Kirby Misperton Geothermal Community Heat Network

Report commissioned by Kirby Misperton Parish Council

Funded by the Shared Prosperity Fund of North Yorkshire Council
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Contents

1. Executive Summary

The three wells that are located on the KMA well site near to the village of Kirby Misperton, if converted for geothermal heat production, are capable of supplying all of the heat needs in the village including Dewars, Hotel, the Rectory Office building, St Laurence Church, the village hall and all residential properties. The geographic distance of the permanent residents of FlamingoLand from the main village makes it difficult to connect them to the same central network. A new geothermal well located within the boundaries of the theme park would be a better option for those properties.

The most economically viable approach is to convert the KM8 well in a first phase of development which would then serve Dewars Hotel, the Rectory Office, St Laurence Church and those residential properties in the central and northern sections of the village who are wishing to participate. A second phase (bringing the KM7 well on-line) could be added to serve the Village Hall and the remaining residential properties. The reason to split the development into two phases is so that the economically viable phase 1 de-risks the second phase, making it easier to finance.

Using a Levelised Cost of Heat (LCOH), which incorporates up front capex costs, to compare alternative systems, in the first year of operation the geothermal system has a similar LCOH as gas but is cheaper than Air Source Heat Pumps (ASHPs). By year 15 the geothermal system is cheaper than both alternatives and by the end of the project (year 40) the geothermal system is cheaper than both gas and ASHPs by 44% and 26% respectively. A fully utilised KM8 well (phase 1) could save a total of 8,885 tCO_2e in carbon emissions over the 40 year project life.

However, without some form of grant funding for the initial network deployment, the NPV and payback of Phase 1 would be challenging if competitive pricing for the heat were to be maintained. With a 60% capex grant the project becomes investible while retaining competitive pricing for customers and providing an investor payback of 10 years. To this end, CeraPhi have applied for a capex grant from the York & North Yorkshire Combined Authority and have passed the initial phase of assessment. The application, if successful, will be announced in August/September 2025.

For a typical residential customer using 13,800 kWh of gas heating per year, the connection costs of the geothermal system would be approximately £5,500. If they are using an old inefficient gas boiler, energy costs will be cheaper in the first year with the geothermal system and the payback on the initial capex would be 12 years. If a household has recently invested in a new, more efficient gas boiler, then the annual energy costs of the geothermal system will be cheaper after 5 years, but the payback remains the same at 12 years.

2. Background and Introduction

In May 2024, Kirby Misperton Parish Council ("KMPC") applied for a grant from the Shared Prosperity Fund managed by North Yorkshire Council ("NYC") to undertake an engineering and assessment study into a geothermal heat network for the village of Kirby Misperton using three existing but redundant gas wells on the nearby KMA well site. The grant was awarded in August 2024.

The project was to build on the progress made at the nearby KMA well site where a geothermal demonstrator project has been installed (on the KM8 well) which is a UK first in converting a well previously drilled for gas into a geothermal heat producer. This follows on from the 2016 protests by villagers and others against the plans for Third Energy ("TE"), the owner of the KM8 well, to commence hydraulic fracturing in order to produce natural gas from deep shale beds. The protests successfully prevented the hydraulic fracturing from taking place and helped to lead to a government moratorium on such activities in 2019.

From 2019 onwards, the new management and owners of TE have worked with community leaders to bring about a transition of the company away from natural gas to renewable geothermal energy resulting in TE acting as project managers on this project in addition to several other geothermal projects around North Yorkshire. It is fitting, therefore, that Kirby Misperton should be one of the places that benefits from the provision of clean, sustainable heat from redundant gas wells.

As a result of the successful geothermal demonstrator project near to the village in 2024, a project operated by CeraPhi Energy Limited ("CEL"), later that year CEL purchased TE, bringing together the existing assets of TE in North Yorkshire with the geothermal engineering expertise of CEL. The precise technology to be employed is a closed-loop monobore system, whereby each well is shut off to the surrounding geology with water circulated down and back up each well, gaining temperature as it does from the natural temperatures existing at depth in the wells. In this way there is no environmental impact since each well represents a closed system from which heat exchangers can extract heat at the surface.

Alignment with Climate Strategy

This project is aligned with the Climate Change Strategy issued by NYC, providing a reduction in greenhouse gas emissions by replacing existing fossil fuel heating systems with a zero-carbon heating source providing mitigation against climate change. North Yorkshire has committed to being the UK's first carbon negative region by 2040. The region has a head-start in heat decarbonization via geothermal wells, being the location of the country's first demonstrator project converting a redundant gas well into a geothermal well (as noted above). This project can help to turn that initial work into a village-scale heat decarbonization scheme that can demonstrate a decarbonization solution that could contribute significantly to the 2040 target in a way that is only now being considered into any council decarbonization plans.

With respect to COP28, a UN two-year review states how far off track we are for restricting global warming to 1.5degC. Countries must reduce greenhouse gas emissions by 40% by 2030, yet emissions are currently rising. If successful, widespread roll-out of this pilot project could have huge potential to meet such targets, not only within North Yorkshire, but nationwide and beyond.

The development of geothermal heat systems has moved closer to reality with a recent demonstrator test near the village positioning Kirby Misperton at the forefront of geothermal innovation in the UK. This was highlighted in a recent article on BBC's The One Show.

Study Outcomes

This study was intended to provide the following outcomes:

1. Public outreach in the form of letter drops, public meetings etc. in addition to direct contact with Dewars Hotel and other large energy users, enabling a village-wide indication of interest, supporting the case for a heat network;
2. A third-party technical assessment of the three wells located at the nearby KMA well site and costings for the necessary works to convert them into geothermal wells;
3. An economic assessment of the proposed geothermal heat network leading to a business case for the development and installation of the entire network;
4. An estimate of up-front connection costs for each customer of the network; and
5. An assessment of the carbon emissions savings that can be achieved, broken down by each user type.

The achievement of these outcomes is addressed in Section 9 below.

3. Community Outreach

Community Outreach for the project commenced prior to project award at the KMPC annual public meeting on May 18th 2024 where TE presented the concept of the study to those community members present and answered any questions raised. Once the award had been granted, with the assistance of KMPC, we drafted an information letter to be delivered to each property in the village. Between 7th and 9th October 2024 each property was visited at least once to provide the information letter and request energy usage and cost data. Where there was no answer at a property, a second visit was made but following that the information letters were posted through letterboxes. In order to simplify the outreach process and the subsequent collection of data, the residential properties were split into four sections as shown in Figure I below: North, Central, South and FlamingoLand ("FL") permanent residents.

