Bishop’s Castle Heat Network Feasibility Study

A Report on behalf of

Shropshire and Telford Community Energy (STCE), Lightfoot

& Bishop’s Castle Climate Action Group

Funded by a Power to Change Next Generation grant through STCE

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V7c 23rd March 2023

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1. Executive Summary

1.1. Project Background

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)[1] 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 and commissioned *Sharenergy* and *Locogen* to develop proposals for the wind turbine and the *Energy Workshop* to submit a wind turbine pre-planning application.[2]

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.

1.2. Bishop’s Castle

Bishop’s Castle is a small town in South Shropshire. There are 828 households, a Community College, a Primary School, a 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

[1] www.stcenergy.org.uk
[2] *See appendices*

Hospital [closed presently] and a Doctor’s Surgery, several pubs, the Castle hotel and Three Tuns brewery. There is also a parish church (St Johns) and parish hall [Church Barn] and a separate community hall [Public Hall]. 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 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 section 5*) with carbon emissions per person - significantly above the national average.

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

The Government has issued a consultation on future heating options. This suggests that replacement oil boilers might not be available from 2025. The results of this consultation have not been issued yet, but expect that replacement oil boilers will be banned at some point, probably a few years later than suggested.[3]

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 slope from the bottom of the town by the church and College which may affect the design of a Heat Network.

1.3. Heat Network

A Heat Network could offer an effective way of reducing the high carbon impacts of heating and hot water use in the town. It would also enable the removal of oil and LPG tanks, improve air quality in the town and remove the liability of replacing defunct boilers from individual householders. Heat from a Heat Network would need to be cheaper than oil or LPG for people to join the scheme. It is assumed that those joining at the start would not pay a joining fee, although a standing charge would be levied on a quarterly basis, similar to such charges for electricity or mains gas.

[3] *https://www.gov.uk/government/consultations/phasing-out-fossil-fuel-heating-in-homes-off-the-gas-grid*

Many of the properties are not suited to individual heat pumps due to lack of sites for external air source units or boreholes for ground source. To get a significant number of dwellings fitting individual heat pumps would be a huge task, with each household having to decide on the options, arrange a contract etc.

Carbon Alternatives have studied various options for the Heat Network, utilising Energy Performance Certificate (EPC) data and the 'Thermos' heat network software. No waste energy resource or heat from chilling has been identified in the town but there is apparently spare biomass boiler capacity at Ransfords' sawmill. It is assumed that grant funding of 50% could be obtained through the Green Heat Network Fund (GHNF)[4]. This would require the system to be connected to at least 100 houses (11% of the town) or supply a minimum of 2000MWh / year of heat, though a larger network would be possible.

Ground source heat pumps (GSHPs) on this scale would have to use deep closed loop boreholes, which are expensive, and the extra efficiency gained would not cover the additional costs. The British Geological Survey's open loop heat pump screening tool indicates that Bishop's Castle is not favourable for open loop heat pumps, which tend to have better economics at this scale.

Air source heat pumps (ASHPs) offer a reasonable alternative; whilst the efficiency is lower than ground source heat pumps, in the coldest weather this is balanced by a much lower capital cost and reduced risks. It is assumed that the Heat Network would run at a temperature high enough so that most radiators would not need to be replaced, though this will result in lower efficiencies.

New biomass boilers specifically installed for a Heat Network would require a sizeable, carefully graded feedstock and careful attention and maintenance. There is however the possibility of using spare capacity available from the existing biomass boiler at Ransfords' sawmill. This is powered using waste stumps, i.e. timber that cannot be used for any other purposes, even for wood chip.

Carbon Alternatives have carried out financial modelling for two potential heat networks:[5]

Scenario 1: A larger network supplied mostly by air source heat pumps, with thermal storage and oil boilers providing back-up and top-up.

Using grid electricity for such a system does not provide cheaper heating than oil or LPG heating or offer a return on investment. The viability of air source heat pump systems however improves if cheaper electricity can be sourced from a local renewable energy source. The best fit for this renewable energy source would be wind power and two potential sites for a 1MW wind turbine have been identified to the East of the town. A pre-planning application has been submitted for these sites. Wind power gives a better match to the seasonal energy demands of a Heat Network than photovoltaic panels (PV), but it has been identified that adding 500 kW of PV to the scheme would increase the

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[4] *https://www.gov.uk/government/publications/green-heat-network-fund-ghnf*
[5] *See section 5.4 for detail including maps*

viability further as the PV could provide energy at times the wind is not blowing. This arrangement gives around 5.3% Internal Rate of Return (IRR)[6] over 30 years.

Scenario 2: A smaller Heat Network utilising the spare heat capacity from Ransfords' biomass boiler.

Matching the available heat results in a smaller Heat Network, this smaller network prioritises the larger loads as these will have the best economic returns. These loads are the Community College, SpArC, Enterprise House and the houses along the pipe routes that serve the larger loads. This network shows reasonable viability at 3.2 to 4.7% IRR over 30 years (depending on the biomass price negotiated) and would not be reliant on installing the wind turbine or solar panels, although these could be utilised to extend the scheme.

Scenario 1 would supply a heat demand of around 5,000 MWh/a, Scenario 2 2,000MWh/a, so both schemes would be eligible for Green Heat Network funding. Either network could be extended to other parts of the town once the core area is established.

The returns on investment are only indicative at this stage and will be very dependent on detailed design costings and the future prices of electricity and oil, because some electricity will still need to be purchased, and the price of heat delivered cannot rise above the equivalent price of oil.

A hybrid system combining these two scenarios could be investigated in the next stage of work.

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 is located near SpArC then any surplus electricity from the renewable arrays could be 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. Governance

If the scheme progresses, there are five options:-

[6] *The IRR gives an indication of return on investment over the life of a project.*

1, Set up a new Community Benefit Society (CBS). A CBS would enable a share offer to be launched giving community ownership for the scheme, including the wind turbine and PV panels. This would however be a big commitment for a group of volunteers, on a project with a 40-plus year lifespan. It would be expected that a scheme of this size would operate with paid staff or external contractors to undertake the day-to-day operation of the scheme.

2, Partner with an existing CBS, such as *Shropshire and Telford Community Energy* (STCE). Whilst STCE have been supportive of the scheme to date they have made no commitment to taking the Bishop’s Castle Heat Network on as a live project. The advantage of using STCE rather than a new CBS is that they have access to wider resources and expertise and could then consider developing similar schemes elsewhere.

3, Partner with a specific Heat Network CBS. In 2022 *Sharenergy* submitted a grant application to the *Energy Redress* scheme to establish a UK, community-owned Heat Network society. Unfortunately, this bid was not successful, but *Sharenergy* are looking into other ways of setting this up. If funding is found *Sharenergy* would be very interested in including the Bishop’s Castle Heat Network scheme in the new society.

4, Partner with a Local Authority (i.e., Shropshire Council) 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 work on highways 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, but the scheme could then be bound up in the workings of local government.

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.

1.6. Conclusions & Next Steps

Bishop’s Castle appears to be an ideal place for a Heat Network. The town has no mains gas and there are limited opportunities for the deployment of individual heat pumps or for whole- house retrofit. Two options have been identified: a smaller network utilising only heat from Ransfords or a larger network incorporating heat pumps, a wind turbine and PV panels. A third option combining these two schemes is worthy of further consideration.

Scenario 1 (the scheme with heat pumps powered by a combination of wind and solar power) offers an acceptable return on the investment but this scheme would be subject to obtaining planning permission for the renewables and other options are still worth considering.

Further work on the scheme is recommended.

- This study has not calculated the figures for a scenario whereby heat pumps are supplemented by Ransfords’ biomass boiler. That would be a useful next step.

- A pre-planning application has been submitted for the wind turbine sites. The response to this application will dictate what happens with the heat pump option.

- If the wind turbine pre-planning application response is positive, then ecology and other required studies should be started on the preferred site with more detailed analysis of the wind resource.

- Negotiations should also be started with SpArC and the Community College and the relevant landlords over the sites for the turbine, PV panels and the Energy Centre.

- A survey of district heating pipe routes to improve pipe installation cost estimates should also be initiated.

If the use of Ransfords' spare capacity is considered to be worthy of investigation, then:-

- monitoring of heat output from Ransford's' biomass boiler to better understand the heat available would be useful.

- the quantity of the spare capacity and availability of low-grade timber at Ransfords should be verified,

- negotiations with Ransfords over the heat price, location of energy centre, etc, should be started.

Limited further funding is available through the *Next Generation* scheme, but this is not sufficient to cover all the items above so further funding needs to be sought. Potential funders and supporters should be approached, including Shropshire Council and the Government's Green Heat Network Fund.

Local support for the scheme will be vital. Further consultation on the proposals should be carried out at regular intervals to keep residents and the Town Council informed of developments.

Figure1 Bishop's Castle Heat & Wind consultation October 2021

2. Community Engagement

A paper (and on-line) 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.

