# Brassington Heat Network Feasibility Study


A Report on behalf of

Brassington Community Heat CiC

Funded by Rural Community Energy Fund (RCEF) Stage 1

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# Contents

# 1. Executive Summary

## 1.1. Background

Brassington is a village in Derbyshire, near Carsington Water, SW of Matlock. It has 233 houses, a primary school, two pubs and a village hall. 15 of the houses are holiday lets, 14 are second homes and 15 are listed as unoccupied. There are some farm buildings on the edge of the village but no other business premises.

Brassington Community Heat CiC commissioned this report into the feasibility of a heat network for the village with funding from the Rural Community Energy Fund (RCEF) through the Midlands Energy hub (now the Midlands Net Zero hub).

Sharenergy have led the project with technical support from Carbon Alternatives and 3D Technical Design. Sharenergy are Community Energy specialists, working with a range of projects and societies across the UK. Carbon Alternatives specialize in heat network design and feasibility, 3D Technical specialise in pipe design and layout. In addition, a wind constraints study was carried out by Locogen.

Brassington is not on the mains gas grid so most of the houses are heated by oil or LPG. As far as we are aware 9 of the houses have individual air source heat pumps; 8 of these are Housing Association properties in the middle of the village. One house in the SW corner of the village has a ground source heat pump using trenched pipes.

The centre and northern part of the village is made up of mostly older solid walled housing, much of it terraced and situated directly onto the pavement. There are however some newer houses intermingled in this area. The southern part of the village, around the primary school is mostly 1950s semi-detached housing that was originally council housing, again with some newer properties intermingled. The roads in the centre of the village are fairly tight and some of the houses are off narrow paths. There is evidence that the roads have been excavated for services renewal, many of the roads are laid directly onto hard rock and we understand that such excavations were difficult to carry out.

Brassington sits on a mix of geological types and there are old mine workings, many of which have not been mapped.

## 1.2. Existing Properties

Of the 141 Energy Performance Certificates (EPCs) studied 11 (8%) are G rated (the worst rating), 35 (25%) are F rated, and 45 (32%) are E rated. So, 65% of the properties are in the lower three bands. It is likely that a higher proportion of the properties without an EPC are in these lower bands, so it is likely that 70% plus of all the properties are in these lower bands. Lower rated properties are more expensive to heat and with fuels such as oil and LPG the carbon emissions are also very high with an estimate of 11.3 tonnes of $CO_2$/household/annum excluding food, travel and general consumption. This compares to a UK average of 3.5 tonnes/household/a.[1]

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

Five of the houses in the village and the primary school were studied in depth, in the five houses the improvement recommendations included:

One cavity fill,
One major loft top up,
One insulate large areas of sloping ceiling,
Two balance the heating system,
Two consider fitting a heat pump,
Two consider fitting PV.

So, whilst there is scope for some energy improvements to these properties the opportunities are fairly limited, especially as much of the village is a conservation area, and without undertaking deep whole house retrofitting the fuel savings are unlikely to be more than around 10%. Ideally if this scheme progresses energy surveys would be provided to all interested households with assistance to undertake energy improvement measures.

All the five properties could connect to a heat network but:

- One has only recently fitted a new bottled LPG boiler
- One has very low oil usage (only 700l/a)
- One has no existing radiator system
- Two have problems with some radiators not getting hot enough.

The school has an oil boiler feeding a mix of fanned radiators and radiant ceiling heaters with oil use of 4,500l/a (45,000 kWh, equivalent to 2 to 3 houses). New glazing is to be fitted at the school and the loft insulation could be topped up in some areas, but the walls are solid stone and difficult to insulate.

Derbyshire Dales District Council are considering offering grants for home energy improvements to householders in Brassington over the coming 9 months through the HUGs programme. This could include fitting individual air source heat pumps.

Most of the properties, including the school, have the current boiler and fuel tank at the rear of the property which is not ideal for connecting to 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 village. It would also enable the removal of oil and LPG tanks, improve air quality in the village 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 in, it is assumed that those joining at the start of the project would not pay a joining fee, though a standing charge would be levied on a quarterly basis, similar to such charges for electricity or mains gas.

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, utilizing EPC data and the Thermos heat network software. No waste heat resource or need for chilling has been identified in the village. It is assumed that grant funding of 50% could be obtained through the Green Heat Network Fund (GHNF)[2], this would require the system to be connected to at least 100 houses (43% of the village).

Ground source heat pumps on this scale would have to use deep boreholes; it's considered that this would be risky given the mix of geological types and the existence of badly mapped mine workings. This also rules out the use of the ambient loop systems developed by Kensa which are being installed at Stithians in Cornwall.[3]

Biomass boilers would require a considerable, carefully graded feedstock and careful attention and maintenance. It would be difficult to source such resources locally. A biomass system also does not appear to offer a return on investment. It is considered that biomass is better used as a top-up fuel in good quality wood burners than as a whole village heating solution.

Air source heat pumps offer a more reliable 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 risk. It is assumed that the heat network would run at a variable temperature which would be high enough to ensure sufficient heat output for the prevailing external temperature, such that most radiators would not need to be replaced. This will result in lower heat pump efficiencies for a small proportion of the year.

Carbon Alternatives have carried out financial modelling for a heat network supplied mostly by air source heat pumps, with 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 but is still very marginal. The best fit for this renewable energy source would be wind and fortunately there are four 2MW wind turbines within 1.4 km of the village. This site is owned by Engie and initial discussions with Engie representatives have shown that they could be interested in supplying electricity to the heat network.

