Marches Heat

Rural Community Energy Fund (RCEF)

Stage 1 – Feasibility Report

Into Shared Loop Ground Source Heat Pumps

For Ludlow 21

Dave Green April 2021

The Wintles

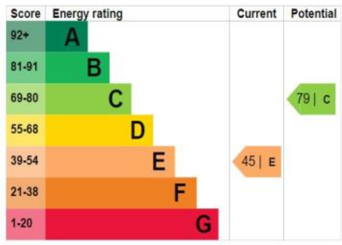
Burwarton

Contents

Executive Summary

This study has looked at 17 properties: 6 bungalows in Burwarton belonging to Shropshire Rural Housing (SRH) and 11 owner-occupied houses in the Wintles estate, Bishop's Castle. The work was commissioned by Ludlow 21 to investigate the possibility of using shared loop ground source heat pumps for these sites, with the remit to look at alternatives if this was not deemed viable.

The Burwarton bungalows are all small at 53m^2 plan area, semi-detached, built in 1995 with insulated cavity walls, double glazing, reasonable levels of loft insulation, electric panel heaters and dual electricity meters. They all rate as E 47 to 49 on their Energy Performance Certificates.



The graph shows this property's current and potential energy efficiency.

Properties are given a rating from A (most efficient) to G (least efficient).

Properties are also given a score. The higher the number the lower your fuel bills are likely to be.

The average energy rating and score for a property in England and Wales are D (60).

The Wintles properties are more varied. They are all detached houses, but vary in size from 113m^2 to 243m^2, with some 2-storey and some 3-storey. They are all built between 2003 and 2013 of timber framed construction with double or triple glazing and LPG boilers run from a shared tank. The properties were marketed as Eco-homes, but the Energy Performance ratings are in the mid-range, varying between E54 to C69, with most of them in Band D (55 to 68). A standard modern property would be Band B, a new Eco house would be Band A. The main reasons for these lower ratings are the high ratio of external envelope to floor area and the LPG heating. There is also a great variation in the energy used per metre squared at the Wintles, from 18 to 112 kWh/m^2/a.

When the feasibility study was initiated, shared loop ground source schemes benefitted from the Non-Domestic Renewable Heat Incentive (NDRHI). This scheme paid out a per-kWh subsidy over 20 years at a rate that was reasonably attractive to people looking for a longer-term investment and thus was considered suitable for a community energy scheme, especially if a lower cost per property could be gained through the use of a shared loop system. However, the quotes received showed only a 5% discount for going for shared loops and this, along with the small heat demand figure ruled out a community energy shared loop scheme for Burwarton, though SRH could potentially still take this project forward with their own funding, depending on the level of support for such schemes available from any replacement for the NDRHI.

By contrast, we believe that a shared loop scheme could have been viable for the Wintles with the support of the NDRHI, though it may have required some payment from the homeowners, either as an upfront contribution or by an ongoing service charge.

Unfortunately, although the Domestic version of the Renewable Heat Incentive (RHI) was extended to the end of March 2022, the Non-Domestic version was closed at the end of March 2021. It is not yet clear what will replace the NDRHI for schemes over 45kW but the Clean Heat Scheme support for installations up to 45kW is proposed as a single up-front payment of £4,000 per property regardless of the technology used. This is not sufficient to support a viable community energy scheme. There is some heat network funding available, but this is only for much larger schemes.

It therefore appears that neither site is viable for a shared loop scheme at this time. We await the publication of the delayed Heat and Buildings Strategy. If a new funding scheme were to offer support for shared loop schemes this could be re-visited for the Wintles.

We have also investigated the use of individual heat pumps for all the properties, and the use of High Heat Retention Storage heaters for the Burwarton bungalows.

Our conclusion is that either air source or ground source heat pumps could be suitable for the Wintles properties, air source being more suited at the smaller size, ground source at the larger. The returns on the investment depend largely on the amount of energy used. Larger energy users could make savings over 20 years; these savings are higher if the cost of replacing current boilers is taken into account. Average users would still see a saving if the cost of replacement boilers is allowed for. This analysis assumes the heat pumps are commissioned before the end of March 2022 and the Domestic RHI is claimed. The main downside is that a relatively large upfront investment is needed, particularly for a ground source system.

The Burwarton properties are probably too small to justify individual ground source systems so air source would be preferred. These could show a net saving of £2.9k over 20 years, but as these are rented properties the savings would not be seen by the Housing Association who would need to make the investment. SRH may however judge it worthwhile making this investment to improve the EPC rating of their properties. This will become more important as the requirements under the Minimum Energy Standard legislation are tightened over the next few years.

Alternatively, the Burwarton properties could be fitted with High Heat Retention Storage Heaters (HHRSH). These would avoid the need to fit a wet radiator system and are cheaper to fit than an air source heat pump. If models are chosen that feature in the approved list in the energy assessment software, they can produce a significantly increased energy rating, from E49 to D66.