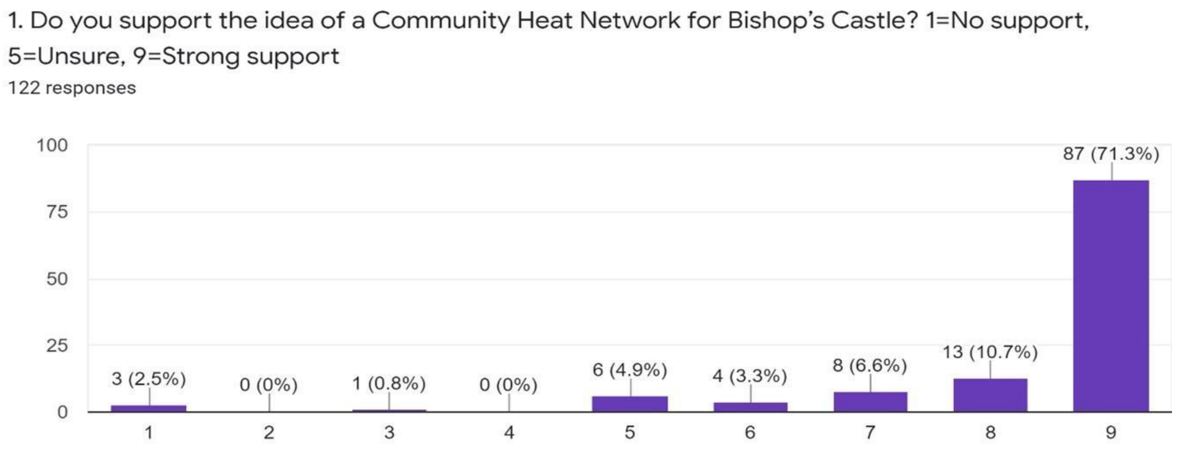

Figure 2 Survey response2021 Q1

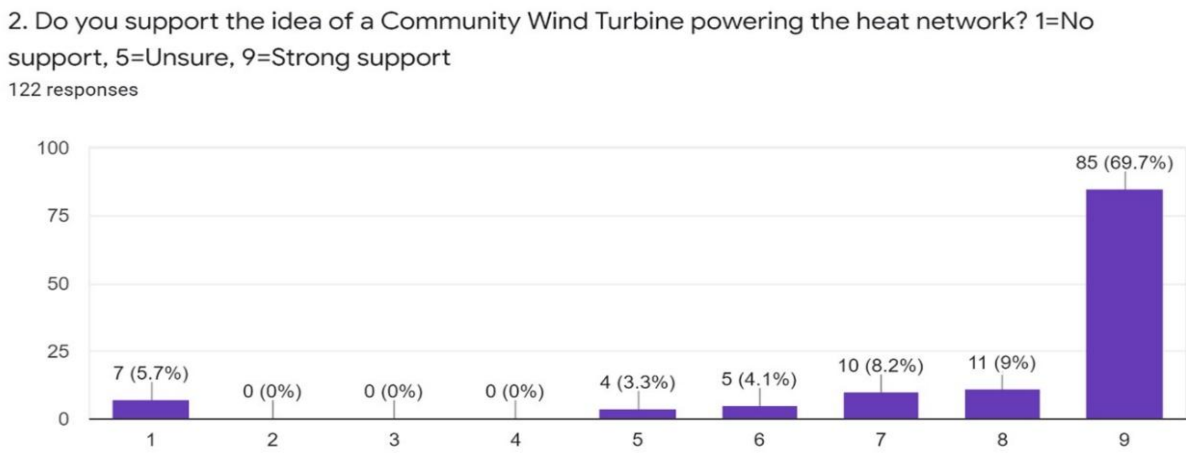

Figure 3 Survey response 2021 Q2

There were only three objections to the Heat Network and seven objections to the wind turbine. There are two potential sites for the wind turbine. It is likely that one of these sites will be eliminated as part of the pre-planning process, some of the wind turbine objections relate to only one of these sites.

Bishop's Castle Town Council has been 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 has not been included this is for reasons of timing and resources and the Town Council have indicated interest in the scheme.

Residents of Bishop's Castle have been kept informed of the progress of the scheme through the town newsletters and the *Lightfoot* website.

Further consultation is planned when this report is published and the results of the pre-planning application for the wind turbine are known.

3. Community Benefits

If this scheme progresses the community would benefit through:-

- Reduced carbon emissions,
- The ability to remove oil tanks and boilers,
- Improved air quality,
- Reduced fuel costs and protection from energy price spikes,
- Assistance with fitting energy efficiency measures,
- The opportunity to invest in the CBS,
- Reduced dependency on imported oil and LPG,
- Support for local businesses and organisations – the biomass heat option would provide additional income for Ransfords.

Other Community Energy schemes that benefited 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 CO_2 savings and/or improve energy efficiency. In this way the community will benefit directly from any surpluses generated.

4. Technology

This work was commissioned with the sole aim of 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 a renewable energy source to power the proposed heat pumps.

4.1. Why install a Heat Network?

'Heat Network' is the term now used for 'district heating' (DH) or 'community heating'. Heat Networks are the interconnection of heat loads such that they can be served from centralised heat sources.

Heat Networks currently provide 2% of UK heat demand and the *Committee on Climate Change* estimated in 2015 that with Government support, they could provide 18% of heat demand by 2050 in a least-cost pathway to meeting carbon targets[7].

Heat Network advantages include:-

- The load diversification across a Heat Network and the use of thermal storage means the capacity of the central Energy Centre is smaller than the sum of the capacities of plant installed for heating each building. There is also better utilisation and possible higher operating efficiencies from expensive low-carbon heating plant such as heat pumps
- Flexibility to change the heat source, and scope to locate plant at an optimum location e.g. a heat pump that takes heat from a river can be located near to that river; a Heat Network initially heated by biomass can be switched to heat pumps at a later date.
- Allows removal of individual boilers in each building
- Heat network connection equipment in each building requires very little maintenance and no legally required gas safety check, as is required for gas boilers.
- Allows for simpler inclusion of thermal storage. Thermal storage is a tried and tested, low risk technology, and can be up to 100 times cheaper per unit of energy stored than batteries.

Larger/centralised plants offer a number of advantages: -

- Can be cheaper to build and operate than boilers/heat pumps in each building.
- Maintenance costs usually lower per unit of heat generated.
- Easier to achieve direct supply of cheaper electricity from local renewable generation to heat pump.
- Collectively all these factors result in lower life-cycle costs for larger plant.

Heat Networks are an established technology, although more common in other countries. For example, over 60% of homes in Denmark are heated from a Heat Network, and many of these are community owned. In the UK Heat Networks are less common and tend to be in cities, eg in London Battersea Power station used to heat thousands of homes in Westminster before it closed, and all the sports and other buildings on the Olympic Park in east London are on a Heat Network. On a smaller scale the best example is the Heat Network currently being installed in the village of Swaffham Prior, east of Cambridge.[8]

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[7] Reference Green Heat Networks consultation document 2020

[8] https://www.cambridgeshire.gov.uk/residents/climate-change-energy-and-environment/climate-change-action/low-carbon-energy/community-heating/swaffham-prior-heat-network/about-swaffham-priors-heat-network

Based on EPC data, currently Bishop's Castle properties are mostly heated by oil and LPG boilers, but around 100 houses (11%) are already on heat pumps, another 93 are on storage heaters and 33 are on other electric heating. The use of individual heat pumps is likely to increase over the coming few years. However, there are substantial issues with fitting heat pumps to many of the properties in the town, especially in the older, tightly-developed core where there is little space for fitting air source heat pump units or ground source loops or boreholes. This route to decarbonising heat also puts heavy reliance on the actions of individual householders who have to source installers, compare quotes, make complex financial decisions and see the work through to completion. Also, most individual heat pumps work to low flow temperatures which works better with larger radiators, and they require a hot water tank if supplying the domestic hot water, so fitting an individual heat pump can be quite disruptive.

If a Heat Network can be developed instead it would get around many of these issues. The decision process is simpler, to join or not to join, multiple quotes don't need to be sourced, flow temperatures can be higher, and a heat exchanger can be utilised for domestic hot water. Larger plant is more efficient and generally cheaper, though there are some transmission losses. Centralised plant is smaller in capacity terms than the sum of the sizes of individual plant due to the diversification of heat demands across larger numbers of buildings. Centralised plant also allows for easier and cheaper integration of thermal storage which reduces required plant size and maximises the use of electricity when the costs are lowest. It is also easier to provide a centralised back up system than to provide one for each individual property. Additionally, in Bishop's Castle there is the possibility of accessing cheaper renewable electricity if a heat pump solution is favoured.

4.2. Biomass

If a good local source of sustainable biomass is available, then this can be a low carbon solution, as the carbon released in the burning process is absorbed on a short cycle through forestry re-growth. Thinning of forests and re-planting can both allow for increased carbon absorption to replace the carbon burnt. However, there are issues with biomass, including possible reductions in air quality, higher maintenance costs, the need to carefully manage the quality of fuel and the need for fuel deliveries. We have doubts about the sustainability of using biomass for large-scale heat demand.

However, Ransfords sawmill apparently have spare capacity on their current biomass boiler that could be used to supply relatively cheap heat to a network. This could be used to supply a smaller network or to supplement the heat pumps in a larger network.