Even with the wind turbine at 60% take up in the village, the return on investment would be 0.3% over 30 years and only around 2.2% over 40 years. This is a very low rate of return which leaves very little margin for error. This assessment is based on a prudent view of fuel prices over the next few years. If the current very high prices continue, then this analysis could be re-visited.

The scenario with 60% take-up of the air source heat pump and wind combination gives around 700 tonnes of carbon saved/annum. If a way could be found to get paid for this at, say, £50/tonne that would give an additional income of £35k/a. If these payments can be maintained this brings the 30-year IRR to 2.0%, and the 40 year IRR to 3.8%. This is still very low, there is no current mechanism in place to attract these payments and it will

[2] https://www.gov.uk/government/publications/green-heat-network-fund-ghnf
[3] https://www.inyourarea.co.uk/news/stithians-to-benefit-from-8-7m-ground-source-heating-project/

be difficult to argue any additionality to attract carbon payments once the heat network is established.

The return on investment does improve with higher rates of take-up as the cost per property falls but this is considered unlikely at least in the short to medium term and indeed even achieving 60% take up would be challenging. Whilst there was a very good turnout and a high level of interest at a public meeting in Brassington Village Hall on 28th April 2022 only a handful of feedback forms have been submitted to date.

It is anticipated that costs for installing heat networks will fall as they become more common and fossil fuel prices are likely to rise relative to electricity prices, so a heat network may well become viable in Brassington in the future.

It is also noted that at the moment there is no funding for smaller renewable heat schemes. Individual homeowners can claim the Boiler Upgrade Scheme £5k and networks over 100 houses (or 200 houses in areas with mains gas) can get Green Heat Network funds but there is nothing for schemes in between these, such as used to be available through the Non-Domestic Renewable Heat Incentive. Such middle-sized schemes would be more appropriate, and less challenging for Brassington and similar villages.

## 1.4. Heat Network Routing

3D Technical Design have carried out a detailed assessment of routing options for the heat network [4]

They have highlighted the potential difficulties relating to excavation in rock due to very shallow soil in many areas of the village, including Hillside and Bowling Green, where the road structure appears to be located directly on the bedrock. They recommend that investigation of rockhead levels and strength would be needed for further evaluation of the network routes, but that is outside the scope of this initial study.

3D Technical have also highlighted the issues relating to the confined routes within the village and that any heat network installation would need to be carefully planned with local agreement on appropriate works phasing and traffic management plans.

Some routes within the village are considered so constrained as to be best avoided, such as the footpath connecting Manor Close and Church Street, and another path connecting Church Street and Hillside. Other routes have issues with possible hazards such as 11kV cables that would need careful consideration to ensure safe installation with minimal interference to existing infrastructure.

## 1.5. Additional Wind Turbine

A further alternative would be to build a new community owned wind turbine next to the existing wind turbine site to the East of the village. Locogen have carried out a wind constraints study which show this site could be feasible but there are several issues, including adjacency to an SSSI and the possibility of being refused planning due to aggregated impact of this development alongside the four turbines at Carsington wind

[4] see appendix 2

farm and another four across the road.[5] Derbyshire Dales District Council's Planning Department have indicated that a wind turbine on this site would not meet current national planning guidance as the site is not mentioned in a Local or Neighbourhood Plan. It may be possible to find a way around this, but the District Network Operator has also indicated that they would not give permission for a new wind turbine at this location for at least 5 years due to issues with faults in the system locally which a new turbine could exacerbate. It is therefore not possible to pursue the option of a new wind turbine at the moment, but this situation could change in the near future.

## 1.6. Governance

If the scheme progresses, there are two options;

1. Set up Community Benefit Society (CBS) to replace the Community Interest Company. A CBS would enable a share offer to be launched giving community ownership for the scheme. This CBS could also look to carry out other projects including, potentially, the new wind turbine if planning and grid constraints can be overcome. This would however be a big commitment for a group of volunteers, on a project with a 40 plus year lifespan, even if the day to day management and billing were contracted out.

2. Partner with a Local Authority who can take the lead and raise the grants and capital required. This is how the Swaffham Prior scheme is being delivered. This arrangement would relieve the pressure on the local volunteers, but the scheme could then be bound up in the workings of local government.

## 1.7. Next Steps

If Brassington Community Heat feel there is life in this project, a copy of this report should be sent to the Heat Network Delivery Unit (HNDU) at BEIS to ascertain whether they are likely to support the proposal and what further work is required before their funding can be made available. Discussions could also be held with the Derbyshire Dales and Derbyshire Councils, who could apply to HNDU for 60% grant funding for further feasibility work.

Unfortunately, the RCEF is now closed so alternative funding will need to be obtained to take the project through to a point where the GHNF can be utilized. Local authority backing could be vital in securing such alternative funding.

*Fig 1 Brassington Community Heat Public Meeting 28.4.2022*

[5] See appendix 3

# 2. Community Engagement

Brassington Community Heat CiC undertook a survey of the village in October 2021. The survey was completed by 89 households (50% of households excluding holiday lets, second homes and unoccupied properties). 94% of respondents were owner occupiers indicating a lack of interest from those renting their properties. The results of that survey are attached as appendix 4. That survey did not include any questions on the heat network.

Updates on the progress of the studies have been provided through the Village newsletter and social media.

A public meeting was held in the Village Hall on 28th April 2022 where Dave Green of Sharenergy and Martin Crane of Carbon Alternatives presented their findings. 50 people attended this meeting and a news item of the meeting appeared on East Midlands Today the next day.[6]

A feedback form was circulated at that meeting. This form was also made available online and a link has been circulated, however, only four forms have been submitted to date, plus four general statements of support for the scheme. The four survey responses were all very positive.[7]

# 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.

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 CBF's are no longer to be expected from Community Energy schemes, certainly not in the early years. The finances of this scheme are 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.