All these systems would show significant carbon savings, with embodied carbon repaid in around one year. The Wintles properties show CO_2 savings of around 36 tonnes/property over 20 years, allowing for embodied energy and the gradual fall in electricity carbon factor. The Burwarton properties would save 8 tonnes of CO_2 per property with heat pumps, around 5.6 tonnes/property with storage heaters. Heat pumps could however add load to the grid at peak times, storage heaters avoid this issue.

Recommendations,

1 That Shropshire Rural Housing consider fitting either Air Source Heat Pumps or High Heat Retention Storage Heaters to the Burwarton bungalows. This could be on a mix and match basis depending on the occupants' preferences. Alternatively, SRH could consider a self-financed shared loop ground source scheme if the new funding stream is supportive enough.

2 That the Wintles residents consider fitting individual Air Source or Ground Source heat pumps, depending partly on the size of their property, the amount of energy use and the amount of capital they have available.

3 Anyone fitting a heat pump is advised to do so before the end of March 2022 so the Domestic RHI can be claimed before the scheme closes. It is always possible the scheme could close early if all funds are used up, so time is of the essence.

4 The viability of shared loop ground source schemes should be re-assessed when the replacement of the NDRHI for schemes over 45kW is announced.

5 Alternatively a larger heat network scheme, could be considered for Bishop's Castle[1].

A case study statement is included as section 10

[1] *See https://heatingswaffhamprior.co.uk/*

2. **Community Engagement**

As no viable community energy scheme has been identified no wider community engagement has been undertaken. However, the residents of the Wintles and the staff at Shropshire Rural Housing have been kept informed of the results of the energy surveys and the heat pump study through online meetings.

3. **Community Benefits**

The main benefit to the wider community through the installation of heat pumps would come through reduced carbon emissions and reduced reliance on imported LPG. Even if a viable community energy scheme had been found it is highly unlikely it would have been able to pay out to a Community Benefit Fund in the short or medium term although some payments could possibly have been made in the later years if the prevailing economics, fuel prices, inflation etc, allowed.

4. **Technology – Replacement Heating Systems**

4.1 **Existing Heating Systems and Energy Use**

This study has concentrated on two sites: six bungalows in Burwarton owned by Shropshire Rural Housing and eleven owner-occupied homes in the Wintles estate, which totals 42 houses, in Bishop's Castle.

4.1a Burwarton properties

The six Burwarton properties are all very similar. They were all built in 1995, all with a floor area of 53 m^2 with filled cavity walls, insulated lofts (between 200 and 300mm) and fully double glazed. All have Economy 7 meters, are heated by electric room heaters, and all have hot water from a dual immersion. We calculate their EPC scores to range from 47-49, all in the E range. Under the existing Minimum Energy Standard regulations these houses can be rented out, but there is discussion about tightening up these regulations to exclude E rated and potentially D rated properties, so this could be an issue in the future. Their heat demand varies slightly, averaging 6,144 kWh/a, their hot water demand averages 1,799 kWh/a, giving a total heat and hot water demand of 7,943 kWh/a each.

4.1b Burwarton Energy Use

The Burwarton occupants spend an average of £1,000/year on electricity, with a range from £780 for someone who is at work during the day and "does not like their property too warm" to £1,300 for someone who is home most of the time and likes the property to be "very warm".

4.1c Wintles properties

The Wintles houses are all timber-framed detached houses built between 2003 and 2013. Their floor areas vary from 113 m^2 to 243 m^2 with an average of 173 m^2. They are all heated by individual LPG boilers (although some of their Energy Performance Certificates state mains gas in error) with some underfloor heating. Hot water is from the LPG boilers and solar thermal panels. Two houses also have photovoltaic panels (PV). The heat demand varies from 7,700 kWh/a to 19,331 kWh/a with an average of 12,785 kWh/a. The hot water average is 2,670 kWh/a, giving a total average heat and hot water demand of 15,455 kWh/a. At current LPG prices this average energy use would cost around £930/a, with a range of £630 to £1,325.

We calculate the Wintles EPC ratings to vary between 54E to 69C, with nine of the properties in the D band (55 to 68). There was a concern that that these ratings might under-score the properties as they were probably built to a higher standard than the building regulations current at the time - this is not reflected in the defaults used by the RdSAP EPC software. The RdSAP software, which is designed for use with existing properties, also makes no account for solar gains. However, we have also looked at the two of the Wintles properties using the full SAP software which is used for new builds. They score slightly better, mostly because they take account of solar gain, but not significantly[2].

Even so, these ratings are lower than might be expected as the properties were marketed as being eco-homes. The main reasons for this lower score are the high 'envelope to floor area' ratio and the use of LPG. The EPC rating is based on cost/m^2 and LPG is an expensive fuel that scores badly. In addition, some of the worst scoring properties also had a boiler that is not featured in the database used by the SAP and RdSAP software, so a default boiler was used. In our experience this always reduces the score.

4.1d Wintles Energy Use

The reported LPG use at the Wintles varies greatly.

	LPG Use m^3/a	LPG Use m^3/m^2/a	kWh/a *(at 25.5kWh/m^3)*	kWh/m^2/a
Highest	500	4.4	12,750	112
Lowest	180	0.7	4,590	18
Average	321	1.9	8,186	48

Fig 1 Wintles LPG usage

These figures do include some cooking, but this is likely to be minimal and can be ignored for our purposes.