A heat price would need to be negotiated with Ransfords, which should be lower in cost than would be the case for woodchip boilers located elsewhere, as the fuel is generated on the site so the delivery costs would very low, and it is the lowest grade of wood fuel available. If the existing 1.3MW of boilers can be worked harder then there would be additional Renewable Heat Incentive (RHI) payable to Ransfords for the additional heat supplied (minus the heat lost in the Heat Network pipework which is not eligible for the RHI). The RHI is payable for 20 years from 2019 and is currently worth 2.22p/kWh, rising each year with inflation. It appears that around 25-30% of the boiler capacity is available. 30% equates to 3,400MWh/yr which has been modelled as a constant 400kW of heat being available. The heat purchase price has been modelled at 2p and 3 p/kWh. 3 p/kWh equates to an approximate wood chip price of £96/tonne and the RHI value Ransfords would receive equates to another £80/tonne, so this gives a value per tonne of woodchip of £176 which is above the current price. Heat from 2039 is assumed to cost 5p/kWh to make up for the removal of RHI. A thermal store is modelled so the constant 400kW available can supply peak load loads of over 400kW. Some rent would be needed to be paid for the Energy Centre and thermal store space (housing back up plant and pumps) if sited at Ransfords. Ground Source Heat Pumps

4.3. Ground Source Heat Pumps (GSHP)

GSHPs use electricity to drive the pumps and compressors required to draw low temperature heat from the boreholes. For a scheme of this size an open loop system would be required where the water in the aquifer is drawn to the surface, and heat is extracted before the water is reinjected into the aquifer. However, the British Geological Survey 'open loop GSHP screening tool' indicates that the ground below Bishop's Castle is not favourable for an open loop system. The alternative is closed loop where fluid is circulated in pipework placed in boreholes to draw heat from the surrounding ground. To achieve sufficient heat extraction for a 525kW heat pump, 200 boreholes each 200m deep would be required. This would be a significant capital outlay of around £1.5m. GSHPs are generally more efficient than air source heat pumps but the efficiency can drop over the years as the soil temperature drops and there is considerable additional cost which gives a negative IRR over 30 years. A large scale GSHP solution is not therefore considered to be viable.

4.4. Ambient Loop Ground Source Systems

An ambient loop system has a small heat pump in each house utilising a shared ground loop system. There could be several separate such loops in Bishop's Castle but the total system would need to include at least 100 houses in order to attract Green Heat Network Funding. The advantages of an ambient loop system are stated as being:-

- There is no billing for heat use,
- The individual heat pumps can be set to the households' requirements e.g. flow temperatures,
- Costs are more flexible, with heat pumps purchased only as extra houses connect,
- There are very low heat losses from the system,
- Pipe work may be cheaper.

However, a similar number of boreholes are needed as for the centralised GSHP and so the capital costs are high.

It would be cheaper to drill the boreholes in large groups so that much of the capital outlay is still required at the beginning of the scheme, but if this is done, the flow rates in ambient loop systems are much higher than for a conventional DH system (e.g. with a flow temperature of 70°C) so the pipe sizes are larger and hence trenches need to be bigger. Pumping costs are also proportionally higher.

All properties would need to have their own domestic hot water cylinder, which could be problematic for those properties that currently have combi boilers.

Thermal storage would be harder to incorporate in the system and it would be difficult to get the individual heat pumps to be powered by a renewable resource.

Carbon Alternatives are therefore not recommending an ambient loop system for Bishop's Castle.

4.5. 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 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 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.

4.6. 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 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 a battery and it is more efficient.
- The heat pump operations at times of highest electricity price can be minimised.
- 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.

The techno-economic modelling in *energyPRO*[9] has been undertaken with a thermal store of 150m^3 of water. A rough economic optimisation has been undertaken to set

[9] http://www.energysoft.com/

this size, with the capital costs of the store paying back in 5-10 years of reduced operating costs and higher (unvalued) CO_2 savings.

4.7. Back Up Plant

It is suggested 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 initial analysis, the 1043kW heat pump can provide 95% of the heat required despite the peak load being estimated at around 3MW. It is the thermal store that is helping the heat pump supply most of the peak requirement which is estimated to be 3 times larger than the heat pump output.

If the lowest CO_2 option is favoured, a larger heat pump would be required, with associated higher project capital costs, or direct electric heating used instead of the oil, 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. Often there can be opportunity to use some existing boilers to provide some of the back-up heat. The boilers of 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 xBuderus GE515 350kW installed 1997

All of these boilers are old and so it is not worth putting a large effort into utilising these boilers. The spaces they 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. This building could also be a good place for the thermal store which would be around 9.5m tall and 5m in diameter. The store would be shorter than the existing chimney which it could sit next to, with the building extended up to cover the store. The floor of the boiler plant room is lower than ground level.

4.8. 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 electricity generation improves the viability considerably, especially as the thermal store allows maximum use of the renewable power. Supplementing the suggested 1MW wind turbine with PV panels improves the viability further.

A wind constraints study was carried out by *Locogen* in 2021[10] and two sites were identified, both to the east of the town. Landscape and visual impact studies have been completed for both these sites and a pre-planning application was submitted in January 2023. The wind turbine suggestion has garnered considerable public support but there is some concern over at least one of the sites. Planning guidance has been very restrictive on new wind turbines for a number of years; this appears to be changing, but both sites are close to or within the border of the Shropshire Hills Area of Outstanding Beauty (AONB) so planning permission cannot be guaranteed.

Sites for a solar array have not been investigated in any depth but they could either be close to the wind turbine or close to the energy centre. We are suggesting a fairly small array by modern standards. Most new commercial solar farms are now 20 to 50 MW, 40 to 100 times bigger than our proposed 500kW.

	ASHP 1043kW Wind turbine 1MW	ASHP 1043kW Wind turbine 1MW & 500kW PV	Biomass
% heat from ASHP or Biomass	92%	97%	100%
% of electricity from PV or wind turbine	61%	79%	0
% of renewable electricity exported	41%	52%	0

Table 1 impacts of renewable electricity generation

[10] See appendix 2

Figure 4 Potential Wind turbine sites

Figure 5 Illustrative Space take of 500 kW of PV

4.9. Recommended Heat Source

The recommendation is for an air source heat pump of around 1MW (a specific ASHP of 1043 kW has been modelled). This could provide over 92% of the total heat required each year. This proportion includes the use of a 150m^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 back-up and to allow for the rare 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 10% 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. The top up and back up boilers could be electric instead of oil which would provide additional carbon savings, but the running costs would increase.

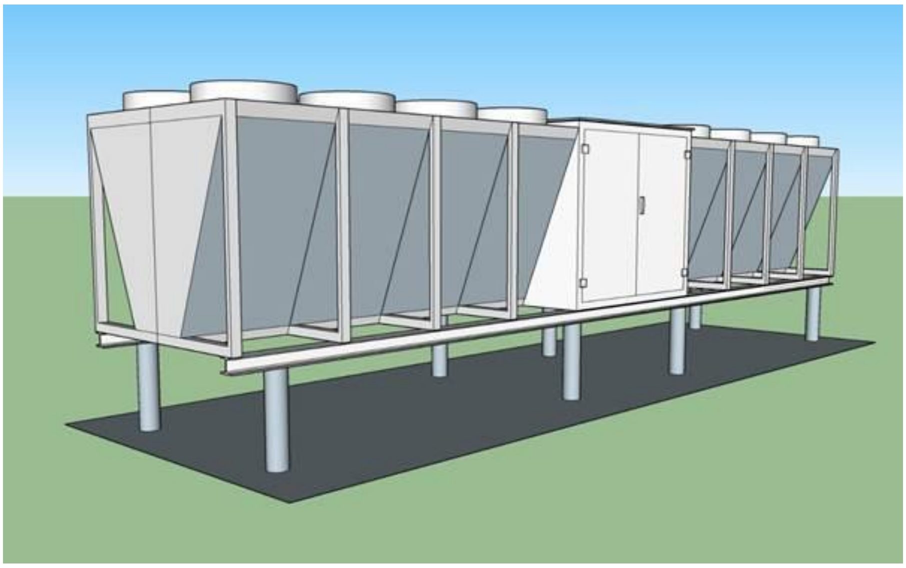

Figure 6 Indicative 827kW ASHP from Solid Energy, 11.6m long, 2.3m wide, 3.5m high.

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

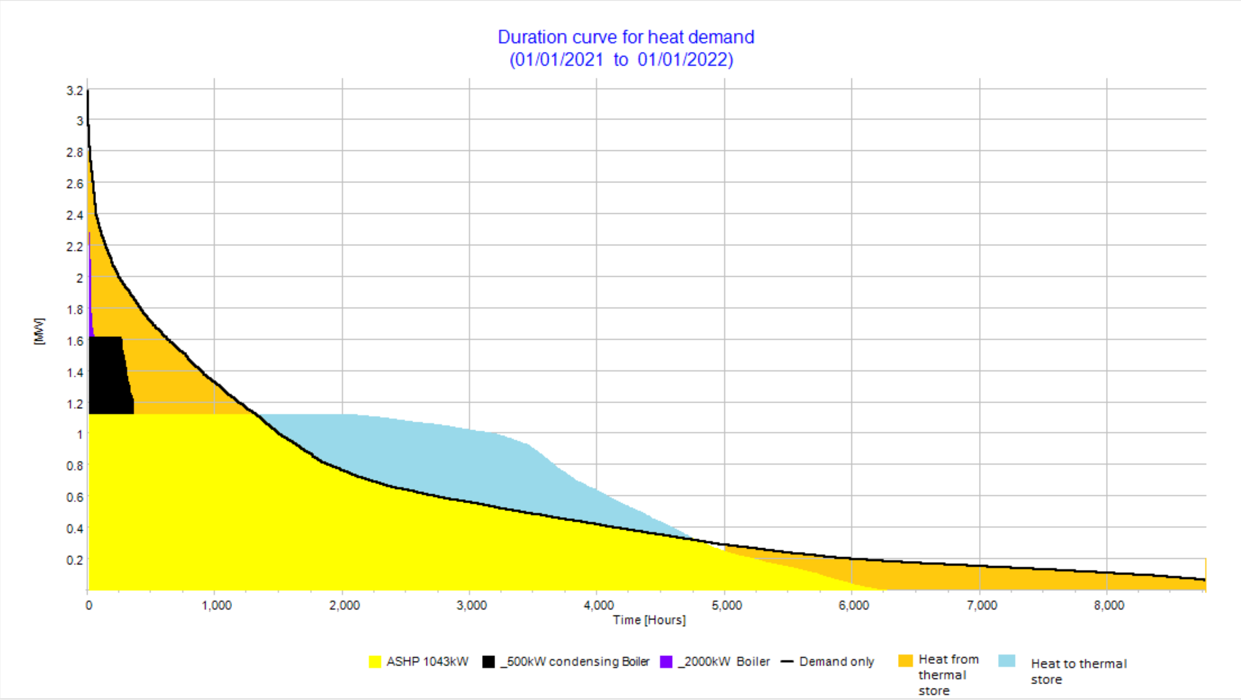

Figure 7 Heat demand supplied by heat pump, thermal store and back up boiler.

