs are much less certain than for more common community energy projects like PV where there is a much larger and more experienced contractor base.

All figures for fully built out heat network at year 5	**Base case heat network, Wind, PV, private wire to SpArC**	**As Base case but no PV**	**Heat network, Wind, PV, Data centre**
Heat supplied MWh/yr	4,074	4,074	4,074
Heat sales £k	328	328	328
Private wire electricity sales	36	36	414
Electricity export £k	125	96	0
Standing charges £k	66	66	66
Oil £k	48	54	12
Electricity import £k	77	106	47
Operating profit yr 5	336	277	694
IRR 40 year (inc. max GHNF grant)	3.8%	2.6%	11.0%

Table 12 Large Scale Heat Network Options financial analysis

The only realistic current financial scenario for a large-scale heat network therefore appears to be the option with the data centre as a heat source with an IRR of 11% but this has been discounted due to poor internet access.

With SpArC installing their own heat pumps supported by the Public Sector Decarbonisation Scheme, the heat network economics improve, as the additional electricity sales more than offset the reduced heat sales.

Inflation rising at faster than 2.5% would increase the income from sales of heat, but at higher rates of inflation there will be a desire to peg prices to assist the customers of the network and the price of electricity, maintenance, etc., will also increase, in which case the scheme would return a slightly higher but not significant surplus.

9.8. Carbon Savings

The carbon emissions savings from the large-scale heat network options have been estimated at

	Base case heat network, Wind, PV, PW to SpArC	**Base case but no PV**	**Heat network, Wind, PV, Data centre**
CO2 emissions, tonnes/yr	79	155	-159
CO2 reduction, tonnes/yr	917	840	1,134
Kg CO2 per kWh heat delivered	0.019	0.038	-0.039

Table 13 CO_2 savings from large scale heat network options assessed (negative emissions show more electricity exported than energy imported)

The current average CO_2 emission from heating in Bishop's Castle is around 0.223 kg CO_2 per kWh of heat. Thus, it can be seen that carbon reductions of over 80% can be achieved through a large-scale heat network. These savings could be further increased in the future by replacing the oil boilers with a low carbon alternative.

The CO_2 reduction figure includes an allowance for the generation from the wind turbine and PV, so where the emissions are negative, this is due to the renewable electricity generation exceeding the electricity used by the heat pump and the exported electricity offsetting the oil used in boilers. These figures take a mid-range carbon factor for the imported electricity expected over the next 20 years of 128g/kWh. [18]

Without a heat network installation there would be CO_2 reduction over time as around 30% of the current heating is from electricity use and the carbon factor for electricity imported from the grid is falling. Additionally, if in the absence of the development of a heat network, more houses change to individual heat pumps, the carbon emissions will fall. We would not however expect the fall in carbon emissions without a heat network to exceed 40% as it will be difficult to fit individual heat pumps to most of the houses in the core heat network area of Bishop's Castle.

	Heat SpArC & BCCC only, private wire to SpArC, Wind only	Heat to BCCC, private wire to SpArC with own ASHP, Wind only	No heat, private wire to SpArC & BCCC, Wind only	No heat, private wire to SpArC, Wind only	No heat, private wire to SpArC & BCCC both with own heat pumps, Wind only
CO_2 emissions tonnes/yr	-116	-128	-140	-166	-106
CO_2 reduction tonnes /yr	177	152	206	230	178

Table 14 CO_2 savings from alternative options assessed

[18] *Appendix D HNDU GHG Emissions Factors v1'*

The scenario emissions in Table 14 are all negative due to the amount of electricity generated and exported by the wind turbine, so under these scenarios the renewable generation now exceeds the energy needed to provide for each scenario's heat and power loads.