In total, the north, central and south parts of the village encompassed 94 residential properties with an additional 49 permanent residents of FL. We were able to obtain direct energy data from at least one property in each village segment but having assessed the type of property in each of the 143 properties, we were able to use publicly available data to estimate mains gas usage for heating and hot water. In distributing the information letters in early October, we were able to invite all villagers to a day-long public open exhibition held at the Memorial Hall in the nearby town of Pickering on 7th November 2024. This was an opportunity to engage with residents and stakeholders on this specific project but also the technology being employed and other projects in the local area.

In addition to the residential properties, we also engaged with the stakeholders of other buildings and community assets in the village. These comprised of the village hall, St Laurence Church, Dewars Hotel & Restaurant and the Rectory Office building in FL (the latter two of these being owned by FL). All of these buildings lie close to the central road in the village as shown in Figure IX on page 15 below. We had previously held discussions with the church and FL regarding geothermal solutions and so this study was able to build on those already established relationships and the data collected directly from these four key off-takers.

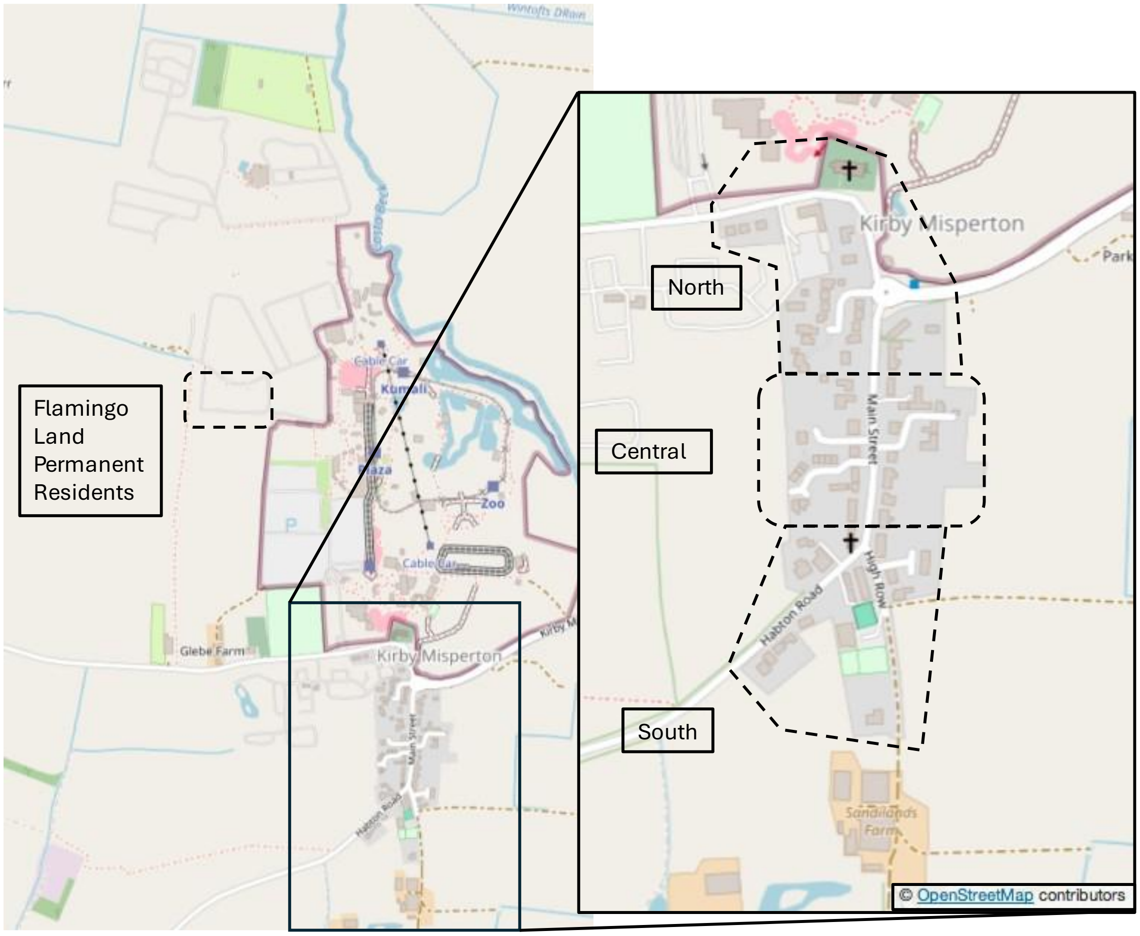

Figure I: Kirby Misperton Residential Areas

4. Energy Needs & Load Assessment

Energy Needs

In assessing the heat requirements of the village, we had to consider both the total heat demand, in kilowatts (kW) per annum as well as the peak demand, measured in kilowatt-hours (kWh), ensuring that any proposed system can handle peak requirements as well as total demand over time. Seasonality was also assessed using the collected data to ensure that any variations from expected seasonality were taken into account. As shown in Figure II below, due to the need to heat a swimming pool and spa in the Dewars complex, seasonality is less pronounced than with the church. Residential properties showed a similar seasonality to the church.

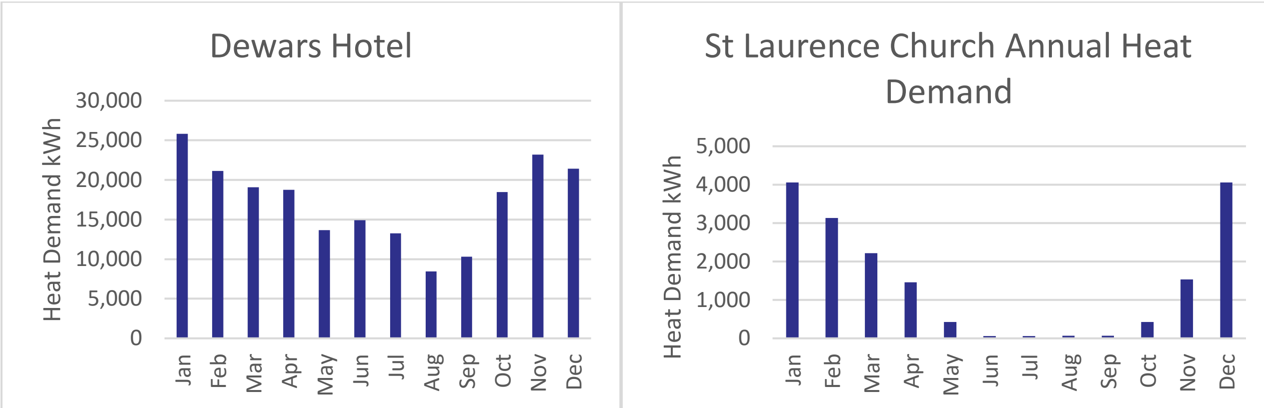

Figure II: Seasonality of Dewars Hotel and St Laurence Church

By consolidating the directly-sourced data with publicly available data for residential properties, the estimated peak demand, required annual hours of operation and resulting total thermal demand is summarized in Table I below.