Note, in Fig 7 the blue area is heat generated by the ASHP but diverted to the thermal store, the orange area represents the usage of that energy, so some of it can be used when demand is very high, but conversely some would be available when loads are very low. 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.

The alternative recommendation for a smaller and less complex scheme is to utilise the biomass heat available from Ransfords' sawmill. This is less complex as the economics are not reliant on the construction of PV or a wind turbine and the low carbon heat source is already operating. Back-up boilers would need to be installed but Ransfords can provide space for these. The use of the biomass heat could be seen as the first phase of a Heat Network that can expand and incorporate heat pumps and renewable electricity generation at a later stage. It is recommended that the boiler output at Ransfords is monitored to get an accurate assessment of the heat available over the year. The possible Heat Network supplied by the biomass boiler could be significantly larger if a small proportion of the heat supplied was from back up oil boilers.

4.10. Network Pressures and Piping

If the scheme progresses *Carbon Alternatives* would, in the next stage, report on the selection of pipe pressures, pipe sizing and pipe types for the Heat Network.

The pipework would probably be a mixture of steel and plastic pipe. The steel pipe is more durable but more expensive and less flexible. Plastic pipe could be used for the lower diameter runs at the ends of each part of the network. The pipework would have the flow and return together within an insulated core.

5. The Heat Demands and the Opportunity

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[11]. There has been only limited new building in the last eight years. 62% of households are owner occupiers, 17% social rented and 21% private rented. 18% of householders are single person pensioners. There is a community college, a primary school, a Sports and Arts Centre with swimming pool and gym (SpArC), a Library/Resource Centre (Enterprise House), two estates of small industrial units and Ransfords sawmill. There is a care home, a small cottage Hospital (presently closed) and a Doctor's Surgery, several pubs, a hotel and a brewery. There is a parish church and parish hall and a separate community hall. There is no mains gas supply in the area, so most heating is from oil or LPG boilers.

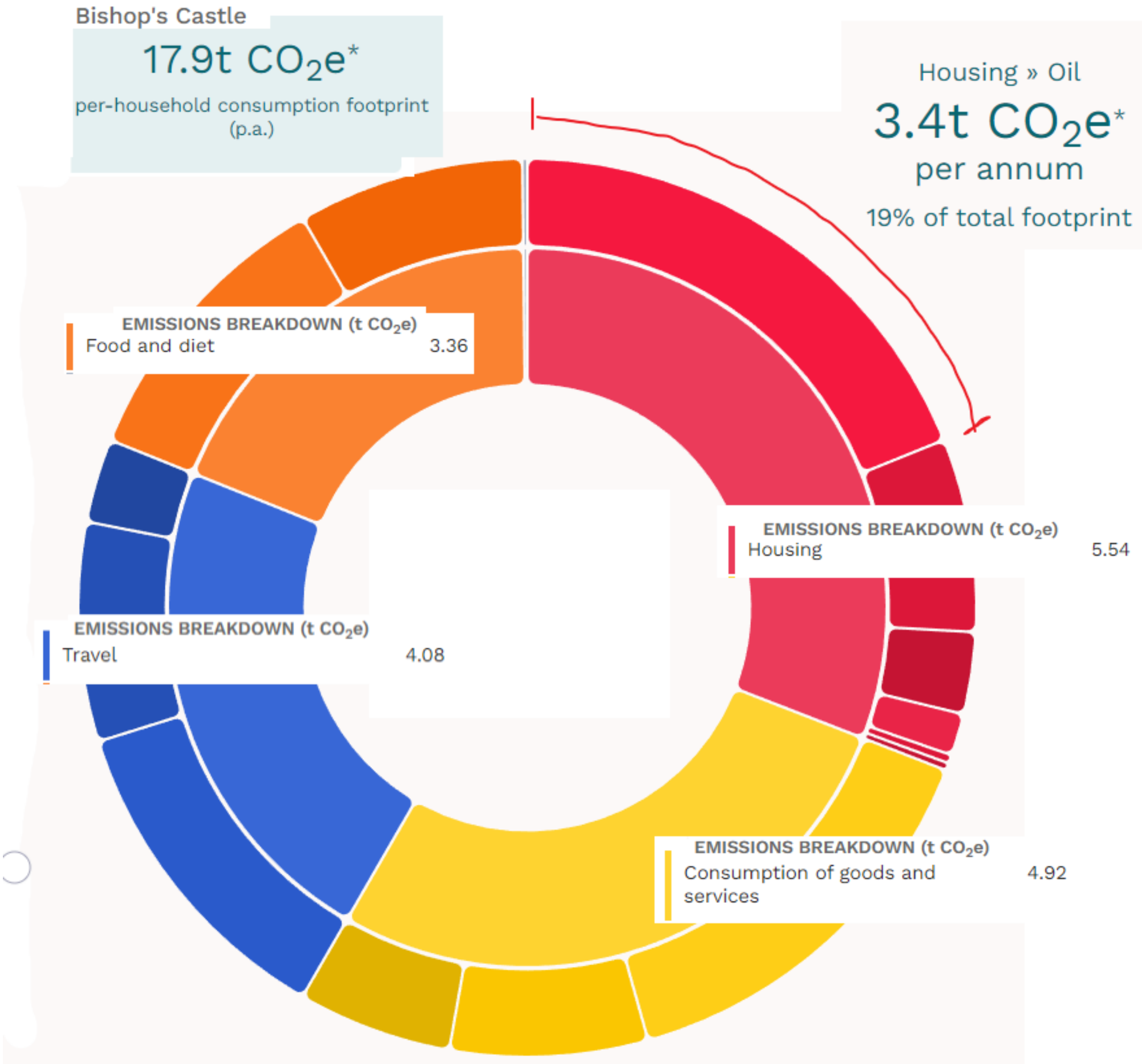

Figure 8 Bishop's Castle carbon emissions from the Impact tool [12]

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[11] *https://www.shropshire.gov.uk/media/3420/bishops-castle-parish-profile-2014-1.pdf*
[12] https://impact-tool.org.uk/

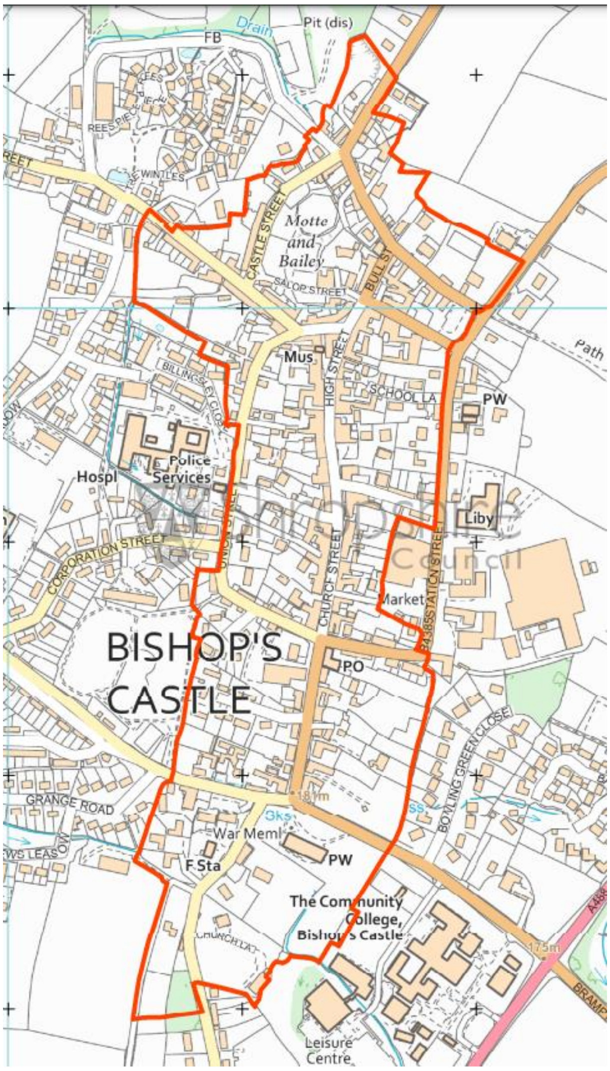

Figure 9 Bishop's Castle conservation area

5.1. Energy Performance Certificates (EPCs)

Of the 507 domestic EPCs on the register 122 (24%) are C rated or better, 180 (36%) are D, 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 spectrum so the total figures for all properties is undoubtedly significantly worse than this. 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.