The current price of £1.386/m^3 gives a cost range of £250 to £693/a, there is also a £40/a service charge for using the LPG from the bulk tank.

These figures are considerably lower than the heat and hot water demand figures estimated in the EPCs. There are four possible reasons for this:

- the defaults used in the EPCs and ignoring solar gain have exaggerated the heat demand.
- greater use of the wood stoves than expected in the EPC software.
- lower occupancy than standard.
- careful use of heating.

4.2 **Heat Pumps**

4.2a Heat Pump Theory

The obvious choice for a replacement system would be a heat pump. Heat pumps run off electricity but using a compression cycle, similar to that found in a fridge, to extract heat from air, ground, or water.

[2]*Advice has been given by Elmhurst, the UK's largest energy assessment accreditation body, that full SAP software should not be used unless the full build data is available and verifiable, having drawings is not enough, someone has to state that the buildings were completed according to the drawings.*

Air source heat pumps are the cheapest and most common form of heat pump. Efficiencies have been improving in recent years but in very cold weather air-source heat pumps are still less efficient than ground or water source heat pumps. They are sometimes used in combination with gas boilers in a hybrid system whereby the boilers can take the load in the coldest weather when the heat pump is least efficient.

Ground source heat pumps can be installed using boreholes or horizontal plastic pipes known as 'slinky's in trenches. Boreholes used to be rare, but are becoming more common - although slinkys can be cheaper they take up a considerable amount of room and require a considerable area of excavation. Both sites studied would only be suitable for boreholes. For Burwarton, boreholes of 95m per property are recommended, for the Wintles it varies from 165m to 291m per property.

The efficiency of a heat pump system is expressed as a Coefficient of Performance or CoP. A CoP of 3 means that three units of heat are delivered for each unit of electricity used to drive the system. The CoP depends mostly on the temperature differential - heat pumps are less efficient if required to produce water to a higher temperature. For this reason, heat distribution systems (i.e., radiators) in heat pump powered systems run at lower temperatures than systems powered by a conventional boiler. Underfloor heating systems are therefore ideal for heat pumps as they work on a lower temperature flow but heat pumps can also work with existing radiator systems, though sometimes larger radiators are required. Radiators designed to work with low temperature systems are also available.

Heat pumps are generally slow-react systems. They work best if allowed to accumulate heat gradually in a buffer tank which is then available when the house temperature falls below its set point. They are therefore better suited to properties with high occupancy.

Photovoltaic panels can work well alongside heat pumps as they can deliver some of the electricity needed to drive the pump. However, the match between times when solar energy is high and times when heating is most required is not good.

4.2b Carbon Factors

The carbon factor for UK electricity is gradually falling and has halved in the last fifteen years. In 2021 it is only roughly the same as mains gas per delivered kWh of heat (allowing for the efficiency of gas boilers). Heat pumps can reduce the carbon impact further by delivering between two and five units of heat for each kWh of electricity used. However, whilst most carbon calculations just use one factor for electricity whatever time of day it is used, the carbon intensity of electricity actually varies according to the time of day, (due to the variation in generator technology used) as can be seen in the graph below. Typically, night-time electricity has a lower carbon intensity than daytime electricity, especially during winter when solar has much lower impact on the energy mix.

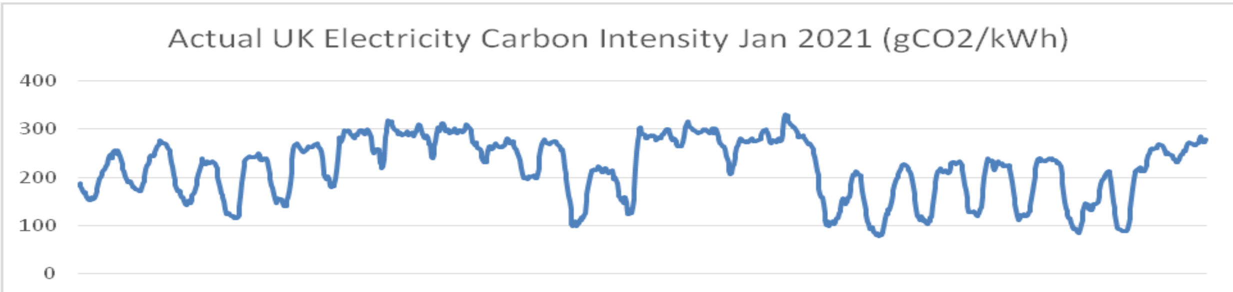


Fig 2 variation in UK electricity carbon factor for January 2021 using half hourly readings, from carbonintensity.org.uk

The Government has set a target of 600,000 heat pumps a year to be installed by 2028, up from only 30,000/year now. It has been assumed that around 90% of these will be air source with only 10% ground source. This is reflected in the Clean Heat Grant which will start in 2022 which offers the same upfront sum for either technology, even though ground source is considerably more expensive to install. Regen's recent paper 'Re-thinking Heat'[3] estimates that if 40% of these systems were ground source it would reduce the peak load on the grid (between 4pm and 7pm on cold winter days) by 3.1GW, which is the size of one nuclear power station. This is partly due to the greater efficiency of ground source systems but also because they can work more effectively over-night. It is also possible to set air source heat pumps to switch off in the PM peak-period, but this requires a sizeable buffer tank to be fitted, and this can also be over-ridden by the occupants.