10. Alternative Options

As the envisaged large scale heat network does not appear to be viable under current conditions, a number of alternative options have been explored. All of these include the wind turbine, none include PV. These options are:

1. Heating the College only, private wire to SpArC which has fitted its own heat pumps.
2. No heat provided, private wire to SpArC and the College.
3. No heat provided, private wire to SpArC only.
4. No heat provided, private wire to SpArC and the College, both of which have fitted heat pumps.
5. Delivering electricity to multiple customers in the town & encouraging the fitting of heat pumps.

A further option of heating SpArC and the College only, with private wire to SpArC is no longer relevant as SpArC has funding for its own heat pumps.

Option 1 would make the heat network too reliant on one customer so isn't recommended. A combination of Options 3 and 5 appears the most likely at this stage. The SpArC decarbonisation project team have expressed an interest in the site being connected to the wind turbine. Sharenergy have produced a separate report on Option 5 as part of their Energy Redress Fund Community Heat Development Unit project. Selling electricity directly to the grid without utilising any of the above options would not be viable. None of the alternative options would qualify for the Green Heat Network Fund which will make getting development funding more difficult, but the capital costs are much lower and the hurdle of gaining GHNF approval is removed.

	Heat to C.College, private wire to SpArC with own ASHP, Wind only	No heat, private wire to SpArC & C.College, Wind only	No heat, private wire to SpArC, Wind only	No heat, private wire to SpArC & C.College, both with own heat pumps, Wind only
Heat supplied MWh/yr	231	0	0	0
Heat sales £k	18	0	0	0
Private wire electricity sales	67	78	36	126
Electricity export £k	151	162	175	149
Standing charges £k	1	0	0	0
Oil £k	3	0	0	0
Electricity import £k	20	22	9	43
Capital cost £k	2,394	2,218	2,184	2,218
Operating profit yr 5	181.3	178	170	204
IRR 40 year	6.6%	7.2%	6.8%	8.6%

Table 15 Financial analysis of alternative options

The 5th alternative option is to use the recently adopted P442 code modification, or the proposed P441 which would codify the current Energy Local [19]arrangement, to supply electricity through the grid to multiple properties using the small supplier exemption to avoid some of the charges normally associated with doing this. It is at present unclear exactly how P441 will work but Sharenergy are looking into this in some detail. It is possible that this would enable a reduction in electricity price to dwellings across the town which could be used as part of a strategy to encourage people to fit their own heat pumps. The advantage of this system is that it would be available to the whole town, and surrounding villages, not just the historic core but it would entail greater internal disruption, and it would not be suitable for properties where there is no room for a heat pump.

Sharenergy have written a case study report on the potential use of a P441 Energy Club to distribute electricity from the wind turbine to households in Bishop's Castle[20] as part of their Community Heat Development project. See appendices.

11. Planning & Permitting

11.1. Wind Turbine

Planning permission for the wind turbine was granted in June 2025. This did not include details of the cable run. Work needs to start on site by June 2028. The wind turbine permission is not linked to the heat network.

11.2. Energy Centre

The proposed energy centre location is well hidden; the band of trees to the north of the proposed location will have to be made a little narrower, but the view from the north would remain unchanged apart from the boiler flue. The flue height is kept relatively low due to the relatively limited use of the boilers and specification of very low pollution burners on the most used boiler.

The heat pump air condensers, the fan units that take heat out of the air, are in a more visible location as they need good air flow around them, and maximising the distance from the nearest houses reduces the possible noise issue. The proposed location does not reduce the number of car parking spaces at SpArC. The acceptability of the siting of the air condensers may be more controversial.

Both of the proposed sites for the energy centre and the air condensers are in Shropshire Council/community ownership. As the heat network would be of benefit to the community it is assumed that generally there should be landowner support for the development of the heat network.

The selected boilers and burners would meet the requirements of the Medium Plant Combustion Directive, legislation designed to limit the pollution impacts of larger boiler installations.