# 4. Technology

This work was commissioned with the sole aim of investigating the feasibility of a heat network for Brassington. Other renewable energy options have not been investigated,

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[6] https://www.youtube.com/watch?v=DFJuB1bVaAc
[7] See appendix 5

other than looking into the possibility of a renewable energy source to power the proposed heat pumps.

The alternative technological solutions for the heat network are covered in detail in the report from Carbon Alternatives (see Appendix 1). We are only providing a summary here.

Brassington properties are mostly currently heated by oil (58%) and LPG (9%) boilers, with around ten houses (4%) on heat pumps and another ten on storage heaters. The use of individual heat pumps is likely to increase over the coming few years and Derbyshire Dales District Council are working on a scheme which could fund around 10-15 heat pumps in the village. However, there are substantial issues with fitting heat pumps to many of the properties in the village, especially in the older tightly developed core of the village 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. 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 round many of these issues. The decision process is much 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 utilized for domestic hot water. Larger plant is more efficient and generally cheaper. It is also easier to provide a centralized back-up system than to provide one for each individual property. Additionally, in Brassington there is the possibility of accessing cheaper renewable electricity if a heat pump solution is favoured.

## 4.1. Biomass

If a good local source of sustainable biomass can be sourced then biomass 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. However, there are issues with biomass, including possible reductions in air quality, maintenance issues, the need to manage quality of fuel and fuel deliveries. The internal rate of return (IRR) for a biomass scheme with 60% take-up has been calculated as minus 3.3% over 30 years (ie it makes a loss). We also consider that biomass as a whole village heating solution is not a sustainable solution.

## 4.2. Ground Source Heat Pumps

Ground source heat pumps (GSHP) use electricity to drive the pumps and compressors required to collect heat from ground water through boreholes into the aquifer (open loop) or through pipes in trenches or boreholes where heat is absorbed into the water circulating in the pipes (closed loop). The local geology is complex and the possible yield of ground water for an open loop system very hard to predict so this option has been discounted. For a scheme of this size closed loop boreholes would be the only viable option and for a 525kW system 200 boreholes each 200m deep would be required. This would be a significant capital outlay of around £1.5m and there is considerable doubt about the suitability of the rock strata locally and about unmapped mine workings. GSHPs are generally more efficient than air source heat pumps but the efficiency can drop over the years if 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.

## 4.3. 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 different loops in a village like Brassington, 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 no heat losses from the system
- pipe work may be cheaper.

However, the flow rates in ambient loop systems need to be much higher than for a centralized heat pump system, (around 6 times the volume is required) so the pipe sizes are larger and hence trenches, the largest cost of a heat network installation, are no smaller than conventional district heating pipe whose diameter is increased due to the pipe insulation. So, the install cost for ambient loop cannot be much cheaper than for conventional heat network pipe. Pumping costs are also proportionally higher.

It would be cheaper to drill the boreholes in large groups so much of the capital outlay is still required at the beginning of the scheme. Whilst the boreholes can be spread around the village with an ambient loop system, this is not considered to be an advantage in Brassington where open space is very limited, and the available space would have multiple owners who would need to agree to the borehole installations.

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

The largest Kensa shoebox heat pump is nominally 6kW but would only deliver 4.2kW at higher flow temperatures. This will not be sufficient heat for many of the Brassington properties.

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

We are therefore not recommending an ambient loop system for Brassington.

## 4.4. Air Source Heat Pump

Air source heat pumps (ASHP) 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 GSHPs 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 it is easier to power a single heat pump energy centre by a renewable energy source than a heat pump in each house as would be the case for an ambient loop system. A central heat pump 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.

Carbon Alternatives are recommending an 827kW air source system. This could provide all the energy required for all but 1,700 hours per year (4.65 hours per day). Providing a thermal store can greatly increase the hours that the heat pump can supply all the heat required. A store of 100m3 of hot water is recommended. 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 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. 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.

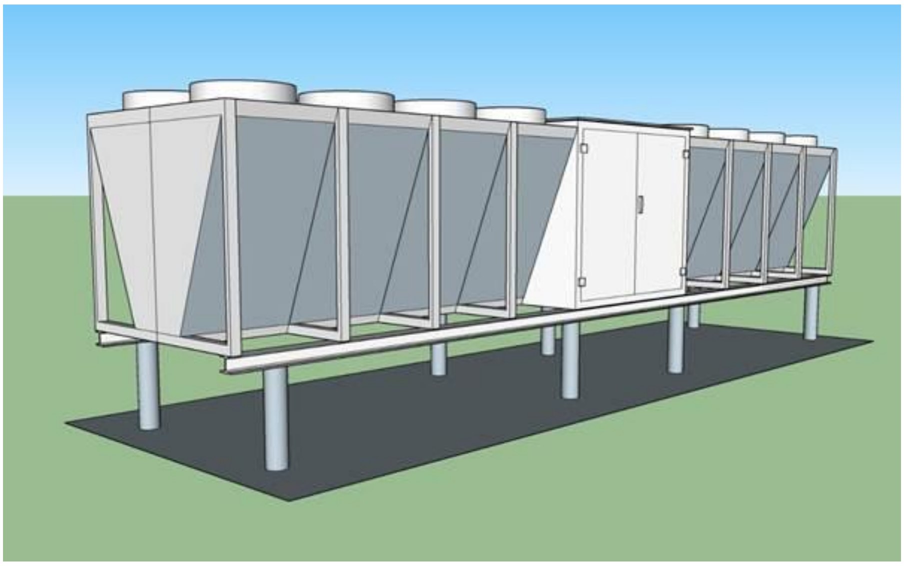

*Fig 2 Indicative 827kW ASHP from Solid Energy, 11.6m long, 2.3m wide, 3.5m high.*

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.