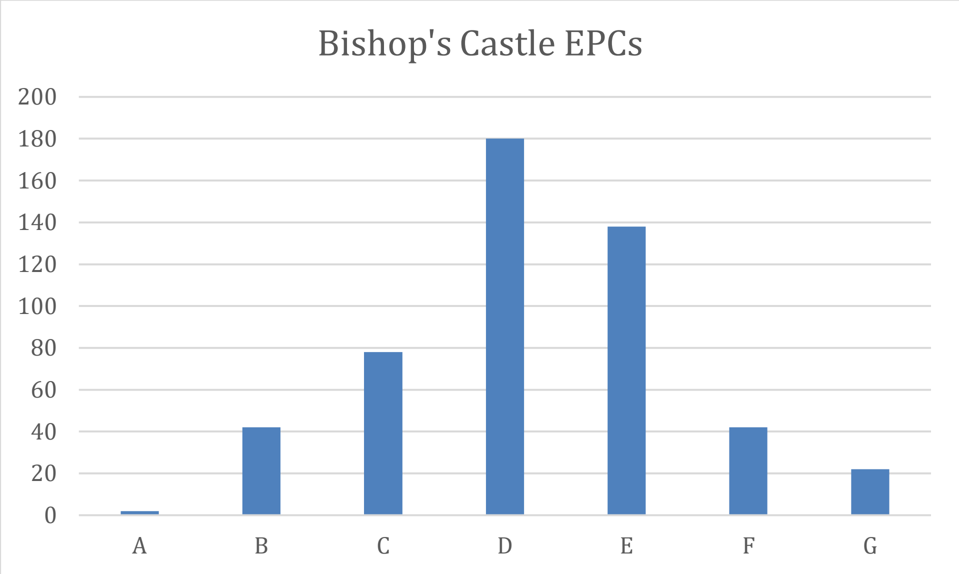

Figure.10 Bishop's Castle EPC ratings

5.2. Existing Heating Systems

The EPC data has been analysed to provide Table 2

	No of dwellings	% of stock	Average KWh/property	CO_2 per property	CO_2 /kWh
GSHP	33	6.5%	10,012	365	0.036
ASHP	64	12.6%	10,212	435	0.043
LPG	44	8.6%	13,357	2,858	0.214
Oil	208	41%	18,425	4,938	0.268
Wood	20	4.0%	16,893	256	0.015
Coal / Smokeless fuel	12	2.3%	18,589	6,743	0.363
Electric	126	25%	13,392	1,710	0.128

Table 2 Current heating mix based on 507 EPCs for Bishop's Castle, with the electricity carbon factors given as an average expected over the next 20 years.

The 19% of houses which already have heat pumps include some Housing Association ground source shared loop properties on Billingsley Close, (16 properties), Clive House (11) Kerry Green (5). The air source heat pumps are concentrated in Grange Road, (18), Clove Piece (8) and the Leys (4) and Oak Meadow (24 recently built). This information is not necessarily complete.

The centre of the town is made up of mostly older, solid walled housing, much of it terraced and situated directly onto the pavement.

The Care Home and Hospital are heated by a biomass boiler. Ransfords have a biomass boiler which is mostly used for drying treated timber. A previous community energy proposal for biomass heating for the Community College and SpArC fell through.

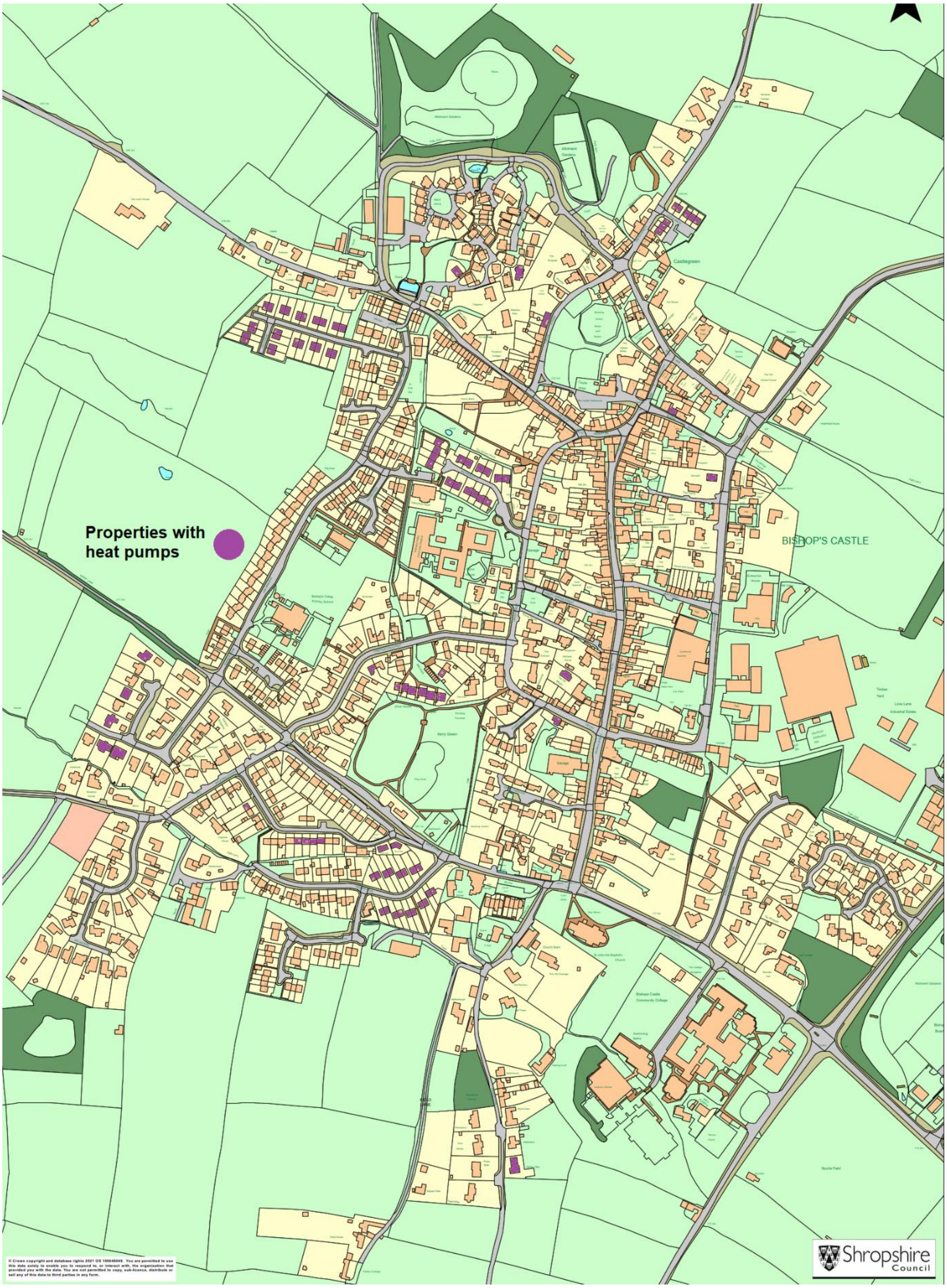

Figure 11 Map of existing heat pumps in Bishops Castle from EPC data (there may be more where a heat pump has been fitted but the EPC has not been updated)

5.3. Heat Loads

Heat loads have been computed for a range of buildings. The actual number and type of building served by the Heat Network will vary as the plans develop.

	MWh/a	number	Data source
Enterprise House	48	1	DEC
Castle Hotel	289	1	Thermos
Residential	1,411	43	EPCs and Thermos
SpArC	598	1	Oil bills
College	500	1	DEC
Non-domestic / retail / unknown	2,113	45	Thermos and EPCs
Total	4,670	92	

Table 3 Heat loads

The load type is taken from Thermos, which takes this data from *OpenStreetMap*[13] Some of the residential, and some of the unknown, will be buildings with multiple residences in it. *OpenStreetMap* in many situations draws the building outline on to the map without separating out the individual properties e.g. the whole terrace is on the map but not the number of individual houses. Where possible *OpenStreetMap* has been updated e.g. separating buildings into 2 semis and splitting terraces into the correct number of individual houses. This has been done where the information can be drawn from: the Ordnance Survey map, Google Maps, Google Street view (some of which is more than 10 yrs old). This is difficult for the High Street and Church Street and so the mapping is not that accurate. Putting the EPC data into Thermos is similarly challenging for Church Street and the High Street as it's not easy to place every EPC address and street number onto the map. Both the mapping and the placing of the EPC data onto the correct building has been done for all of Bishop's Castle and is much more accurate away from the older parts of the town such as Church Street, High Street, Welsh Street, Salop Street, Bull Street etc.

5.4. Heat Network Areas, Energy Centre and Wind Turbine

Carbon Alternatives have carried out financial modelling for two potential Heat Networks:[14]

Scenario 1: A larger network supplied mostly by air source heat pumps, with thermal storage and oil boilers providing back-up and top-up.

Using grid electricity for such a system does not provide cheaper heating than oil or LPG heating or offer a return on investment. The viability of air source heat pump systems improves if cheaper electricity can be sourced from a local renewable energy source. The best fit for this renewable energy source would be wind power and two potential

[13] https://www.openstreetmap.org/
[14] *See section 5.4 for detail inc maps*

sites for a 1MW wind turbine have been identified to the East of the town. A pre-planning application has been submitted for these sites. Wind power gives a better match to the seasonal energy demands of a Heat Network than photovoltaic panels (PV), but it has been identified that adding 500 kW of PV to the scheme would increase the viability and reduce oil use further as the PV will provide energy at times when wind energy is not available. This arrangement gives around 5.3% Internal Rate of Return (IRR) over 30 years.

Scenario 2: A smaller heat network utilising the spare heat capacity from Ransfords' biomass boiler.