	No. of properties	Estimated Peak Demand (kW)	Annual hours of heating *	Annual Thermal Demand (kWh)
Kirby Misperton South	27	158	61,600	361,200
Kirby Misperton Central	40	257	95,000	622,500
Kirby Misperton North	27	175	64,100	417,100
FL Permanent Residents	49	196	107,800	427,984
St Laurence Church	1	14	1,460	20,660
Village Hall	1	13	1,460	18,990
Dewars Hotel/Restaurant	1	102	2,400	245,258
FL Rectory Office	1	69	2,400	164,961
	147	984	336,220	2,278,653

* total for all properties in subsection

Table I: Summary of village peak and annual demand

Load Assessment

Having established the baseline demand (in both kW and kWh) we were then able to assess the load that would be required for the system and factor in more efficient ways of heating than are currently available for the village. By heating properties in a more efficient manner we are able to lower the peak demands by providing lower levels of heat for longer periods.

For instance, the seasonality of demand for the Dewars Hotel shown in Figure II above can be satisfied via two solutions – an 11kW baseload heat pump which would operate all year round (8,760 hours per year) and a 47kW peak pump which would only operate for 4,380 hours per year. The contribution of these two systems to the heat demand of Dewars is illustrated in Figure III. By providing lower levels of heat but for longer periods, the peak demand can be satisfied in a more efficient way.

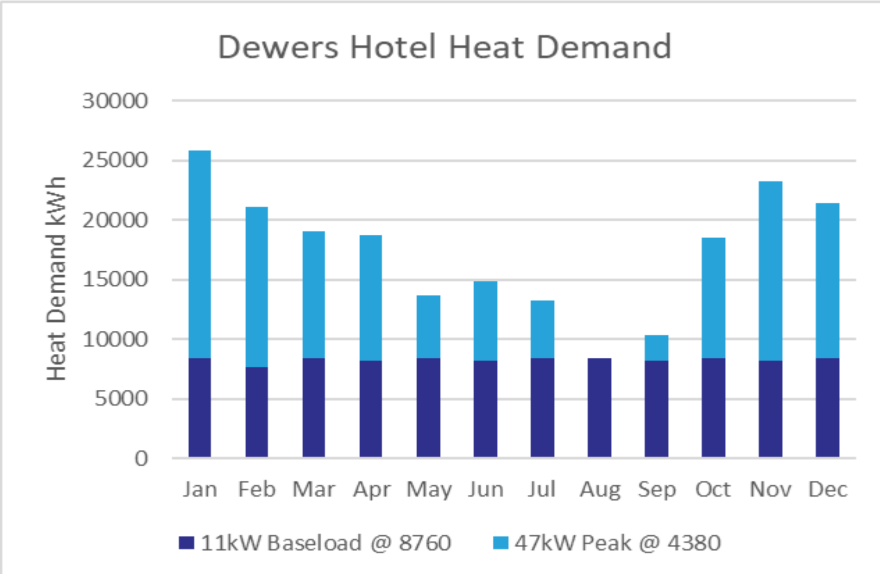

Figure III: Reconfigured thermal demand for Dewars

The same efficiencies can be applied to residential properties. Rather than using gas boilers to rapidly heat a property once or twice a day and then allowing those properties to cool before then needing the gas boiler to rapidly heat once more, lower levels of heat can be provided for longer periods of time, maintaining an ambient temperature and making it easier to then achieve peak requirements when required (because the property temperature is already at ambient, rather than cool).

Applying these approaches across the village i.e. increasing the hours for which heat is provided but lowering the peak requirements, would have the following impact on hours of operation and peak demand (Table II). These are the village demands that any system needs to address.

	No. of properties	Original Estimated Peak Demand (kW)	Original Annual hours of heating per property	Reconfigured Peak Demand (kW)	Reconfigured Annual Hours of Heating
Kirby Misperton South	27	158	2,200	75	4,635
Kirby Misperton Central	40	257	2,200	121	4,668
Kirby Misperton North	27	175	2,200	83	4,639
FL Permanent Residents	49	196	2,200	89	4,862
St Laurence Church	1	14	1,460	8	2,582
Village Hall	1	13	1,460	7	2,713
Dewars Hotel/Restaurant	1	102	2,400	58	4,229
FL Rectory Office	1	69	2,400	38	4,341
	147	984		479	

* total for all properties in subsection

Table II: Reconfigured village peak demand

5. Well Design and Hydraulic Modelling

Having identified the heat demands (both annual and peak) for potential off-takers of the heat networks, the CEL technical team focussed on the well designs and hydraulic modelling for the wells at the KMA site. North Yorkshire is particularly well suited to deep closed-loop geothermal systems due to higher-than-average subsurface temperatures at depths below 1,000 metres. This is due a salt crust left from a Permian Era sea that covered much of northern Europe including parts of North Yorkshire (see Figure IV) which acts as a thermal conductor.

Figure IV: Footprint of Zechstein Sea from 250 million years ago.

The thermal gradient (i.e. the rate at which temperature increases with depth) sits at an average of 30°C per kilometre across the UK. However, due to this geological feature (which lies between 1,200 metres and 1,700 metres across North Yorkshire) the temperature gradient is much higher. Measurements taken at the demonstrator well verified temperatures in excess of 70°C at a depth of 2 kilometres instead of the normal 60°C. The thermodynamic modelling undertaken by the CEL team takes account of temperature production over 40 years and allows for a certain amount of cooling over time i.e. the demand from the village has to be satisfied by the system's output in year 40. In the early years of operation the kW output will be far higher than the village needs but those needs will remain satisfied in year 40.

There are three wells on the nearby KMA well site (KM3, KM7 and KM8) which are of differing depths and deviation (away from the vertical) which are illustrated in Figure V together with two other wells on another nearby site (KMB).