4.2c Effect of Heat Pumps on Energy Ratings

We have calculated the revised EPC scores for the properties.

4.2d The Burwarton bungalows would gain:

- 18 points for an air source heat pump, taking them to a D67 rating, (assuming a Therma V model, 11 points for the default heat pump).
- 20 points for a ground source heat pump, taking them to C69.
- 17 points for high heat retention storage heaters taking them to D66 (assuming 3 storage heaters fitted from the models available in the database, *see section 4.4*).

4.2e The Wintles houses would gain:

- Between 9 and 11 points for air source (Therma V) or ground source heat pump, taking most of them into the B and C bands.

4.3 **Shared Loop Systems**

Most heat pumps, whether air, ground, or water source, are fitted with a separate system for each property. Savings can be made however by sharing a heat source amongst several properties. This works particularly well with ground source systems and for properties where each property does not have its own land for a borehole or where multiple air source heat pump units would be an eyesore (on blocks of flats for example). Shared loop ground source systems normally save on the costs of drilling boreholes which is a significant part of the cost of a ground source system. Shared loop systems can also provide summer cooling which helps to replenish the ground temperature around the boreholes.

Shared loop systems can work in two ways:

- Where the refrigerant is pumped to the individual building where a small heat pump extracts the heat for that individual dwelling. This is known as an ambient loop system.

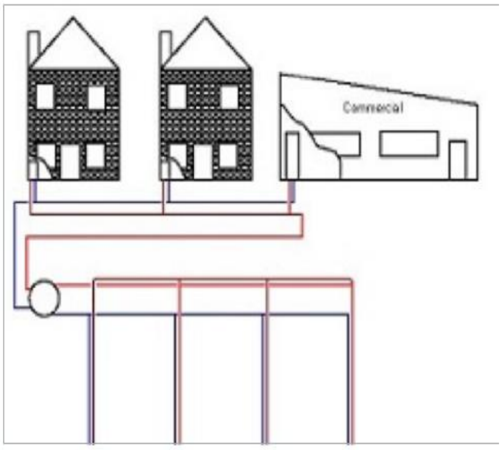
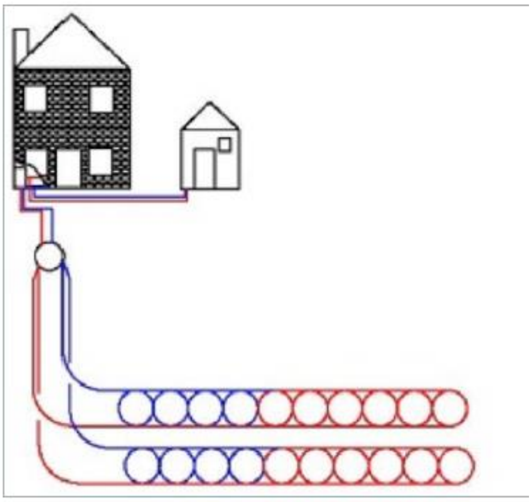


Image: Kensa Ltd

[3] see *www.regen.co.uk/publications/rethinking-heat/*



- Where the heat is extracted by a larger central heat pump and hot water is then circulated to the dwellings. There is a simple heat exchanger in each dwelling.

Ambient systems save on the cost of a fully insulated heat network and on the heat loss through such a system. It can also simplify billing arrangements – instead of metering and charging for heat as in conventional heat networks, heat users pay for heat via their normal electricity bill according to how much heat they extract from the system. Kensa have pioneered the use of ambient systems with their 'shoebox' heat pumps[4].

Regen's 'Re-thinking Heat' report suggests that shared loop systems also enable the cost of the loop to be separated from the cost of the heat pump itself. The loop is a longer-term element which should work for forty plus years, whereas the heat pump units will probably need replacing after twenty to twenty-five years[5]. Regen also suggest that the use of the shared loop could be the subject of service charges to the occupiers much as we currently pay for using the gas and electricity networks. Regen argue that these changes alongside reductions in cost due to an increase in the number of installs and greater competition could transform the economics of ground source systems, bringing them close to the cost of air source systems.