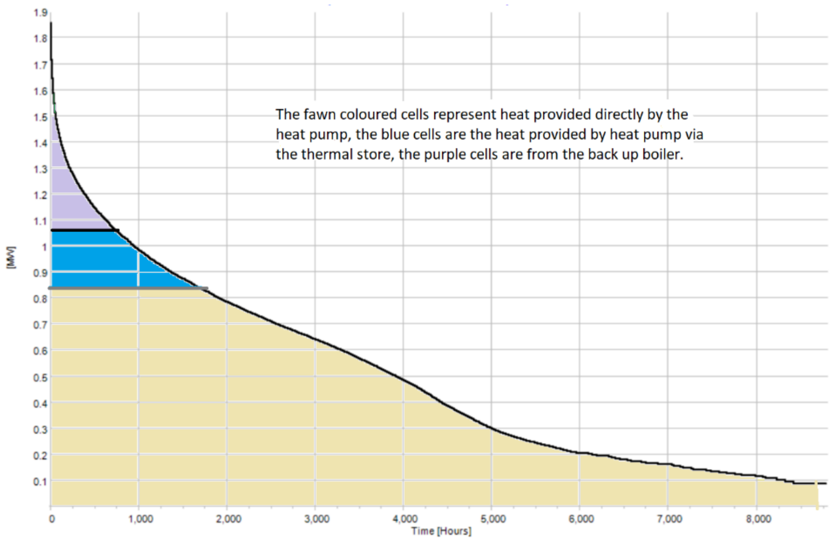


*Fig 3 Heat demand supplied by heat pump and thermal store.*

Fig 3 does not allow for additional use of the oil boilers as a back-up in case of any maintenance issues with the heat pump.

## 4.5. Renewable Energy 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 main sources of renewable energy 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 energy gives a much better fit with a heat network. Providing lower cost electricity through a local renewable energy source improves the viability considerably, especially as the thermal store allows maximum use of the wind power.

There is a wind farm with four existing 2MW turbines just over the ridge to the east of Brassington with access possible via Wirksworth Dale, though this road is now a dead end. Discussions with Engie who own the site have indicated that they are open to the idea of supplying electricity directly to the heat pumps.

An alternative would be to build a new wind turbine on land adjacent to the existing wind farm. This would provide additional renewable energy rather than utilizing an existing facility. There is a potentially suitable site at the top of Wirksworth Dale. Locogen have carried out a wind constraints study on this site [8] and they conclude that it would be suitable but there may be planning constraints. A similar proposal nearby was refused planning permission in 2016 due to fears of over development of wind turbines.[9] In addition to the four turbines at the Engie site there are already a further four turbines of a similar size just to the North. Derbyshire Dales Planning Department have been consulted, and they advised that an application for a turbine on this site was unlikely to

[8] see appendix 3
[9] See appendix 6

be approved. This accords with National Planning Guidance which states that any wind turbine site should be identified in a Local or Neighbourhood Plan before an application can be submitted. This could be challenged, especially as the turbine would be community owned and supplying renewable energy to a heat network. However, the District Network Operator (Western Power) were also consulted, and they stated that due to fault issues on the local network they could not give permission for a new wind turbine at this location even if none of the electricity was exported. This situation is not likely to change for at least five years.

If the heat network is to be pursued in the next five years, then connecting to the Engie site would be the preferred option. If the scheme comes to fruition after five years or so it would be worth re-visiting the option of installing a new community wind turbine.

## 4.6. Network Pressures and Piping

Carbon Alternative's report includes an appendix on selection of pipe pressures, pipe sizing and pipe types for the heat network.

Because of the 43m height difference between the bottom and top of the village the pressure in the pipework at the bottom of the village is on the borderline of what is possible for plastic pipe to have a 50+ year life and operation at 75°C on the coldest winter days. Pressures on the system can however be reduced by siting the energy slope near the middle of the slope. Plastic pipe is cheaper to install than steel pipe especially at the smaller pipe sizes so is preferable, but a mix of plastic and steel would be perfectly acceptable. The pipework would have the flow and return together within an insulated core.

## 4.7. Carbon Savings

The current heating carbon emissions for Brassington have been estimated at 1,151 tonnes/a of which 833t (72%) is from oil use.

If 210 houses sign up to the heat network (100% of those who could sign up) then the carbon savings vary from 62% for the 526kW ground source system up to 90% for the 827 kW air source with wind turbine, a reduction of between 718 and 1,040 tonnes per annum.

| Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | ASHP 525kW | ASHP 525kW Wind turbine 2MW | ASHP 827kW | ASHP 827kW Wind turbine 2MW | Biomass 600kW | Biomass 800kW | GSHP 526kW |
| Thermal store size $m^3$ | 50 | 75 | 75 | 100 | 50 | 75 | 50 |
| $CO_2$ emissions tonnes/yr | 463 | 332 | 254 | 111 | 248 | 129 | 433 |
| $CO_2$ reduction | 60% | 71% | 78% | 90% | 78% | 89% | 62% |

*Table 1 $CO_2$ savings from options assessed, based on 210 houses connecting to the heat network.*

However, it is highly unlikely to get every available house to connect to a heat network. If 60% of the available houses (126) were to connect the savings for the ASHP with wind become 58% (667 tonnes/a) which is still considerable. With a smaller take-up the savings/property actually rise as there would be less need for the oil back up and less electricity would be imported, with the wind turbines taking the greater part of the strain.