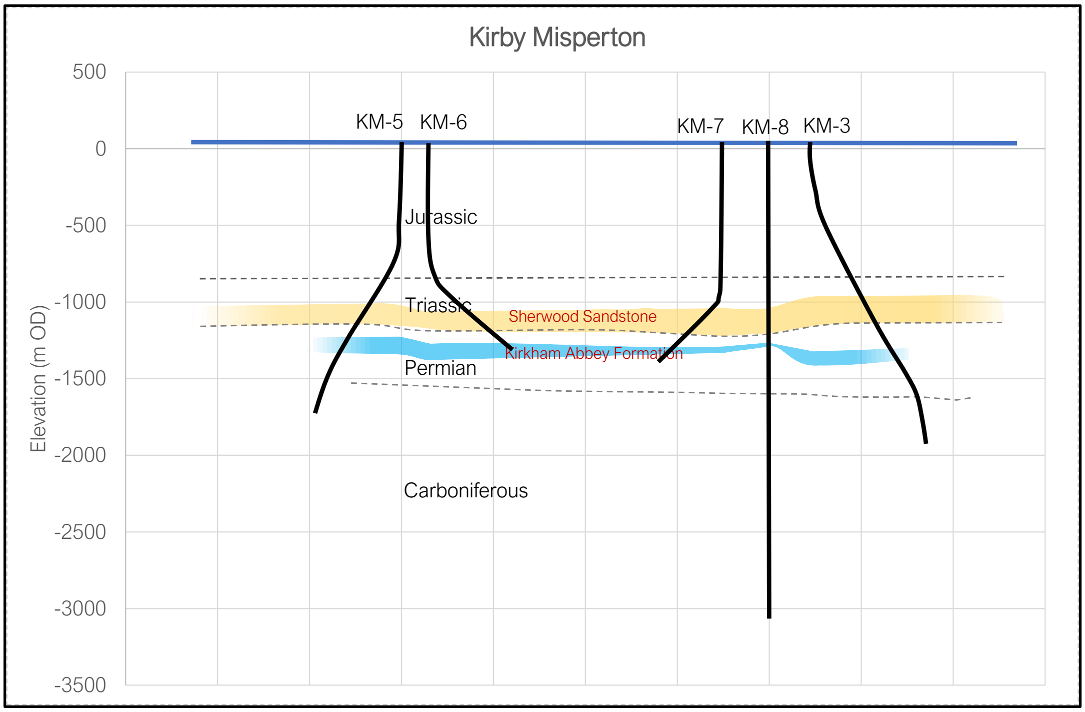

Figure V: Cross section and geology of KMA wells

The differing well characteristics are summarised in Table III. These characteristics (age, depth, deviation and current condition) impact the suitability of each well for geothermal repurposing. The KM8 well is already a closed loop well and is very deep, meaning it would take little upfront investment to convert the well for a heat network. The KM3 and KM7 wells, by contrast, would require more up-front investment to convert them because the existing geological perforations would have to be closed prior to them being used for a closed loop system.

	Year Drilled	Vertical Depth (metres)	Measured Depth (metres)	Current Status
KM3	1987	1,320	1,725	Used as an injector well until 2019 (for re-injecting water). Contains two temporary plugs but has perforations into the surrounding geology.
KM7	2012	1,186	1,245	Drilled for conventional gas production but suspended. Contains two temporary plugs but has perforations into the surrounding geology.
KM8	2013	3,000	3,000	Drilled for hydraulic fracturing but never perforated and therefore already a closed well. Currently hosts the geothermal demonstrator system.

Table III: Characteristics of the wells at the KMA well site

Due to the different characteristics, KM8 is the most easy to convert (and therefore cheaper), followed by KM7 and finally KM3 (which has more complicated tubing and perforations than KM7). Therefore, if we were to convert these wells in phases, we would start with KM8, followed by KM7 and lastly KM3.

In addition to the above, the temperature output of each well will depend on the flow rate but the flow rate will impact how much pumping power is required. Therefore, there are many elements to take into account when deciding on what each well can offer and how best to use that well. The CEL team also ran the modelling for a generic 1,800 metre well (i.e. a new well drilled specifically for geothermal use) that had been used in other nearby studies completed in 2024.

The results of the modelling for all three wells, plus the generic design for a new well, are summarised in Table IV. All the above outputs are what is possible at the end of a 40-year operating life.

Flow rate (litres/sec)	Outlet Temp (°C)	Output (kW)	Required Pumping Power (kW)	Coefficient of Performance
KM3 Well				
2	9	79	0.3	266
4	7	124	2	56
6	6	145	7	20
8	5	162	17	10
10	4	182	32	6
KM7 Well				
2	10	81	0.2	326
4	7	119	2	65
6	5	137	6	23
8	5	151	14	11
10	4	167	26	6
KM8 Well				
2	20	170	2	90
4	19	313	13	24
6	16	400	43	9
8	14	482	100	5
10	14	585	192	3
New 1,800m well				
2	12	103	0.5	206
4	10	159	3	53
6	7	184	8	23
8	6	203	19	11
10	5	224	35	6

Table IV: Hydraulic modelling results

What the above results show is that as flow rate increases the outlet temperature increases but so does the kW output. Therefore, the KM8 well can produce a temperature of 20°C after 40 years but it will only do this at a flow rate of 2 litres per second resulting in output of 170 kW. Whereas increasing the flow rate to 10 l/s would lower the temperature to 10°C but result in output of 585 kW, although this would require far more power for pumping (and increase the electricity costs of pumping). Therefore, there is a balance to be made between temperature and kW output.

A common way to compare different systems is to calculate the Coefficient of Performance ("CoP"). This is done by dividing the output (in kW) by the input power for the process (in this case the pumping power). As a guide, modern heat pumps have a CoP of at least 4, meaning for every kW of electricity consumed 4kW of heat is produced. In the example of KM8 above, at 2 l/s the system would have a CoP of 90 but would only produce 170 kW whereas at 10l/s the COP would only be 3 (and therefore not very efficient).

By plotting the above results onto a chart, it is easier to identify the optimum operational design for each well (see Figure VI).