Matching the available heat results in a smaller Heat Network. This smaller network prioritises the larger loads as these will have the best economic returns. These larger loads are the Community College, SpArC, Enterprise House and the houses along the pipe routes that serve the larger loads. This network shows reasonable viability at 3.2 to 4.7% IRR over 30 years (depending on the biomass price negotiated) and would not be reliant on installing the wind turbine or solar panels, although these could be utilised to extend the scheme.

Scenario 1 would supply a heat demand of around 5,000 MWh/a, Scenario 2 2,000MWh/a, so both schemes would be eligible for Green Heat Network funding. Either network could be extended to other parts of the town once the core area is established.

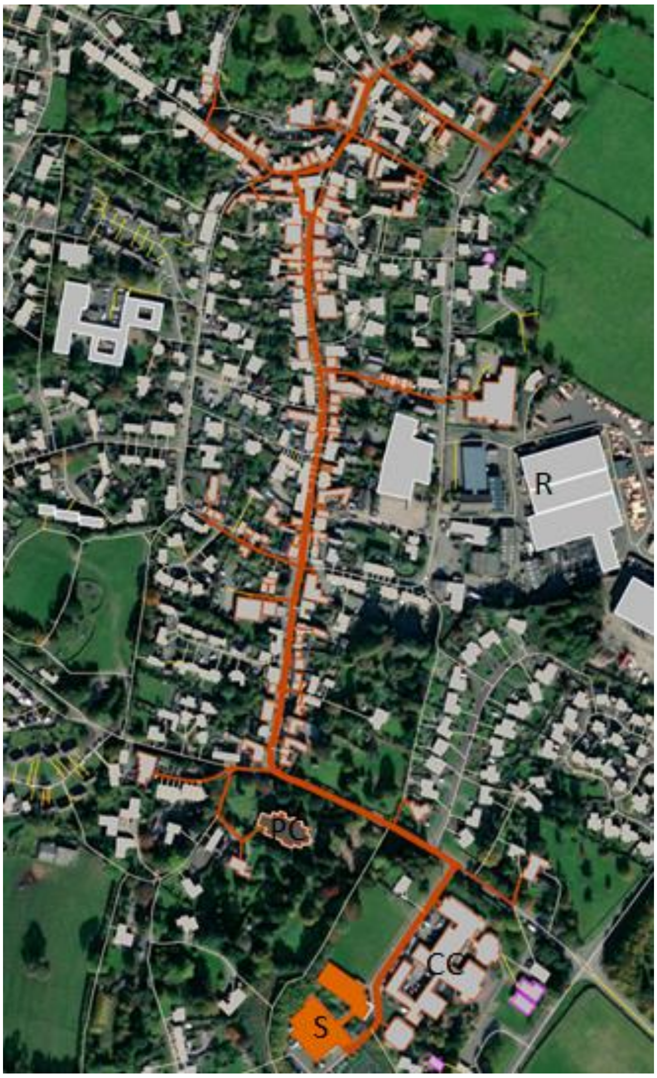

Figure 12 Proposed larger heat network based on heat pumps

The orange building at the bottom labelled S is SpArC, the grey building NE of this labelled CC is the Community College, the grey building outlined in orange labelled C is the parish church. The larger grey buildings labelled R are Ransfords

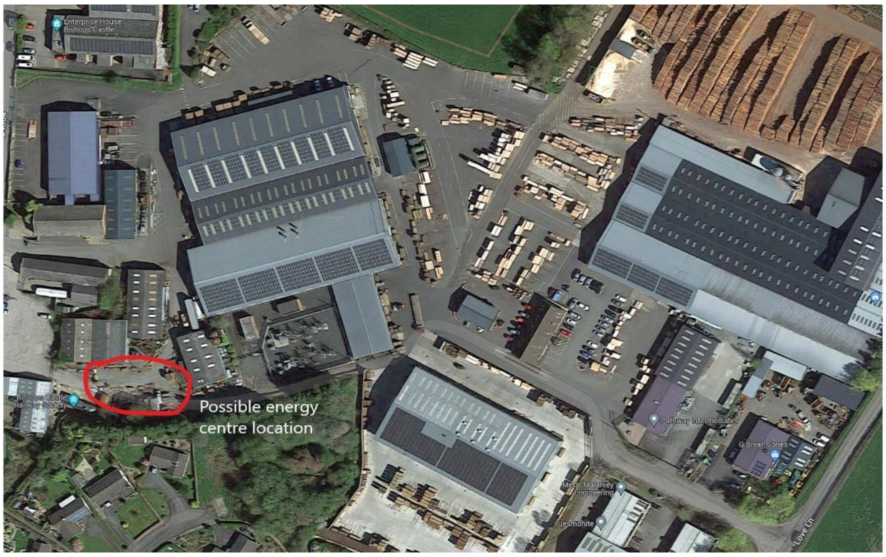

Figure 13 Possible energy centre location at Ransford's

Figure 14 Proposed smaller heat network based on biomass boiler at Ransford's

The building at the bottom labelled S is SpArC; the grey building NE of this labelled CC is the Community College; the grey building labelled PC is the parish church. The larger grey buildings labelled R are Ransfords.

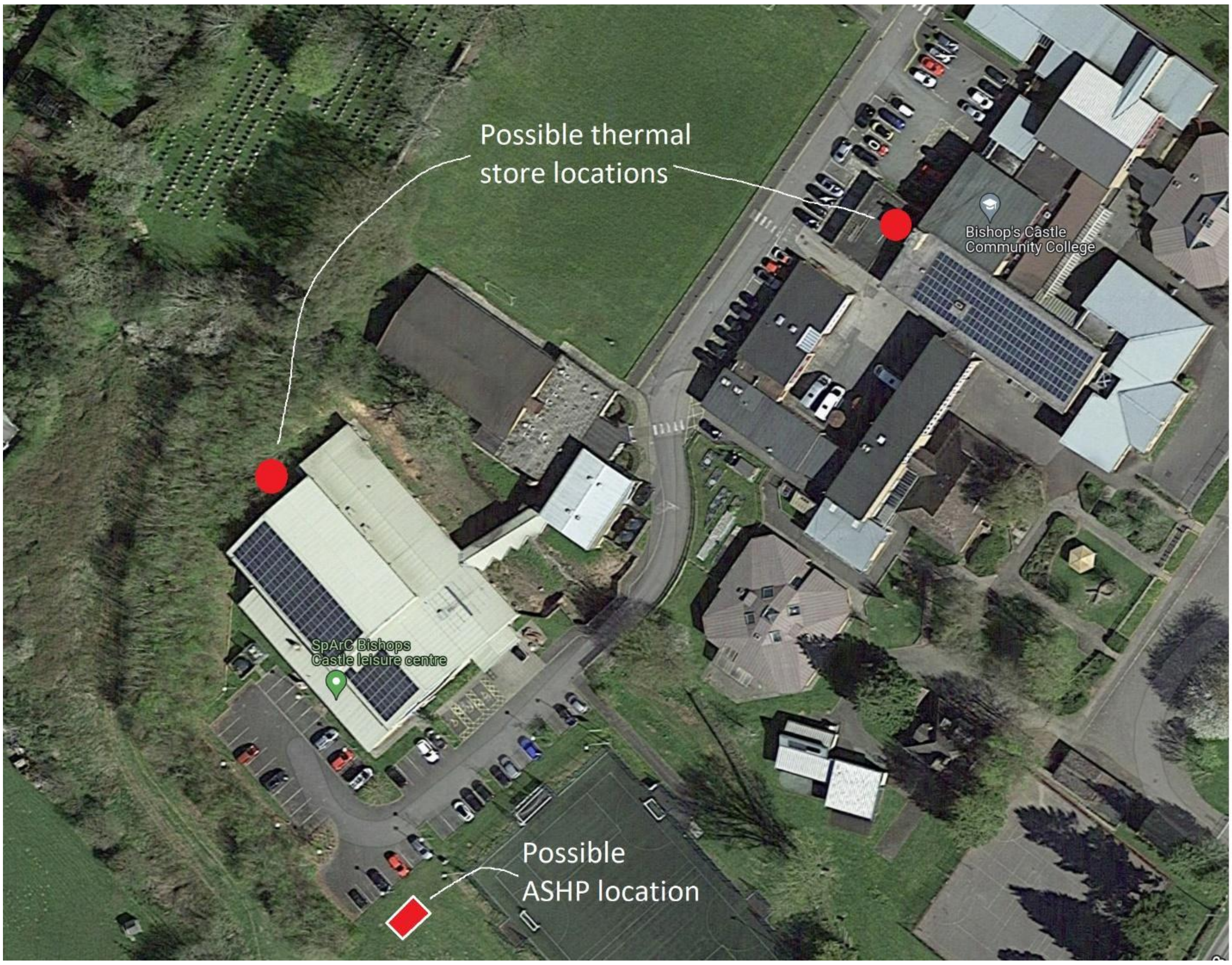

Figure15 Possible energy centre and thermal store sites at SpArC/Community College

Possible thermal store locations. The SpArC hall is approximately 10 m high so the thermal store would be lower than the existing roof line if located near to the ridge of the roof.

Figures 16 &17 Possible thermal store locations at Community College & SpArC

Figure 18 Indicative energy centre building. Any heat pumps would be situated adjacent to this.