| Scenario | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | ASHP 827kW Wind turbine 2MW | | | Biomass 800kW | | |
| Proportion of houses | 100% | 80% | 60% | 100% | 80% | 60% |
| $CO_2$ emissions tonnes/yr | 111 | 46 | 27 | 119 | 67 | 52 |
| $CO_2$ reduction | 90% | 76% | 58% | 89% | 74% | 55% |

*Table 2 $CO_2$ reductions when fewer houses connect, 100% = 210 houses, 80% = 168 houses, 60% = 126 houses*

These figures take a mid-range of carbon factor for the UK grid electricity expected over the next 20 years of 128g/kWh. These figures assume the heating demand per property falls by around 10% due to home energy efficiency measures to be fitted alongside the heat network. The total of 1,151 tonnes would fall gradually without a heat network being installed as around 10% of this comes from electricity use and the carbon factor for electricity is falling. Additionally, as more houses change to individual heat pumps the carbon emissions will fall. We would not 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 Brassington.

# 5. Financial Projections

## 5.1. Assumptions Made

We are in a situation of considerable flux in energy prices. Carbon Alternatives have assumed that prices will fall in the next couple of years, before the Brassington heat network could be installed, but will not go back to their previous levels.

| | | p/kWh | Notes |
|---|---|---|---|
| Oil price | 80p/litre | 10p/kWh | Allowing for efficiency of the boiler |
| Electricity price from grid, day | | 26p/kWh | |
| Electric from grid, night | | 21p/kWh | |
| Electricity from wind farm, day | | 14p/kWh | |
| Electricity from wind farm, night | | 11p/kWh | |
| Average electricity price for the scenarios using wind energy | | 18p/kWh | |

| | | | |
|---|---|---|---|
| Woodchip | | 5p/kWh | £180/tonne, allowing for 4,000kWh/tonne and boiler efficiency |
| Sale price of the heat | | 9p/kWh | |
| Standing charge | £400[10] | | Per property/annum |
| Connection Charge | Zero | | For those properties joining when the heat network is installed. |
| Inflation rate | 2.5%/a | | Across the board |
| Share Interest paid | 2.0%/a | | |

*Table 3 Assumptions made*

For the scenarios without the wind turbine, it may be possible to get 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.

Oil prices are particularly difficult to estimate. 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 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. Heat pump economics are mostly determined by the difference in price between electricity and the fuel the heat pump will replace; if the electricity is 3 or 4 times the price of oil or gas then the fossil fuel heating will be cheaper. If electricity prices are 2 to 2.5 times the price of fossil fuels, then heat pumps become the cheaper option.

Inflation at faster than 2.5% would increase the income from sale of heat but then the price of electricity, maintenance etc. will also increase so the scheme would return a slightly higher profit (but not significantly so).

It has been assumed that each property will pay £400/annum as a standing charge. This has been calculated to be similar to the average costs of owning and maintaining an oil boiler. The standing charge ensures that even very low energy users are still paying something for being connected to the network. Properties with electric heating might be charged a higher standing charge to cover the cost of installing radiators, but they will see higher savings.

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 at the beginning, rather than waiting to join later.

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

[10] *Properties with electric heating might be charged a higher standing charge to cover the cost of installing radiators, but they will see higher savings.*

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 Brassington would not be viable. The energy case studies undertaken by Sharenergy revealed significantly lower oil usage in all five properties, but it is likely that this was not a representative sample. The EPC software assumes average occupancy for a property; if someone works from home, is an invalid or elderly, 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 the use of hot fill appliances. Reducing the use of secondary wood stoves would improve the air quality in the village, and it is likely that there will be more restrictions on the use of such stoves in the coming years.

## 5.2. Green Heat Network Fund

The Green Heat Network Fund (GHNF) can provide up to 50% capital and later stages of development funding 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.

## 5.3. Capital Costs

Carbon Alternatives have calculated capital costs for the full 210 available houses as between £6.2m (for the smaller sized ASHP) to £7.2m for the ground source heat pump scenario. This is £29.5k to £34.3k per property gross, with the GHNF reducing this to £15.3k to £17.8k per property. This is 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 Brassington 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 50 years plus, so the heat network cost over a 40–50-year cycle should actually be similar to a scheme promoting individual heat pumps.

The cost of an 827kW ASHP with connection to the wind farm and 100% take up is £6.43m or £15.9k/property with the GHNF. The biomass options are a very similar price.

However, as previously noted, getting 210 houses to join the network is unrealistic. Two options have been further investigated for the large heat pump with wind and biomass scenarios, 80% take-up (168 properties) and 60% take-up (126 properties). The 80% scenario has costs of around £5.7m or £17.6k per property (after the GHNF), the 60% scenario is around £5.1m or £21k/property (after the GHNF). This is a significant rise in costs per property of 10% and 32% respectively. We consider the 80% take-up to be unrealistic in the short to medium term, and it would be difficult to make a convincing business case that assumed such a high take-up.

## 5.4. 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 heat pumps after 20 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.

## 5.5. 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 recognized 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. Stretching to 40 years is possible but indicates that a project is very marginal with very little room for manoeuvre.

On the 100% take up (210 properties) model only three scenarios had a positive IRR over thirty years, the 827kW ASHP with wind at 2.2%, 600kW biomass at 3.9% and 800kW biomass at 5.7%. The other scenarios (the smaller ASHP, ASHPs without wind and the GSHP) were therefore discounted from further investigation.

At 80% and 60% take-up the biomass IRRs both became negative over 30 years, with the 60% scenario at minus 3.3%.