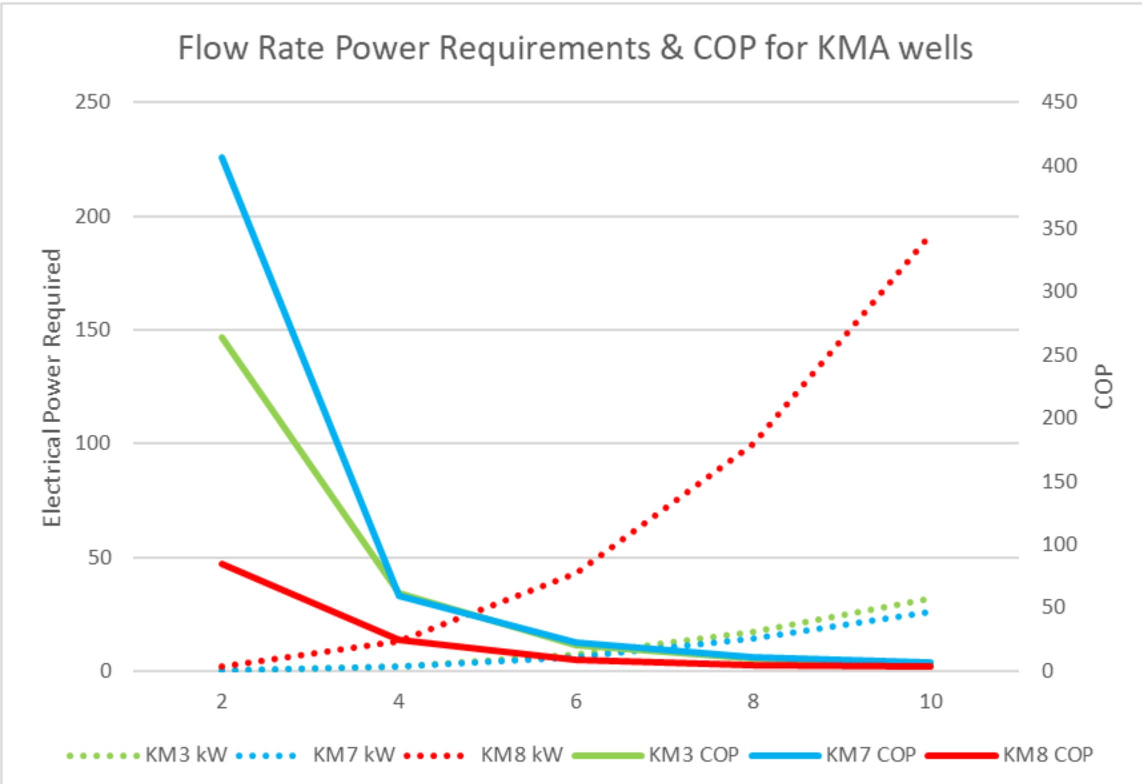

Figure VI: KMA well flow rates and COPs

The pumping power requirement for an 8 l/s or 10 l/s system (the vertical axis) on all the wells would be prohibitive (with the cost of the electricity for pumping outweighing the benefits of the higher CoP). From Table IV, with all three wells operating at 2 litres/second a total peak output of 330 kW is possible. However, this output does not incorporate the uplift of power provided by the heat pumps. When including this uplift the output of the wells amounts to 440 kW. Since this is less than the minimum peak requirement identified in section 4 (479 kW) this leaves the 4 l/s and 6 l/s scenarios as the remaining viable options. Including the impact of heat pumps, the potential output of all three wells under these two scenarios is 740 kW and 911 kW respectively – both more than enough to cover the heat requirement for the village.

6. Surface Equipment and Distribution Network

The Wellhead

Once drilled, the surface equipment required for a closed loop system is minimal. At the top of the well, there will be a simple set of valves controlling an outlet (hot water) pipe and an inlet (cooler water) pipe which are the beginning and end of the heat ring-main that is created. Figure VII shows the configuration at the KM8 Demonstrator. The valves and pipes could also be located in a sunken cellar and so could be located below ground. Access via a grill would be required (for maintenance and monitoring) but the surface footprint itself would be very minimal. There are no moving parts within the well bore itself (only circulating fluids) and the operating pressures of the wells will be far lower than their design thresholds (for gas production) which will ensure minimal risk of well failure.

Figure VII: Geothermal Wellhead

Heat Network

Figure VIII shows the indicative heat network design. An Energy Centre would receive the heated fluids from the well(s) using a heat pump, and via a heat exchanger will transfer that heat to the low-temperature heat network that will connect the target off-takers. The current energy centre for the KM8 demonstrator is enclosed within a standard 20ft container.

The heated fluids from the energy centre would then be distributed to a community loop through submerged pipes that would circulate the heat around the village and back to the energy centre. Each end user will then have their own heat pump (at a specification bespoke to their own needs) and short stretch of submerged piping which will transfer the heat from the heat network into their own wet radiator system and, where necessary, boost that heat to enable hotter water use (e.g. showers).

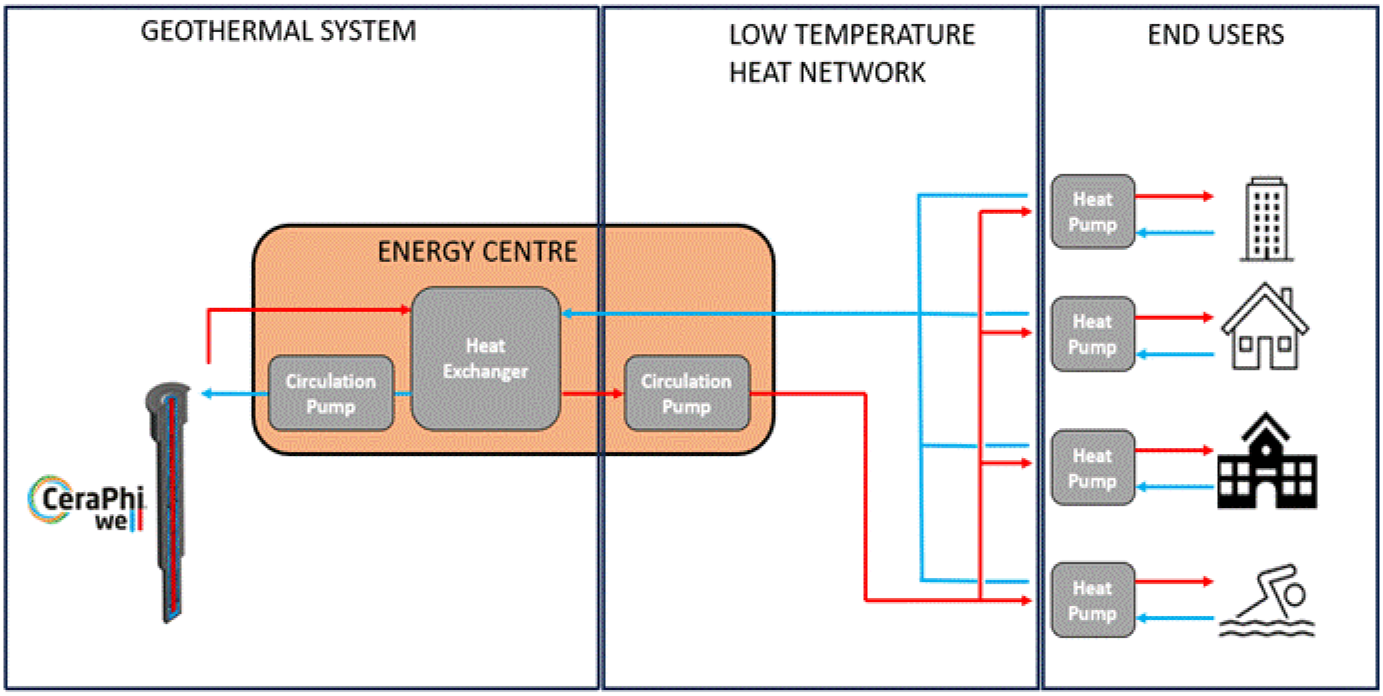

Figure VIII: Heat Network Design and Off-taker Connection

The system is designed to provide parts of Kirby Misperton with zero carbon heat (with all Scope 1 emissions eliminated). The heat pumps will require a power supply (see below) which we have assumed would come from the grid (but could be solar-powered), but due to the elevated temperatures being provided by the network, the heat pumps will operate at a far higher efficiency than a traditional Air Source Heat Pump, lowering Scope 2 emissions. Each off-taker will have a modern Heat Interface Unit installed, which will provide consumers with as much control over their heating as with a conventional system.