4.4 High Heat Retention Storage Heaters.

As the Burwarton bungalows are fairly small and reasonably well insulated, have dual electricity meters and do not currently have a radiator system, the alternative here would be to fit High Heat Retention Storage Heaters (HHRSHs). Normal storage heaters are very poor at retaining heat. For example, if the heater charges up with 5 kWh overnight that 5 kWh will leak out during the day whether its required or not and so another 5 kWh is taken in the following night. HHRSH's can hold onto up to 60% of the heat if the controls are turned down. If the heat is not needed there would still be 3 kWh of heat left in the storage heater the following night so only 2 kWh will be added the following night. This reduces the amount of night- time electricity needed but can also reduce the amount of supplementary heat required at expensive day rates. As the bungalows currently have normal panel radiators costing at least 15p/kWh, moving to storage heaters at 6p or 7p/kWh could show significant savings for the tenant and HHRSHs would increase these savings and offer more control to the tenants. The extra savings from HHRSH's will be greater in properties which are not occupied 7 days per week and less for those fully occupied with high heat needs.

4.5 Carbon Savings

As heat pumps can produce between 3 and 4 kWh of heat for every kWh of electricity used, they give a carbon factor of around 70g/kWh of heat with a current average electricity carbon factor of 250g/kWh. This factor will fall gradually over the next few years as the grid decarbonises. By contrast the LPG carbon

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[4] see *www.kensaheatpumps.com/district-heating*

[5] *See https://www.evergreenenergy.co.uk/heat-pumps/how-long-do-heat-pumps-last*

factor is 200g/kWh, allowing for the boiler efficiency. Heat pumps could however add load to the grid at peak times, ideally, they are run outside of peak hours to avoid this.

If an air source heat pump delivers 12,000 kWh of heat/a at a CoP of 3 that is an operational saving of 1.4 tonnes of CO_2/a in year one. A 10kW air source heat pump has embodied carbon of around 1.6 t of CO_2, so the embodied carbon would be re-paid in just over a year and total carbon savings over 20 years, allowing for the carbon factor for electricity reducing over that time to zero, of 36 tonnes/property, or 75%.

The Burwarton properties only have an energy demand of half this, but use a higher carbon fuel, so savings would be 1 tonne/ annum, giving an eighteen-month payback. However, savings here will fall over time as the current heating is electric, allowing for 2 tonnes of embodied carbon, total savings over 20 years are therefore 8.5 tonnes/property or 47%.

Ground source heat pumps have a higher embodied cost at 3.9 tonnes, but work to a higher CoP so again working on 12,000 kWh/a, the operational saving in year one is 1.6 t, giving a two-and-a-half-year carbon payback, with total savings of 36 tonnes/property.

As mentioned previously these savings will be higher if the heat pumps are used more during the night and are set to avoid the peak times of 4pm to 7pm, Monday to Friday. If a reputable green electricity supplier is used, then the savings at the Wintles would be 48 tonnes/property.

Storage heaters require one kWh of electricity to produce one kWh of heat but because they use electricity mostly at night when carbon factors are lower, they would still show some carbon savings against the current systems and take some pressure off the grid at peak times. If we allow current usage of 5,000 kWh mostly at day rate carbon factors of 250g/kWh and assume this all moves to night use at 125g/kWh that is a saving of 625g CO_2/a. This will fall though as the grid decarbonizes, allowing 1 tonne for embodied carbon this gives savings over 20 years of 5.6t/property or 63%.

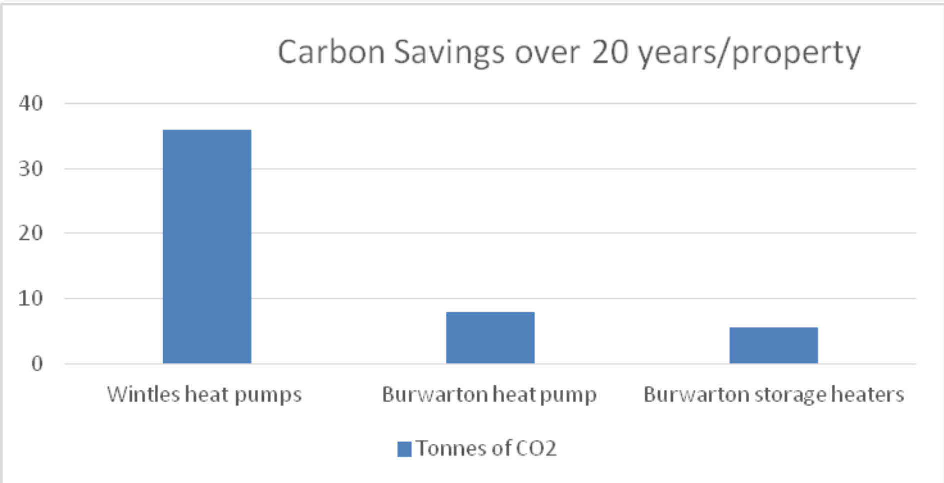

Fig 5 Carbon savings over 20 years

5. **Financial Projections**

5.1 **Domestic and Non-Domestic Renewable Heat Incentive.**

Individual household renewable heating systems come under the Domestic Renewable Heat Incentive (RHI). Any heat pump, biomass boiler or solar thermal system fitted by an accredited Micro-Generation Certification Scheme (MCS) installer can be eligible for RHI payments over seven years, inflation linked and tax-free. The current domestic RHI rates are 21.29p/kWh for ground source systems and 10.92p/kWh for air source systems. If the heat pump does not have a fossil fuel back-up system, these payments are made on the renewable element of the deemed heat and hot water demand found on an Energy Performance Certificate (EPC) for the property. The renewable element is dependent on the rated CoP of the system. With a CoP of 4, 25% of the energy required is coming from electricity so the RHI is paid out on the other 75%. This 'deemed' heat demand gives the owner of the system assurance as to the size of their RHI payments. However, if a fossil fuel boiler is kept as back-up, then the RHI would be paid out on metered heat only.