At 80% take-up the 827kW ASHP with wind scenario the 30-year IRR is just positive at 1.5%; at 60% this becomes 0.3. At 40 years the 60% scenario has an IRR of 2.2%.

The only realistic financial scenario therefore appears to be the 827kW ASHP with wind, but this is only just positive after the 40-year period and there would be very little room for additional capital or maintenance costs, for failing to meet the 60% take up rate, or for lower take up of the energy delivered through the heat network.

| Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | ASHP 525kW | ASHP 525kW Wind turbine 2MW | ASHP 827kW | ASHP 827kW Wind turbine 2MW | Biomass 600kW | Biomass 800kW | GSHP 526kW |
| Capital cost £k | 6,178 | 6,178 | 6,278 | 6,428 | 6,231 | 6,271 | 7,217 |
| Net revenue yr 1[1] | -4 | 77 | 4 | 123 | 152 | 189 | -15 |
| IRR 30 year | negative | -1.3% | negative | 2.2% | 3.9% | 5.7% | negative |

*Table 4 Economic summary of renewable heat source options assuming 100% take up, i.e. 210 houses*

*Note 1, net revenue doesn't allow for depreciation, capital repayment or interest.*

Impacts of fewer houses connecting.

| Scenario | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | ASHP 827kW Wind turbine 2MW | | | Biomass 800kW | | |
| Proportion of houses | 100% | 80% | 60% | 100% | 80% | 60% |
| Capital cost £k | 6,278 | 5,684 | 5,091 | 6,271 | 5,677 | 5,084 |
| Net revenue yr1[1] | 123 | 103 | 75 | 189 | 85 | 51 |
| IRR 30 year | 2.2% | 1.5% | 0.3% | 5.7% | -0.1% | -3.3% |

*Table 5 Economic impacts of fewer heat network connections*

*Note 1, net revenue doesn't allow for depreciation, capital repayment or interest.*

## 5.6. Carbon Accounting

The scenario with 60% take up of the air source heat pump and wind combination gives around 700 tonnes of carbon saved/annum. If a way could be found to get paid for this at say £50/tonne that would give an additional income of £35k/a. If these payments can be maintained this brings the 30-year IRR to 2.0%, and the 40 year IRR to 3.8%. This is still very low, there is no current mechanism in place to attract these payments and it will be difficult to argue any additionality to attract carbon payments once the heat network is established. It can also be argued that the GHNF subsidy has already paid for the carbon savings.

# 6. Planning & Permitting

Derbyshire Dales District Council Planning Department were consulted through a pre-planning application submission on two aspects, the energy centre and the wind turbine.

DDDC's response on the possibility of an extra wind turbine at the top of Wirksworth dale was:

*"Government policy at the moment is not supportive of new onshore wind proposals. Whilst this could change in the future any scheme submitted at the moment would have an in-principle obstacle in its way in terms of government guidance as the council has not allocated the land for wind farm development. Notwithstanding this the suggested location and scale of the turbine would be likely to raise significant landscape concerns as it would not sit comfortably with the wider grouping in the landscape."*

*Email from Jon Bradbury of DDDC 26.5.2022*

DDDC were also given indicative details of the proposed energy centre but no response on this has been received. As the energy centre would be agricultural in scale and feel, and there are existing agricultural buildings of a similar nature around the edge of the village it is considered that planning is unlikely to be a hurdle to developing the heat network.

Western Power Distribution were also consulted. To provide the energy centre with a new HV connection they would need to:

*"install 1,090m of HV cable, rebuild an HV overhead line, consisting of 758m, install a new package substation at Green View, and install a RMU with metering unit".*

*Email from Mark Gell of WPD, 6.5.2022*.

WPD would cover 70% of these costs, with the heat network developer providing 30%. They have provided a budget estimate for connecting an 825kW heat pump to the grid of £191,500 plus VAT. This includes £72k of contestable works (provision of the RMU and metering) that might be provided by an alternative supplier at lower cost.

WPD also commented on the new wind turbine proposal:

*"Connection into any BSP within the Willington Grid Group will contribute to the fault level seen at Willington GSP and Spondon 132kV substations. These sites are projected to exceed their fault level rating as a result of further connections made within the locality. WPD must therefore undertake significant 132kV reinforcement works to mitigate the fault level issue before any projects can be connected and energised. Indicative timescales suggest it will take 5-6 years to complete from initiation of the reinforcement works (NGESO dependent). So at present that isn't something I've investigated due to the timescales."*

*Email from Mark Gell of WPD, 6.5.2022*

# 7. Sites

This work was commissioned specifically to look at heat network options for Brassington.

Brassington is a village in Derbyshire, near Carsington Water, SW of Matlock. It has 233 houses, a primary school, two pubs and a village hall. 15 of the houses are holiday lets, 14 are second homes and 15 are listed as unoccupied. There are some farm buildings on the edge of the village but no other business premises.

Brassington is not on the mains gas grid so most of the houses are heated by oil or LPG. As far as we are aware 9 of the houses have individual air source heat pumps; 8 of these are housing association properties in the middle of the village. One house in the SW corner of the village has a ground source heat pump using trenched pipes.

The centre and northern part of the village is made up of mostly older solid walled housing, much of it terraced and situated directly onto the pavement. There are however some newer houses intermingled in this area. The southern part of the village, around the primary school is mostly 1950s semi-detached housing that was originally council housing, again with some newer properties intermingled. The roads in the centre of the village are fairly tight and some of the houses are off narrow paths. There is evidence that the roads have been excavated for services renewal, we are told that many of the roads are laid directly onto hard rock and that such excavations were difficult to carry out. There is 41m between the bottom and top of the village.