When considering the optimal distribution network we had to consider the location of the existing wells, the anchor off-takers (e.g. Dewars Hotel) and the residential properties and the distances between each of these.

As Figure IX shows, the KMA well site can be easily connected to the main village and anchor off-takers. The well site itself is approximately 750 metres from the edge of the village and the length of a network to connect all residents in the main village (including the four large off-takers) would be 2.4 kilometres. Due to the economic analysis (which is summarised in Section 8) we propose a two-phase build-out of the network. The initial phase would include conversion of the KM8 well and link the northern and central areas of the village including Dewars Hotel, the church and the FL Rectory Offices. A second stage would include the conversion of the KM7 well and link the remainder of the main village including the village hall.

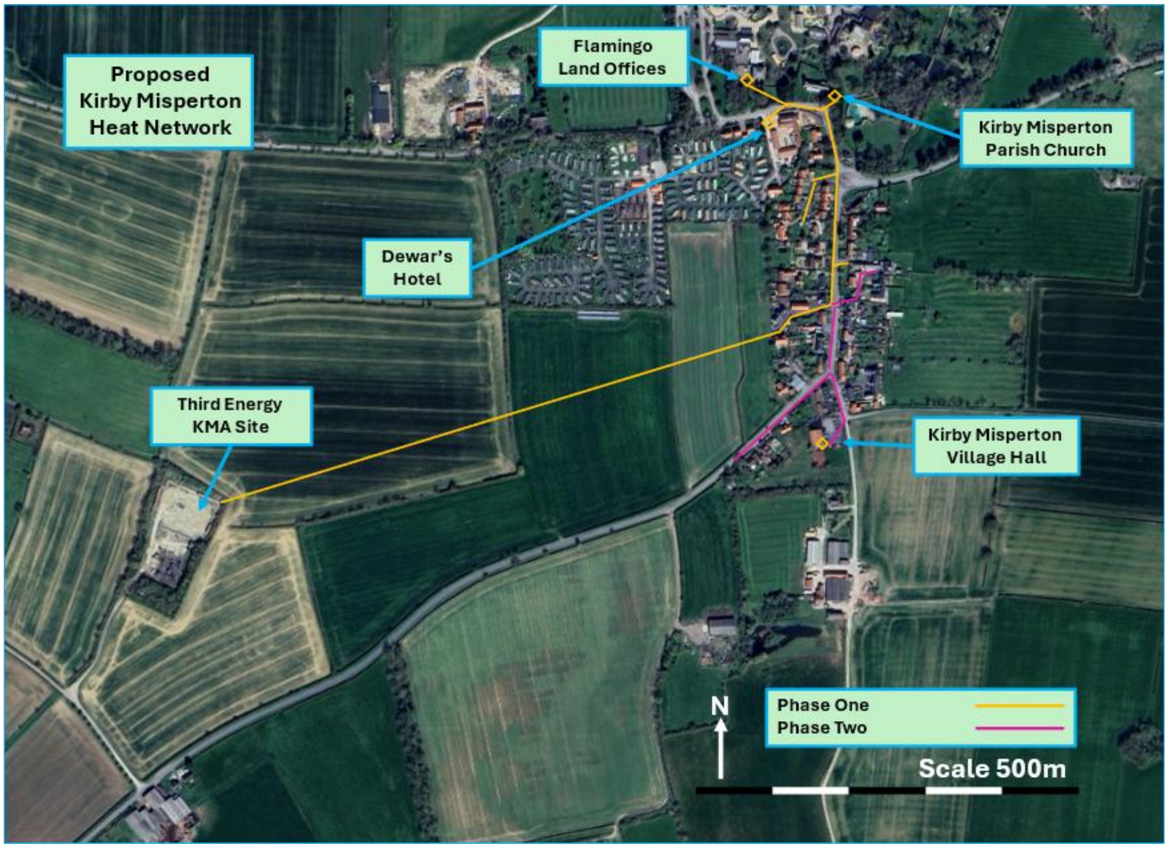

Figure IX: Proposed Heat Network

Unfortunately, as Figure X below shows, the permanent residents of FL lie a further 700 metres from the end of the main village or 1.1 kilometres from the well site itself. Due to the need for a loop (i.e. out and back pipes) this would require an additional 1,400 metres of pipe and trenching from the end of the village or a network of 2.2 kilometres if direct from the well site. Unfortunately, this makes it very difficult to service the FL permanent residents from the KMA wells.

The FL residents would be more easily served by a new geothermal well within the boundaries of FL. CEL and FL management have already discussed such a concept, which could also heat a swimming pool and clubhouse complex in FL, and the generic new well design undertaken as part of this study could provide between 103 kW and 223 kW as shown in Table IV above. Such a well would be sufficient to provide heating to FL assets as well as the 83 kW peak demands of the FL permanent residents (see Table II).

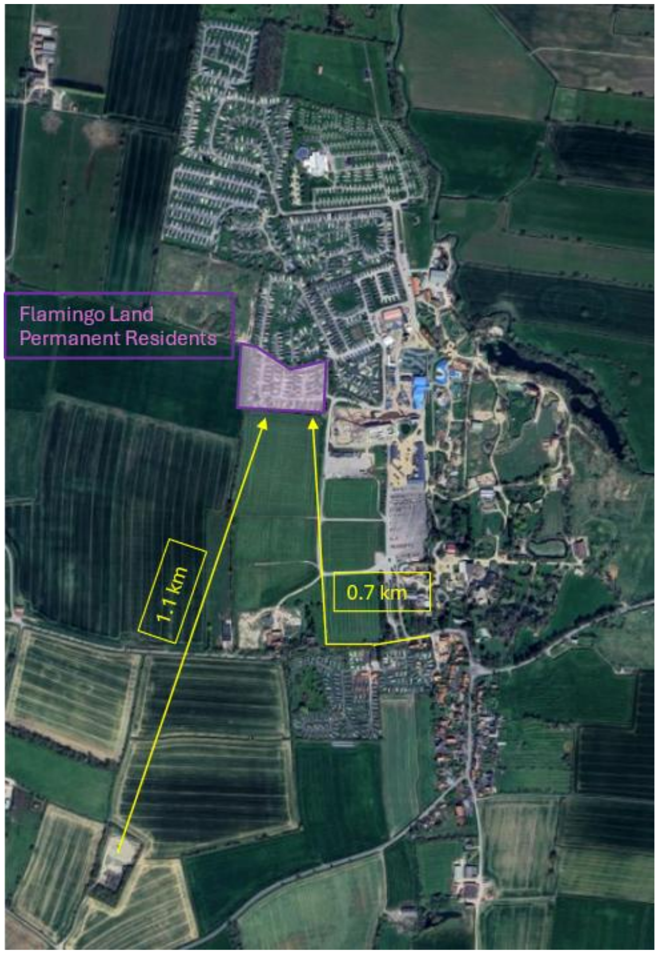

Figure X: Location of FL permanent residents

Power Supply

The Energy Centre in each location will require a power supply (to run the circulation and heat pumps) which could be from the grid. While the eventual power supply was not an intrinsic part of this study, we would recommend the use of solar energy to run the well pumps, thereby further reducing Scope 2. Taking into account the average daily irradiance in North Yorkshire and the daylight hours available, we were able to estimate the required solar plant in each scenario and have included that in our economic modelling. If individual residents wished to use solar for their own heat pump this would reduce their carbon footprint, and that of the village, even further although we have not factored that into our modelling.