6. Financial and Carbon Projections

6.1. Assumptions Made

At the time of writing this report, there is a situation of considerable flux in energy prices. *Carbon Alternatives* have assumed that prices will fall in the next couple of years, before the Bishop's Castle Heat Network could be installed, but will not go back to their previous levels.

		p/kWh	Notes
Oil price		11	Allowing for efficiency of the boiler
Electricity price from grid, day		26	
Electric from grid, night		21	
Electricity from wind turbine		14	
Biomass		2 to 3	
Sale price of the heat		10	
Standing charge	£400		Per property/annum
Connection Charge	Free		For those properties joining when the heat network is installed.
Inflation rate	2.5%/a		Across the board
Share Interest paid	3.0 to 5.0%/a		

Table 4 Assumptions made

The £400 standing charge is based on the Heat Network avoiding the cost of:

Boiler servicing	£100/yr
Boiler repairs averaging	£50/yr
Oil boiler replacement	£2500 / every 12.5 years (£200 /yr)
Oil tank replacement	£1000 / every 20 years (£50/yr)

The standing charge would include the maintenance and replacement every 20 years of the heat interface unit (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 10p/kWh represents a small discount on the estimated medium term oil price of 90p/litre, which based on a boiler with 85% efficiency, results in a heat cost of 11.25p/kWh. 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.

LPG tends to be a little more expensive than oil so the DH connection would be better value for LPG users. For electrically heated properties 10p/kWh is much cheaper than their current unit costs, but the £400 standing charge is much higher than the costs for owning and maintaining electrical heating systems. 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.

For the scenarios without the wind turbine, it may be possible to get marginally cheaper grid prices for bulk purchase, but this would still not make these scenarios viable. With the wind turbine the use of grid electricity would be much lower so a high price/kWh should be assumed. Because the air source heat pump schemes would both sell electricity to the grid and buy it back from the grid, changes to electricity prices do not have as much effect on the economics as they would for a scheme that was only buying or selling electricity.

Oil prices are particularly difficult to estimate and as the Heat Network prices will need to be cheaper than the current oil price, this can 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. At the moment, 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 could help to 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 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. 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 SpArC
- And the resulting amount imported to meet the SpArC and heat pump loads (the most expensive element).

The energyPRO modelling also assumes that the renewable electricity produced will be prioritised for use by SpArC with the heat pumps taking anything not required by SpArC 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 set up 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 SpArC is open and then the system might offer unwanted electricity to SpArC when it has already closed for the night. This system works well if SpArC pay a similar price for the electricity they use whether it comes from the grid or from the renewable resource. If a sizeable discount for electricity is to be offered to SpArC then this modelling would need to be reviewed. In any event SpArC will benefit from reduced heat costs and protection from oil price spikes.

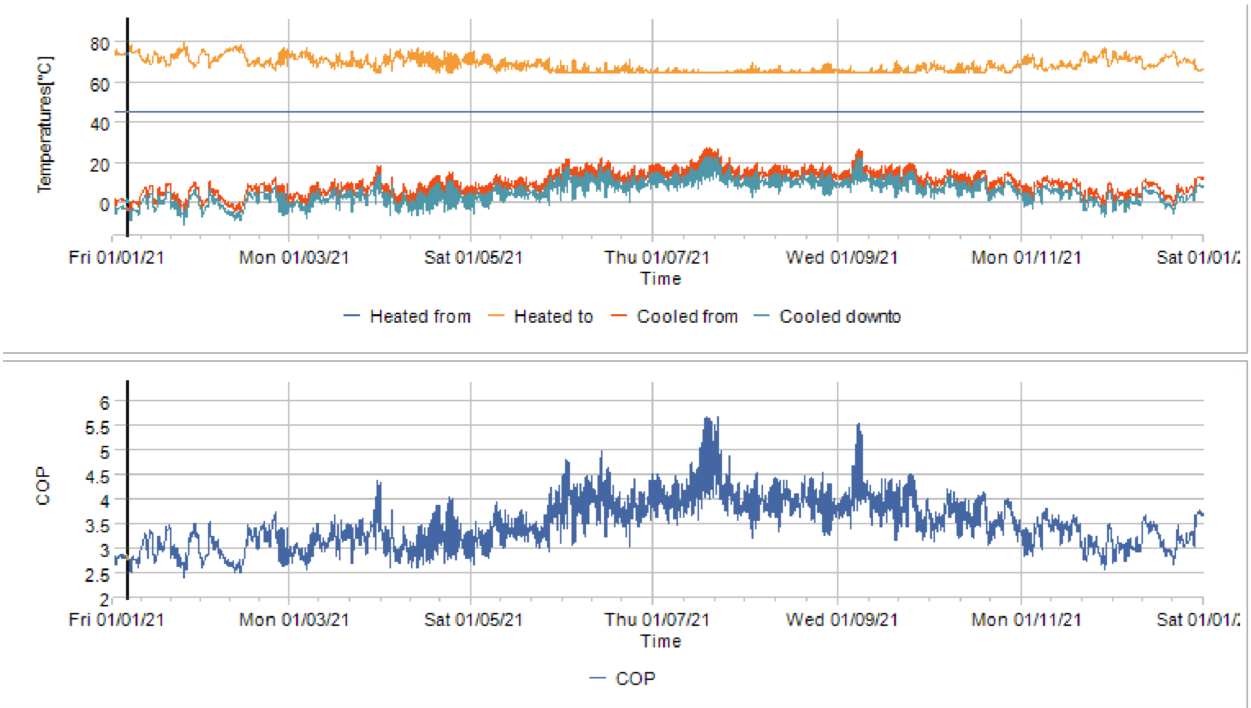

Figure 19 Heat pump Coefficient of Performance (CoP) variation with ambient and output temperatures

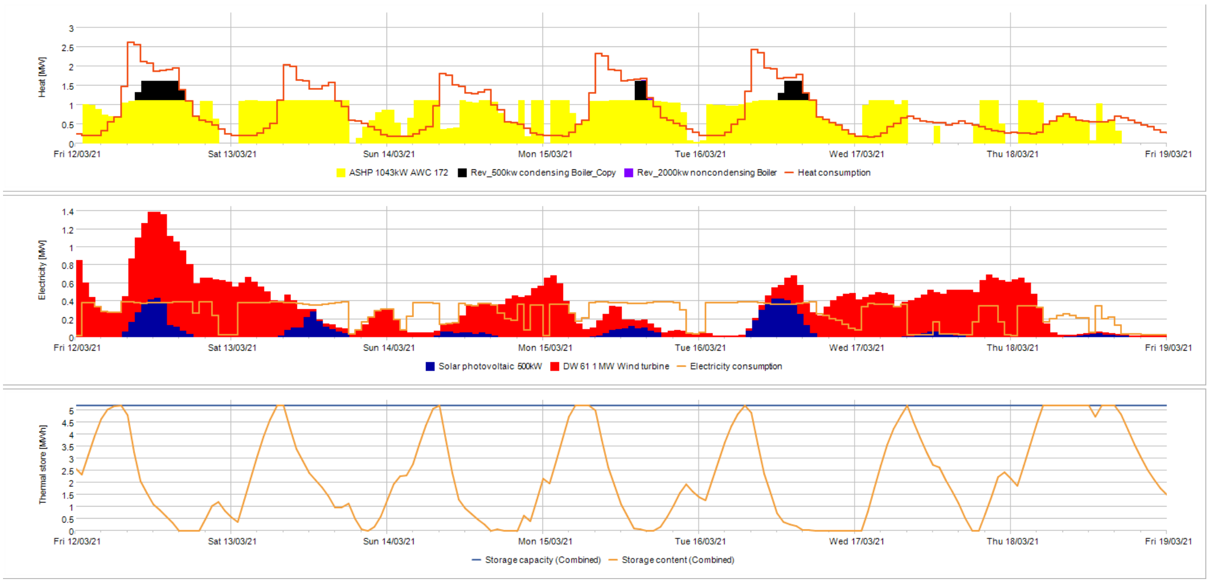

Figure 20 Plant operation for sample week, including thermal store charging/discharging

Inflation rising at faster than 2.5% would increase the income from sale 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 so the scheme would return a slightly higher surplus but not significantly so.

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

The *energyPRO* software has used space heating demand figures from the available Energy Performance Certificate (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. The EPC software assumes average occupancy for a property, if an occupier works from home, is 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. Reducing the use of secondary wood stoves would improve the air quality in the town, and it is likely that there will be more restrictions on the use of such stoves in the coming years.

6.2. Air Source Heat Pump Finances

All scenarios allow for 150m³ of thermal storage	ASHP 1043kW Wind turbine 1MW	ASHP 1043kW Wind turbine 1MW PV 500kW	ASHP 1043kW Wind 1MW PV 1MW
Heat supplied MWh/yr	4990	4990	4990
Heat sales year one £k	458	458	458
Electricity sales to SpArC £k	75	75	75
Oil £k	33		
Electricity import year one £k	157	107	89
Electricity export year one £k	58	81	118
Total energy costs year one £k	132	59	4
Marginal cost of heat delivered p/kWh year one	2.86	1.26	0.09
Capital cost (before grant) £k	9,160	9,660	10,130
Capital needed after grant £k	6,000	6,450	6,900
Extra capital required for renewal of equipment around year 20	£3m		
Life of the project 4	40 years		
Net revenue year one before interest & capital repayments £k	320	400	450
Project IRR 30 year (incl. GHNF grant)	4%	5.3%	5.9%

Table 5 Heat pump finances Year one

It can be seen that the most viable heat pump schemes are those that incorporate 150 m³ of thermal store, a wind turbine and solar panels. It is unlikely that a site sufficient for 1MW of solar panels could be found so the scheme with 500 kW is the preferred option.