## 7.1. Existing Properties

Of the 141 Energy Performance Certificates (EPCs) studied:

11 (8%) are G rated (the worst rating),
35 (25%) are F rated,
45 (32%) are E rated.

So, 65% of the properties are in the lower three bands. It is likely that a higher proportion of the properties without an EPC are in these lower bands, so it is assumed that 70% plus of all the properties are in these lower bands. Lower rated properties are more expensive to heat and with fuels such as oil and LPG the carbon emissions are also very high with an estimate of 11.3 tonnes of $CO_2$/household/annum excluding food, travel and general consumption. This compares to a UK average of 3.5 tonnes/household/a.[11]

Five of the houses in the village and the primary school were studied in depth. A variety of houses were chosen; four of them have central heating with two on oil, one on bulk LPG and one on bottled LPG. The fifth house has a multi fuel stove and electric heaters. The main fuel energy use averages at 14,000 kWh/a which is significantly lower than the 20,000 kWh average expected on the EPCs. However, there was considerable use of secondary heating, primarily wood stoves.

In the five houses the improvement recommendations included:

One cavity fill,
One major loft top up,
One insulate large areas of sloping ceiling,
Two balance the heating system
Two consider fitting a heat pump
Two consider fitting PV.

So, whilst there is scope for some energy improvements to these properties the opportunities are fairly limited and without undertaking deep whole house retrofits the fuel savings are unlikely to be more than around 10%. Ideally if this scheme progresses

[11] 11 https://impact-tool.org.uk/

energy surveys would be provided to all interested households with assistance to undertake energy improvement measures.

All the five properties could connect to a heat network but,

- One has only recently fitted a new bottled LPG boiler
- One has very low oil usage (only 700l/a)
- One has no existing radiator system
- Two have problems with some radiators not getting hot enough.

The school has an oil boiler feeding a mix of fanned radiators and radiant ceiling heaters with oil use of 4,500l/a (45,000 kWh, equivalent to 2 to 3 houses). New glazing is to be fitted at the school and the loft insulation could be topped up in some areas but the walls are solid stone and difficult to insulate.

Derbyshire Dales District Council are considering offering grants for home energy improvements to householders in Brassington over the coming nine months through the HUGs programme. This could include fitting individual air source heat pumps.

Most of the properties, including the school, have the current boiler and fuel tank at the rear of the property which is not ideal for connecting to a heat network.

## 7.2. Geology

The Brassington area has a wide range of rock types and there are also various old lead mineshafts, many of which are unrecorded. This makes planning for ground source heat pump boreholes and prediction of outputs difficult. There are no existing working ground source boreholes in the village, and it appears that some of the new houses near to the school on Meadow Rise had ground source heat pumps, presumably on boreholes, but that these are no longer in use and have been replaced by ASHPs. We have attempted to find out why this happened, but the Housing Association have not been willing or able to provide details.

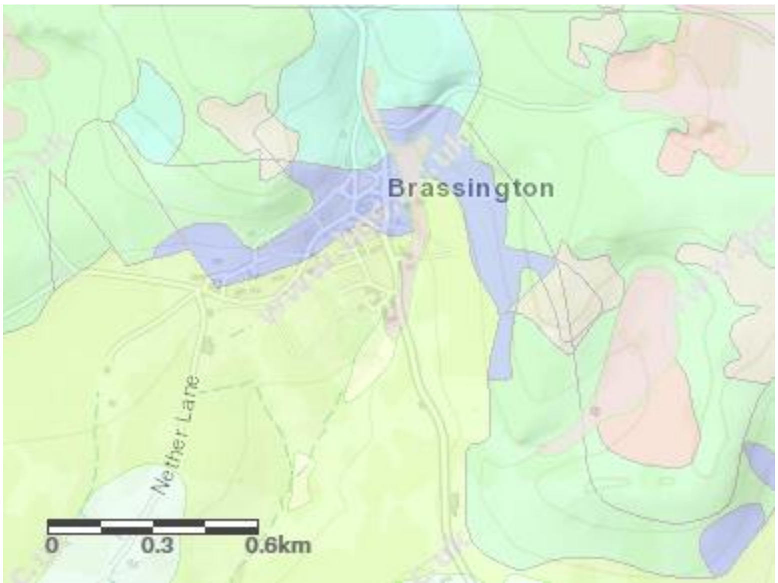


*Figure 4 Geological variation in bedrock and superficial rock – each colour represents a different type of rock.*

## 7.3. Pipe Layouts

3D Technical have carried out a detailed assessment of potential heat network pipe routes and have considered the hazards involved[12]. They particularly point out that much of the bedrock is very close to the surface, and indeed many of the roads and paths appear to have been laid directly upon it, including Hillside and Bowling Green. Further investigation as to the extent of such sub-surface bedrock and its strength would need to be carried out if the heat network proposal proceeds to a further stage.


*Fig 5 Hillside*

3D Technical have also highlighted the issues relating to the confined routes within the village and that any heat network installation would need to be carefully planned with local agreement on appropriate works phasing and traffic management plans.

Some routes within the village are considered so constrained as to be best avoided, such as the footpath connecting Manor Close and Church Street, (the bungalows here have existing ASHPs anyway). There is a similar path connecting Church Street and Hillside. Others have issues with possible hazards such as 11kV cables that would need careful consideration to ensure safe installation with minimal interference to existing infrastructure. The substation on Hillside would need careful consideration to ensure cables are avoided.