7. Household Connection Costs

In order to connect to the village heat network, each property will require a ground-source heat pump (connecting with their existing hot water tank) which will be connected to the network through a short length of piping laid into trenches (similar to existing gas pipes into the properties). As a guide, the approximate costs of the equipment for a standard 2-3 bedroom house are set out in Table V.

	Quantity	Unit Cost	Total Cost
Ground Source Heat Pump (180l cylinder)	1	£10,200	£10,200
Trenching			
Excavate trenches within road area (900mmx1,000mm) and backfill	2	£400	£800
Excavate on hard surface (footpath/driveway - 600mmx1,000mm)	2	£350	£700
Excavate trenches on soft land (grass verges - 600mmx1,000mm)	2	£200	£400
HDPE piping and ancilliary costs	6	£150	£900
HDPE pipework and materials	6	£14	£84
			£13,084
BUS grant available for replacement of fossil-fuel heating system			-£7,500
Net cost to household			£5,584

Table V: Indicative connection costs for a 2-3 bedroom house

The UK government's Boiler Upgrade Scheme (BUS) provides grants to encourage property owners to replace existing fossil fuel heating systems with more efficient, low-carbon heating solutions. Under this scheme, homeowners in England and Wales can receive £7,500 towards the cost and installation of either an air source or ground source heat pump. The subsidy is available to all properties that completely remove their existing fossil fuel heating system and replace it with a heat pump. Properties would continue to be able to use gas for cooking if desired. This subsidy will reduce the per-property cost to approximately £5,500 as shown in the table but this will enable each property to benefit from significantly lower long-term energy costs (see Section 8).

It may be possible to further subsidise the initial connection costs further for those properties that commit to phase 1 although this would have to be agreed once the private investor has been secured. There are also financing schemes available to cover the up-front connection costs.

8. Project Development & Economics

The detailed economic modelling is explained in the full CEL technical report that is available on request but the key assumptions used in the modelling are shown in Table VI. It is worth noting that in some years the gas price is likely to increase by more than the 6% assumed due to spiky commodity market pricing (as has been seen in the last few years) and attempts by the UK Government to bring gas prices closer to electricity prices to encourage the switch to renewables.

Electricity Price (£/kWh)	£0.245
Gas Price (£/kWh)	£0.075
Gas Standing Charge (per day)	£0.310
General Inflation Rate	2.0%
Electricity Inflation Rate	4.0%
Gas Inflation Rate	6.0%

Table VI: Assumptions used for economic modelling

Geothermal heat could be delivered under a subscription model (i.e. a regular fixed payment for connection to the network) but for the purposes of the economic modelling we have used a consumption model so that a per kWh price can be easily compared to those of gas and electricity. We have also used the Levelised Cost of Heat (LCOH) as the metric to compare the alternatives – LCOH includes all upfront capex costs and ongoing energy costs discounted back to a present value and is therefore the best way to compare systems that have no up-front infrastructure cost (e.g. retaining gas) to new systems that require infrastructure (e.g. geothermal).

The first stage of the economic modelling confirmed that because the KM8 well has already been used for geothermal heat production and would require minimal cost to convert it for a village heat network, the first phase should be for the KM8 well to provide heat to the northern part of the village (where three of the four key off-takers are located). A second phase would involve converting KM7 to provide heat into the rest of the village. KM3 would be retained for future expansion of the network if necessary. As noted above, the permanent residents in FL would be included in any new well designed for the FL resort itself and will have to form a separate project. In order to maximise the chances of getting the network financed, the economic modelling has focussed on phase 1 – the conversion of KM8 to provide heat to the central and northern parts of the village (as shown in Figure IX).

The initial capital expenditure and ongoing operating costs of the Phase 1 network are shown in Table VII. We have included solar and battery storage capacity at the well site to generate the electricity for the circulating pumps and distribution pumps which means ongoing power costs for the network itself can be avoided (and Scope 2 emissions avoided) meaning ongoing network operating costs would be approximately £12k and would the only rise in line with general inflation (i.e. not subject to commodity price shocks). Total capital expenditure to install the network (up to the boundary of off-taker properties) would cost £1.0 million including the cost of solar PV and battery storage capacity at the well site.

	Cost
Initial Capital Investment	
Well site preparation and workover	£100,000
CeraPhi well installation capex	£150,000
Surface capex	£30,900
Solar capex (well site energy centre, incl. BESS)	£171,078
Surface distribution (trenching and pipeline)	£350,000
Engineering Project Control (EPC)	£80,198
Project Management	£132,326
	£1,014,502
Ongoing Operating Costs	
Annual pump servicing	£996
Well rental to landlord	£10,000
Annual well maintenance	£1,000
Surface distribution electricity costs	£0
Mechanical circulating pump electricty cost	£0
	£11,996

Table VII: Capex and opex for Phase 1

The economic modelling considered many different scenarios in terms of pricing and network coverage (which partly resulted in the phasing as set out above) but the three most illustrative scenarios were:

- Scenario 1 - Dewars, Rectory Offices, Church and at least 38 residential properties with pricing fixed at 9p/kWh (competitive with gas);
- Scenario 2 - Dewars, Rectory Offices, Church and 17 residential properties with increased pricing; and
- Scenario 3 - Dewars, Rectory Offices, Church and 17 residential offices with pricing at 9p/kWh and 60% grant funding.

The key investment metrics for the above three scenarios are shown in Table VIII.

	Scenario 1	Scenario 2	Scenario 3
Net Present Value (NPV) 40 years	£209,000	£1,048,770	£237,703
Internal Rate of Return (IRR) 40 years	6%	9%	10%
Payback Period (in years)	15	10	10
Heat selling price (year 1) in £/kWh	£0.09	£0.19	£0.09

Table VIII: Headline investment appraisal results

When considering the preferred development path, we need to consider how the initial phase of the project will be financed and therefore the above investment metrics are important to understand whether private investment will be available. Scenario 1 (where three key off-takers and at least 38 residential properties are connected) would provide a payback period of 15 years and a fairly low rate of return (6%). Such returns may be attractive for more proven technologies but for a first-of-its-kind network it would be difficult to attract financing. There is also the risk associated with getting long-term commitment from 38 households which would also make private investment difficult to attract.