Until recently, any renewable heating system that dealt with more than one property came under the Non-Domestic RHI. This included systems where one boiler serves a house and an associated property, or for a shared loop system. The Non-Domestic RHI paid out at lower rates per kWh but for twenty years rather than the seven for the domestic scheme, and was therefore of interest to those with a longer-term economic view, such as community energy schemes. Normally the Non-Domestic RHI paid out on metered heat but the Department for Business & Enterprise, BEIS, determined that shared loop systems for dwellings would be paid out on the deemed heat demand as they would under the domestic RHI. The most recent NDRHI rates were 9.74p/kWh for ground source and 2.9p/kWh for air source.

When this study was initiated, it was hoped that the Non-Domestic Renewable Heat Incentive (NDRHI) would be extended beyond its original March 2021 deadline. Sharenergy contacted BEIS to seek clarification on this and were informed that the NDRHI would not be extended, and in fact the closing date was being brought forward for large heat pumps as the budget was already fully committed.

It is not yet clear as to how the replacement for the NDRHI for larger schemes will operate, but the domestic equivalent (which also applies to non-domestic schemes up to 45kW) will be an up-front grant of £4,000 regardless of technology. This will put ground source and water source heat pumps at a disadvantage as they have higher installation costs, even if they can provide greater savings in the long term. It is hoped that the awaited Heat and Buildings Strategy will contain information on this.

The other alternative for funding heat networks is the Heat Network Investment Project (HNIP). Unfortunately, both sites are too small to qualify for this as HNIP requires a capacity at least 2 GWh of heat/annum. There is the possibility that this threshold will be reduced in future, but even then, both sites would almost certainly need to be part of a larger network to qualify.[6]

5.2 **Individual Ground Source Costings and Returns**

Heat pump specialists Kensa have provided costings for individual ground source heat pumps for all the 17 properties that have been studied.

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[6]*For more detail on a current heat network project see https://heatingswaffhamprior.co.uk/*

5.2a Burwarton Costings and Returns

For the Burwarton properties Kensa have quoted £17,864 each for individual ground source systems, excluding the radiator system. If we allow £3,000 for this the total cost would be £20,864. The RHI income would be £1,079 in the first year, totaling £8,147 over seven years.

The cost savings are high on a per floor area basis for the Burwarton dwellings as their heating is currently electric panel heating on a dual tariff. This means they may currently be paying 20p/kWh for their heating. As this could easily be reduced to around 15p/kWh by taking the properties off Economy 7 tariffs, however, we have calculated the savings on the 15p figure.

There should also be some savings in fuel costs. The EPC calculations suggest a saving of £434/a (from £1,175/a, for the current system, down to £741 with a ground source heat pump) but these savings will be dependent on individual use of the dwellings.

A large proportion of the heat pump use would be for hot water which gives a lower CoP, if we take a CoP of 3.5 the heat pump would cost 4.25p/kWh giving a saving of 10.75p/kWh or 72%. Assuming that 80% of their electricity use is for heating and hot water that would be a saving of £575 in the first year, giving a total of £14,688 in savings per property over 20 years. We've used an average saving between this figure and the £434 suggested by the EPC, £504/a, and allowed 2.5% inflation/a.

Cost	RHI over 7 years	Avg Savings 7 yrs	Avg savings 20 yrs	Net Cost after 20 years
£20,864	£8,147	63,803	£12,885	-£168

Fig 6 Burwarton GSHP

5.2b Wintles Costings and Returns

At the Wintles the price of ground source heat pump installation ranges from £23,340 for the smaller properties, up to £31,173, with an average of £27,382.

The domestic RHI income for these installations varies from £1,900/a to £3,456/a with an average of £2,616. Over seven years allowing for inflation the totals vary from £14,338 to £26,156 with an average of £19,750.

That would give a net average cost after RHI of £7,632. There is however a considerable variation across the properties for the net costs: for the smallest properties it would be £8,982, for the largest it would be £5,015.

There should also be some savings in fuel costs, but these savings will be dependent on individual use of the dwellings.

The current price for LPG is £1.386/m^3. It has been slightly higher than this previously but not greatly. Allowing for the efficiency of the boiler and 25.5kWh/m^3 that corresponds to a cost of around 6p/kWh for delivered energy. With a heat pump at a CoP of 4 and allowing 15p/kWh the cost of energy would be 3.75p/kWh, a saving of 2.25p/kWh. Taking 10% off the usage figures from Fig 1 for the boiler efficiency that gives us savings with a CoP of 4 in the range of £90 to £258 with an average of £165. A CoP of 4 with a ground source heat pump and underfloor heating is a reasonable assumption. If the achieved CoP was around 3 then the savings would be halved. If LPG costs rise faster than electricity costs, then savings would increase over time, but we have assumed the cost differential stays the same.