11.3. Heat Network Pipework

In England, the installation of district heating pipework in roads involves various legal, regulatory and procedural considerations. Unlike other utilities, heat network owners have no automatic right to be able to install pipes in the public realm. So, installing the pipework in public roads requires a license under Section 50 of the Highways Act 1980. This applies to works carried out on highways or other public land. The local highway authority (Shropshire Council) must grant permission for the installation of district heating pipework in the road. This may require submitting a detailed plan, which may include traffic management and other safety measures. Additionally, a Temporary Traffic Regulation Order (TTRO) or a Traffic Management Plan may be required if the work will disrupt road use.

[19] *www.energylocal.org.uk*
[20] www.communityheat.org.uk

12. Operation and Governance

In Stage 1 five options were considered:

1. Set up a new, local, Community Benefit Society (CBS). A CBS would enable a share offer to be launched giving community ownership for the scheme and could also own the new wind turbine. This would, however, be a big commitment for a group of volunteers, on a project with a 40 plus years lifespan, even if administrative support was provided as has been allowed in the costings. It would also be a relatively risky investment for the investors as there is very little leeway in the finances for extra costs or reduced revenues.

2. Partner with an existing CBS, such as Shropshire and Telford Community Energy (STCE), probably using a dedicated subsidiary company or Special Purpose Vehicle (SPV). The advantage of using STCE rather than a new CBS is that they have an existing set-up, access to wider resources and expertise and could then consider delivering similar schemes elsewhere.

3. Partner with a specific heat network CBS. Sharenergy have received grant funding from the Energy Redress scheme to investigate the establishment of community-owned heat network societies. This work may lead to a new wider area heat network CBS being set up.

4. Partner with a local authority who can take the lead and raise the capital required. This is how the Swaffham Prior scheme is being delivered. At the moment only local authorities have the power to dig up roads for installing heat network pipes so some sort of council partnership may be required anyway. This arrangement would relieve the pressure on the local volunteers and remove the risk from the shareholders, but the scheme could then be bound up in the workings of local government and at the moment Shropshire Council do not have the resources to take on this project.

5. Partner with a private sector company to deliver and run the scheme on a commercial basis. This would reduce the workload and responsibility for community volunteers but would also give less local control. The rates of return are also not likely to be attractive enough to a private enterprise.

If the code modification P442 option is pursued, then the owning society needs to be fairly small as the exemptions provided are only available up to a maximum of 5MW generating capacity. STCE already own 10MW, though this may not be used for Licence Exempt Supply.

All options are still possible but Options 1 and 2 are considered to have the most potential especially as the project scale is now reduced. STCE have agreed to pursue the scheme further through the next stage but have made no commitment to owning or managing an SPV.

13. Next Steps

It was envisaged that a GHNF application would be made in the spring of 2025 but as a viable large scale heat network has not been identified this was not submitted.

To deliver the wind turbine and carry on working on the alternative options outlined in section 10, further funding will be required. As the scheme did not receive CEF stage 1 funding it may be possible to apply for this when the next tranche of CEF is announced (this has been promised by the Government in their recent funding announcements). If CEF funding isn't available, then other funding sources will need to be identified. Discussions have been opened with the Midlands Net Zero Hub and the West Midlands Combined Authority.

Maintaining the public and council support for the scheme will be vital. The changes to the proposal have been well received so far, further consultation on the proposals should be carried out at regular intervals to keep residents and the Town Council informed of developments.

14. Appendices Available

14.1. Shropshire & Telford Community Energy Scoping Study (Sharenergy 2021)

14.2. Wind turbine constraints study (Locogen 2021)

14.3. Bishop's Castle Heat & Wind Project Consultation Report (Sharenergy 2021)

14.4. Stage 1 Feasibility Study (Sharenergy & Carbon Alternatives 2023)

14.5. Publicity Materials 2024

14.6. CHDU Bishop's Castle Distributed Heat case study report (Sharenergy 2025)

This feasibility study has been supported by *Shropshire and Telford Community Energy*, utilising funds from the Government's Community Energy Fund (managed by the Midlands Net Zero Hub) and the *Power to Change Next Generation* grant.