A return on investment for the project of 5.3% over 30 years would be acceptable for a community run scheme, but it has to be remembered that this is an initial estimate, and this figure will undoubtedly change as more studies are carried out and detailed costings become available. The returns to investors would need to be lower than this to allow for surpluses to be created. The returns are also dependant on the future prices of oil and electricity, as some electricity will still need to be purchased and the price of heat delivered cannot rise above the equivalent price of oil.

At 5.3% IRR and 2.5% inflation the original capital cost and the 20-year renewal costs of the scheme with a wind turbine and 500kW of PV can all be paid back in 30 years and there is a surplus at the end of this period of around £1.2m in today's values. The scheme should continue for at least another ten years after this. There are also significant other advantages of the scheme for the town and for the wider environment.

6.3. Biomass Scheme Finances

Scenarios with initial biomass heat cost at 2p and 3p have been investigated. Please note that Ransfords, initially, would also earn RHI on this heat. The rate has been increased to 5p from 2039 to allow for higher price required post-RHI.

	Biomass at 2p/kWh	Biomass at 3p/kWh
Heat supplied MWh/yr	20338	20338(?)
Thermal store size m^3	50	50
Oil £k	2	2
Heat sales £k	182	182
Biomass heat cost £k	41	61
Electricity import £k	8	8
Electricity export £k	0	0
Total energy costs £k	49	69
Marginal cost of heat delivered p/kWh	2.4	3.4
Capital cost (before grant) £k	3,210	3,210
Capital cost after grant £k	1700	1700
Net revenue year 1 before interest & capital repayments £k	110	90
Project IRR 30 year (incl. GHNF grant)	4.6%	3%

Table 6 Biomass finances

Biomass even at 2p/kWh gives a lower IRR than the heat pump plus renewables option. There are also some risks to having a Heat Network that is dependent on one business.

6.4. 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 the Heat Networks make the economics challenging but the Government understand 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 that 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 the capital funding was via the Heat Network Investment Project, which has now been replaced by the Green Heat Networks Fund.

6.5. Green Heat Network Fund

The Green Heat Network Fund (GHNF) can provide funding for up to 50% of the capital and later stages of development for Heat Networks. Without such funding no Heat Network would be viable, so all scenarios have assumed a successful bid to the GHNF. However, not all costings may be eligible for GHNF subsidy so slightly less than 50% funding has been assumed. 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 runs until March 2025, but based on the stated Government intention to increase Heat Networks there is a strong assumption that another funding scheme will be announced to replace GHNF well before March 2025 to maintain momentum.

6.6. Capital Costs

The capital costs estimated by Carbon Alternatives are significantly higher than the cost of fitting individual ASHPs if the £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 which will last 40 years plus, so the Heat Network cost over a 40-year cycle should actually be similar to a scheme promoting individual heat pumps. The capital costs estimated for Bishop's Castle assume there has been some learning and cost reduction from the Swaffham Prior project. There are 92 connections to the Heat Network in the ASHP scheme and 51 connections in the biomass scheme.

Capex (£'000)		ASHP 1043kW Wind 1MW	ASHP 1043kW Wind 1MW PV 500kW	Biomass
Heat pump		£747	£747	
Wind turbine and PV		£1,650	£2,050	
Thermal store		£150	£150	£100
EC Building and elec connection		£340	£370	£112
Back up boilers 1.9MW and oil tank		£200	£200	£140
Non domestic sized connections		£75	£75	£75
Pumps, controls, water treatment		£180	£180	£100
Heat network pipe work		£3,150	£3,150	£1,689
House connections, HIU metering		£547	£547	£303
Commissioning		£100	£100	£50
Project management, design, contingency	25%	£1,785	£1,892	£642
Total £k		£8,924	£9,462	£3,212
Total eligible for GHNF		£6,862	£6,899	£3,212
Green Heat Networks Fund Grant	47%	£3,225	£3,243	£1,510
Investment needed £k		£5,700	£6,220	£1,700

Table 7 Capital costs

6.7. Ongoing Costs

All the scenarios allow for costs for billing of customers, administration of a CBS, insurance, maintenance etc. The heat pump scenarios also allow 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 scenarios with larger heat pumps, wind electricity and smaller take up are more expensive to install but have lower running costs as they place less reliance on the back-up oil boilers and grid electricity.

6.8. Rates of Return

Carbon Alternatives have calculated the Internal Rate of Return (IRR) for the different 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 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.

The only realistic financial scenarios therefore appear to be

1, The 1043 kW ASHP with 150 m3 of thermal storage, a 1MW wind, and 500kW solar at a project IRR of 5.3%

Or

2, The Ransford's biomass smaller network which has a project IRR of 4.6% at 2p/kWh for the heat supplied by Ransfords.

6.9. Carbon Savings

The carbon emissions savings from the proposals have been estimated at

	ASHP 1043kW Wind turbine 1MW	ASHP 1043kW Wind turbine 1MW PV 500kW	ASHP 1043kW PV 500kW	ASHP 1043kW Wind 1MW PV 1MW	Biomass heat from Ransfords
CO_2 emissions tonnes/yr	206	110	263	2	37
CO_2 reduction tonnes /yr	913	1,010	857	1,118	405
kg CO_2 per kWh heat delivered exc. construction	0.045	0.024	0.057	0.000	0.020

Table8 CO_2 savings from options assessed.

The current average CO_2 emission from heating in Bishop's Castle is around 0.226 kg CO_2 per kWh of heat.

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 of carbon factor for the imported electricity expected over the next 20 years of 128g/kWh. These figures assume the heating demand per property falls by around 10% due to energy measures to be fitted alongside the heat pump. The CO_2 savings from Ransfords biomass heat are lower as the amount of heat available is smaller. The assumed CO_2 emissions from biomass is the standard Government figure. In reality the woodchip used at Ransfords is waste wood which is generated on site and has no additional CO_2 emissions due to delivery. The biomass option reduces the CO_2 emissions for heating for connected customers by more than 75%.

Without a Heat Network installation there would be some CO_2 reduction over time as around 10% of the current heating is from electricity use and the carbon factor for electricity 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 20% as it will be very difficult to fit individual heat pumps to most of the houses in the core of Bishop's Castle.

7. Planning & Permitting

A pre-planning application for the wind turbine was submitted to Shropshire Council in January 2023. A full planning application would be needed for the wind turbine, Energy Centre and PV panels, plus permissions to connect to the grid and to lay the Heat Network pipes. The wind turbine permission is likely to create the largest obstacle. Permission from the District Network Operator (DNO) to connect the renewable assets to the grid will also be required. The local grid capacity maps appear to show that there is capacity for the scheme to connect to the grid, but this needs to be verified.

8. Operation and Governance

If the scheme progresses, there are five options,

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. This CBS 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 admin 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). Whilst STCE have been supportive of the scheme to date they have made no commitment to taking the Bishop's Castle Heat Network on as a live project. The advantage of using STCE rather than a new CBS is that they have access to wider resources and expertise and could then consider delivering similar schemes elsewhere.

3. Partner with a specific Heat Network CBS. In 2022 *Sharenergy* submitted a grant application to the Energy Redress scheme to set up a UK, community-owned Heat Network society. Unfortunately, that application was not successful but if alternative funding is obtained Sharenergy would be very interested in including the Bishop's Castle Heat & Wind project in the new society.

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.

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.

9. Next Steps

9.1. This study has not calculated the figures for a hybrid scenario whereby heat pumps are supplemented by Ransfords' boiler, but that would be a useful next step.

9.2. A pre-planning application has been submitted for the wind turbine sites. The response to this application will dictate what happens with the heat pump option.

9.3. If the wind turbine pre-planning application is positive then ecology studies should be started on the preferred site.

9.4. Negotiations should also be started with SpArC and the Community College and the relevant landlords over the sites for the turbine, PV panels and the energy centre.

9.5. A survey of heating pipe routes to improve pipe installation cost estimates should also be initiated.

9.6. If the use of Ransfords' spare capacity is considered to be worthy of investigation,

- monitoring of heat output from Ransfords' biomass boiler to better understand the heat available would be useful.
- The quantity of the spare capacity and availability of low-grade timber at Ransfords should be verified,
- negotiations with Ransfords over the heat price, location of Energy Centre etc., should be started.

9.7. Limited further funding is available through *Power to Change's* Next Generation scheme, accessed through STCE, but this is not sufficient to cover all the items above so further funding needs to be sought. Potential funders and supporters should be approached, including Shropshire Council and the HNDU.

9.8. Local support for the scheme will be vital and further public consultation on the proposals should be carried out at regular intervals to keep residents and the Town Council informed of developments.

10. Appendices

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

10.2. Wind turbine constraints study (*Locogen* 2021)

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

10.4. Public meeting Sept 2021 Poster

10.5. Wind Turbine Pre-Planning Application (Energy Workshop 2023)

11. Version Tracker

Date	Version number	Created By	Reviewed by	
29/11/22	1	Dave Green	Martin Crane	
21/12/22	2	Dave Green	Martin Crane	Some revision of calculations
6/1/23	3	Dave Green	Martin Crane	Further revision of calculations
18/1/23	4	Dave Green	Rebecca Oliver, Richard Lane, Jon Halle, Martin Crane	Further corrections to calculations, revision of conclusions. Some clarifications added
28/2/23	5	DG/MC	FH	Addition of map of heat pumps, more info on heat network funding, alterations to exec summary.
3/3/23	6a	DG	MW/DL	Minor tweaks
20/3/23	7	DG	FH	Minor tweaks

This feasibility study has been supported by *Shropshire and Telford Community Energy*, utilising funds from the *Power to Change Next Generation* grant.