Taking the average savings into account over seven years the net average cost would be £6,387, and after 20 years it would be £3,418, not allowing for replacement or maintenance costs, .

If we allow £3k for not replacing the LPG boiler with an equivalent, £50/annum reduced maintenance costs and £40/a reduced LPG service charge the net saving after 20 years is £1,868.

	Cost	RHI over 7 years	Savings over 7 yrs	Savings over 20 yrs	Net Cost after 20 years
	£27,382	£19,750	£1,245	£4,214	£3,418
Allowing for LPG boiler replace etc	£24,382	£19,750	£1,930	£6,500	-£1,868

Fig 7 Average Wintles GSHP

For the larger properties with the highest demand the savings would total £6,590 over 20 years giving a net saving of £1,573, rising to £6,863 if cost of replacing the LPG boiler etc is taken into account.

	Cost	RHI over 7 years	Savings over 7 yrs	Savings over 20 yrs	Net Cost after 20 years
	£31,173	£26,156	£1,947	£6,590	-£1,573
Allowing for LPG boiler replace etc	£28,173	£26,156	£2,623	£8,880	-£6,863

Fig 8, Large Wintles, GSHP, High User

Those properties with PV panels would see a better return on the investment as some of the electricity used to drive the heat pump could be provided by the PV.

5.3 **Individual Air Source Heat Pumps.**

We have also obtained quotes for air source heat pumps for three of the properties from MJS heating. All prices are inclusive of hot water tank and buffer tank and all installation costs except for radiators. For the Burwarton properties we have added £3,000 for installing a radiator system.

5.3a ASHP Burwarton

For 1 Oak Tree Lane, Burwarton, the quote is £13,252 for a 5kW Therma V air source heat pump system including the radiators. Again, with a CoP of 2.5 the DRHI would provide £521/a initially, with a total of £3,932 over seven years. The savings for an average user would be £480/a, taking the total return over seven years to £7,554. The net saving over twenty years is £2,941.

Cost	RHI over 7 years	Savings over 7 yrs	Savings over 20 yrs	Net Cost after 20 years
£13,252	£3,932	£3,622	£12,261	-£2,941

Fig 9, Burwarton ASHP, average user

5.3b ASHP The Wintles

For 17 the Wintles (one of the smaller properties at 114 m^2) the quote totals £11,116, using a 9kW Therma V Monoblock heat pump. With a CoP of 3 the Domestic RHI would pay out 10.92p/kWh on 66% of the heat and hot water demand, or £778/year, or £5,872 in seven years. Allowing savings of 1p/kWh on the average usage of 48kWh/m2/a gives a saving of £55/year and a total return of £7,276 over seven years, leaving a net cost of £3,930. This becomes a net saving of £418 if cost of replacing LPG, reduced maintenance and loss of LPG service charge is allowed for

	Cost	RHI over 7 years	Savings over 7 yrs	Savings over 20 yrs	Net Cost after 20 years
	£11,116	£5,872	£415	£1,404	£3,930
Allowing for LPG boiler replace etc	£8,116	£5,872	£786	£2,662	-£418

Fig 10, 17 Wintles ASHP, average user

If the occupants are higher users, then the savings could be double this, taking the net cost down to £2,526.

For 30 the Wintles (one of the larger properties at 197m^2), the quote is £12,176, for a 12kW Therma V heat pump. Again, with a CoP of 3 the DRHI would provide £1,180 in the first year, or £8,906 over seven years. The savings for an average user would be £95/a, giving savings over seven years of £717, or £2,427 over twenty years, giving a net saving of £843, rising to a saving of £3,442 if cost of boiler replacement etc is allowed for.

	Cost	RHI over 7 years	Savings over 7 yrs	Savings over 20 yrs	Net Cost after 20 years
	£12,176	£8,906	£717	£2,427	-£843
Allowing for LPG boiler replace etc	£9,176	£8,906	£1,096	£3,712	-£3,442

Fig 11, 30 Wintles, ASHP average user

Again, if they are a high user the savings would double giving a net saving over twenty years of £3,270 and any property with PV would see greater savings as some of the electricity needed could be provided by the PV.

5.4 **Shared Loop Systems**

Kensa have indicated that the use of a shared loop system would reduce the cost per dwelling by around £890 each for the Burwarton bungalows and £3,000 on average for the Wintles houses.[7] This is not sufficient to cover the added administrative complexities of a shared loop scheme. The Burwarton scheme savings are small because of there are only 6 small properties involved. At the Wintles most houses require 2 fairly deep boreholes so sharing boreholes does not reduce the number required by much. The use of a shared loop system would almost certainly mean losing out on Domestic RHI funding as this has previously been determined to fall under the Non-Domestic scheme. Unfortunately, the Non-domestic RHI is longer open for new applications.