[12] see Appendix 2

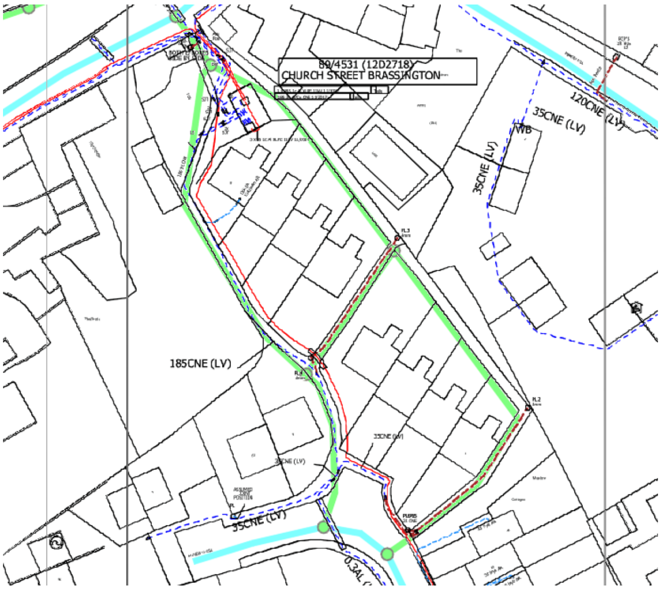


*Fig 6 Manor Close to Church St (green routes are best avoided)*

The risk of unexploded ordinance is thought to be low. There is no mains gas in the area and no significant challenges with telecoms equipment have been identified.

## 7.4. Energy Centre and Wind Turbine

A definite location for the energy centre has not been identified. If the connection to the Carsington Wind Farm is pursued then a location on the east side of the village would be appropriate, limiting the extra cabling costs. A site halfway up the slope of the village would enable lower pressures to be used. The actual site identified in 3D Technical's drawings is only indicative and should not be taken as a definitive location. This area has significant agricultural buildings already so is likely to be acceptable to the local planning authority.

Carbon Alternatives have suggested an alternative site below the Old Gate Inn, to the West of Field End which is slightly more central. The air source heat pumps would need to be situated far enough away from houses to avoid noise nuisance and potential issues arising from creating a cold spot.

If the heat network scheme is pursued, then landowners would need to be approached to ascertain their willingness to house the energy centre and on what terms.

*Fig 7 Indicative energy centre appearance and scale, not including the ASHP which would be adjacent.*


*Fig 8 Possible sites for wind turbine and energy centre*

The potential site for an additional wind turbine is east of the Village at the top of Wirksworth Dale, adjacent to the existing Carsington wind farm. However as explained in Section 6 this would be unlikely to obtain planning permission and would not be acceptable to Western Power Distribution for at least 5 years.

*Fig 9 Possible wind turbine site at top of Wirksworth Dale.*

# 8. Operation and Governance

If the scheme progresses, there are two options:

1. Set up a Community Benefit Society (CBS) to replace the existing Brassington Community Heat Community Interest Company. A CBS would enable a share offer to be launched giving community ownership for the scheme. This CBS could also look to carry out other projects, including potentially the new wind turbine if planning and grid constraints can be overcome. 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 risky investment for those buying shares as there is very little leeway in the finances for extra costs or reduced revenues.

2. Partner with a Local Authority who can take the lead and raise the grants and capital required. This is how the Swaffham Prior scheme is being delivered. 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.

# 9. Scheduling

Under current market conditions it appears unlikely that a heat network could be viable for Brassington, even with a 50% grant from the Green Heat Network Fund. However, if fuel prices stay high and if:

- extra taxes are placed on fossil fuels
- or some mechanism can be found to gain credits for the carbon saved
- and/or building a new wind turbine to power the heat pumps becomes possible
- or funding for smaller schemes becomes available

then it may become viable in the future. Even then unless the funding rules change a high proportion of householders would need to take part. We recommend that this report is submitted to the Green Heat Network Unit at BEIS for comment and that an eye is kept open for changes in market conditions.

# 10. Conclusions (Case Study Statement)

A heat network in Brassington would have several advantages, including substantial carbon reductions and lower fuel bills, and allowing for the removal of oil tanks and less use of wood and coal burning stoves leading to better air quality.

Brassington however offers several challenges: the houses are mostly pre-1900, there are very few commercial energy users, the roads are very narrow and many of the roads are built directly on to the bedrock making installing the pipework difficult. There is a 43m gradient across the village and the geology is not very suitable for ground source boreholes.

The only viable and sustainable solution appears to be using air source heat pumps using electricity from Carsington wind farm. However even this option only just breaks even over 30 years with a small rate of return over 40 years, despite receiving 50% capital funding through the Green Heat Network Fund. This leaves little margin for error.

If fuel prices are to remain high for a sustained period of time, some way was found to sell carbon credits from the scheme, prices for heat networks fall or funding for smaller schemes became available then a heat network might become viable in the future.

*Add statement by Bryan*

# 11. Appendices

1. Report from Carbon Alternatives
2. Report from 3D Technical Design
3. Wind Constraints Study by Locogen
4. Village Survey Report
5. Public Meeting Feedback report
6. Wind Turbine Planning Response 2016

7.

# 12. Version Tracker

| Date | Version number | Created By | Reviewed by | |
|---|---|---|---|---|
| 25/7/22 | 1 | Dave Green | JH, RO, MC | |
| 1/8/22 | 2 | Dave Green | | Mostly grammatical corrections, added section on funding for smaller schemes |
| | | | | |

*Fig 10, Residents of Brassington at the Public meeting 28.4.2022, with Dave Green & Richard Lane of Sharenergy and Martin Crane of Carbon Alternatives.*