If the Non-domestic RHI had still been available at 9.74p/kWh over 20 years that would have given a year one income of £1,440 for the average Wintles property, with a total 20-year income of £36,790, allowing for annual inflation of 2.5%, a net surplus of £10,780, allowing for the 5% discount. If the capital cost was provided by a Community Benefit Society which paid their investors 2.5% and repaid the capital gradually starting at the end of year 5 the Society would spend £8,130 per property on interest and have £2,640 spare per property to cover their costs, or £130/property/annum.

We have re-run the figures for the largest Wintles property, and the end results are very similar.

This indicates that running the finance over a 20-year period this scheme could have worked with the Non-Domestic RHI, but only if an initial fee or ongoing service charge had been levied on the occupants enrolled in the scheme. If we allow for £50/property service charge, rising at 2.5%/annum, the amount available to run the project rises to £3,926 per property but unless these charges were collected by volunteers there would be an admin charge associated with them. The occupants would have also needed to cover the cost of replacing the heat pumps after 20-25 years, although this would be much less than the initial cost.

It may have been possible to raise finance for the ground loops on a longer period than 20 years which would assist with viability and reduce the level of service charge but the scheme would still need some subsidy to be viable.

5.5 **High Heat Retention Storage Heaters Burwarton**

We would expect HHRSHs to cost in the region of £4k per property. The EPC calculations show a cost saving of £270/annum, but this figure would vary depending on the use of the property and the systems and could be much higher than this. We therefore expect a payback of around 15 years. We are not aware of any grant funding available for HHRSH's at this time. This cost would probably need to be borne by SRH, whereas the savings will accrue to the tenants, unless an additional rent is charged.

6. **Planning & Permitting.**

Individual heat pumps do not normally need planning permission unless placed within 1 metre of a boundary. Permission will need to be sought from the District Network Operator; this is not normally an issue but permission could be refused if a large number of heat pumps have been fitted in a small area. There is also an electrical interference risk that the DNO will assess in these circumstances.

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[7] *See appendices 3 and 4*.

7. **Site**

The sites at Burwarton and Bishop's Castle were agreed when the RCEF bid was put together. Ludlow 21 were interested in seeing the difference between a site owned by a Housing Association and one with owner occupiers. The Wintles is of particular interest as most of the owners purchased their properties as Eco-Homes and are surprised to find that they do not score well on their Energy Performance Certificates. One of the forty-two houses at the Wintles already has a ground source heat pump.

8. **Operation and Governance**

As a viable Community Energy scheme has not been found in this work governance and operation are not an issue.

9. **Scheduling**

We recommend that anyone fitting an individual heat pump does so before the end of March 2022, and sooner if possible, to take advantage of the Domestic RHI.

If a shared loop scheme is still of interest any further work would be dependent on the Heat and Buildings Strategy which is expected to be released in the summer of 2021, and on any new funding streams arising from this.

If there is interest in looking into a wider heat network in Bishop's Castle, then the expected review of the Heat Network Investment programme will be of interest. At the moment the programme is limited to schemes with over 2 GWh of heat/annum, it is expected that this minimum requirement will be reduced

10. **Conclusions (Case study statement)**

Ludlow 21 commissioned Sharenergy to carry out a feasibility study for alternative heating systems at two sites, some Shropshire Rural Housing bungalows in Burwarton, and the owner-occupied estate at the Wintles in Bishop's Castle.

The work initially focused on the use of shared loop ground source heat pumps with the possibility of setting up a Community Benefit Society to install and run these systems. However, the finance that has supported similar schemes over the last few years, the Non-Domestic Renewable Heat Incentive (NDRHI), closed to new applicants, part way through the studies. Without the NDRHI it has not been possible to make such a scheme viable.

Studies then concentrated on individual heat pumps; these were found to be viable using the Domestic RHI which runs until the end of March 2022. There is a choice between air source and ground source heat pumps, air source would be more suitable for the smaller properties with lower heat usage, ground source for the larger properties with higher energy usage.

Alternatively, the Burwarton properties could be fitted with High Heat Retention Storage Heaters, which appears to be the Housing Associations preferred choice.

All the schemes showed carbon savings over 20 years varying from 5.6 tonnes per property for the storage heaters at Burwarton up to an average of 36,000 tonnes per property for the heat pumps at the Wintles.

Chris Deaves of Ludlow 21 states that

"Ludlow 21 is grateful to the RCEF for providing the grant that made this study possible and to Sharenergy for not only carrying out in a thoroughly competent and professional manner, but also being proactive in developing aspects of the study as it progressed to derive the maximum value from it.

We are also grateful to the residents on the Wintles estate and to Stuart Jobson, Shropshire Rural Housing Association and their tenants for allowing their properties to be used in this study.

Unfortunately shared loop systems have not been feasible in these locations with the present national grants regime (May 2021) , but the study has highlighted the main drivers to be addressed.

This is an important area of study for Shropshire as there is a high proportion of off-gas-grid properties, many of which are in small communities where benefits of scale are not realisable, and many heritage properties where non-carbon heating presents a challenge. We hope that the results of this study will inform financial and technical policy in these areas."