By increasing the selling price from 9p/kWh to 19p/kWh (Scenario 2) far better returns are possible and, based on discussions CEL has had with potential investors, would be attractive to private investors. This scenario also has the advantage of needing only 17 residential properties to commit to the network. However, one of the main objectives of both TE and CEL is to provide significant savings for heat customers against existing alternatives. Therefore, we ran the third scenario whereby, due to the innovative nature of the project, the initial phase of development could attract 60% grant funding. This level of grant funding is common in green funds being offered by local authorities. During the completion of this study, the York & North Yorkshire Combined Authority ("YNYCA") invited applications to their Carbon Negative Challenge Fund (part of the Mayoral Investment Funds) which was offering 60% grant funding to capex projects. Such funds mean that for innovative projects, a smaller portion has to be privately financed. As Table VIII above shows, this means that while retaining a 9p/kWh price for off-takers, Phase 1 can still provide a 10% IRR and payback of 10 years which we believe is attractive to potential investors.

In terms of how these scenarios compare with other alternative options, the LCOH was calculated for both the existing gas grid solution and an alternate Air Source Heat Pump (ASHP) solution and then compared with the same measurement for the proposed geothermal network. LCOH can be calculated over differing time periods with longer time periods able to offset the upfront capex to a greater extent. For illustrative purposes we calculated LCOH for year 1, year 15 and year 40 in our 40-year modelling. The results of this are shown in Table IX. By incorporating the up-front capex costs, the LCOH is higher than the price that will be charged to customers but it is the best way to compare alternative systems.

	Year 1	Year 15	Year 40
Gas LCOH	£0.12	£0.21	£0.50
ASHP LCOH	£0.15	£0.23	£0.38
Geothermal LCOH	£0.12	£0.20	£0.28

Table IX: LCOH comparisons for Scenario 3

In Year 1, the proposed geothermal system would have a similar LCOH to the existing gas systems but would be cheaper than an ASHP alternative (give the high cost of electricity and the high power need for ASHP systems). After 15 years, the geothermal system would deliver a lower LCOH than the gas alternative and a 15% lower LCOH than ASHPs. In year 40 the geothermal system LCOH would be 44% and 26% lower than gas and ASHPs respectively. It is also worth noting that the gas alternative is unlikely to be available in 40 years given the net zero targets set by the UK Government.

Economics for a Typical Household

In terms of what this would mean to a typical residential customer who is currently on the mains gas, absorbing the up-front cost of £5,584 (from Section 7) and using 13,800 kWh of gas per year, we have compared the costs against three scenarios:

- A household using an inefficient old boiler for the next 20 years;
- A household using a new efficient boiler (which would cost £4,500) for 20 years;
- The Deep Geothermal System ("DGS") at an electricity price of 24.5p; and
- The DGS at a reduced electricity price of 15p.

The reason for providing the scenario with a reduced electricity price is that many operators offer cheaper electricity for consumers that have switched to a low-carbon system and a discount 39% (as used) is currently available in the market and therefore we have used this as the main price benchmark.

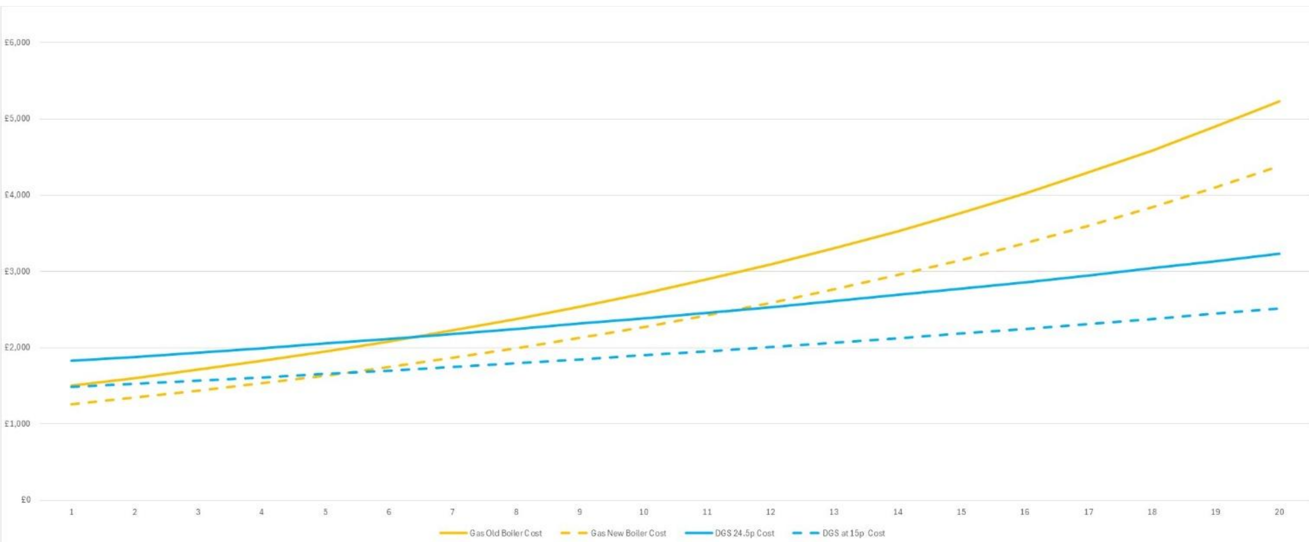

Figure XI: Annual energy costs for typical household with differing heating systems

As Figure XI shows, at normal electricity pricing, the DGS system is more expensive in the initial years and a system using a new boiler provides the cheapest solution, but only for the first five years. After this, DGS system benefitting from a reduced electricity price becomes cheaper. By year 11, even the DGS system without the electricity price discount is cheaper than the gas alternatives.

By comparing these systems, it is possible to calculate that the DGS system with the electricity price discount has payback of 12 years versus a gas system with a new boiler. It also has a payback of 12 years versus a gas system using an old boiler (i.e. no boiler replacement cost) because while there is no upfront cost of a new boiler, the annual gas costs are much higher due to the boiler inefficiency.

Therefore, for a cost of £5,584, a household using an old boiler will see cheaper energy costs in the first year of operation and get a payback of 12 years. For a household installing a new efficient gas boiler, the energy costs will be lower with the geothermal system after 5 years but the payback remains the same at 12 years. It should also be noted that while we have modelled these comparisons over the long-term, it is unlikely, given government net zero legislation, that existing gas systems will even be available over the long term.

9. Project Outcomes and Outputs

The delivery of the anticipated outcomes from Section 2 are assessed in this section.

Public Outreach

As set out in Section 3, considerable public outreach work was undertaken including public meetings and door-to-door leaflet distribution. A further public meeting and leaflet distribution will be arranged to disseminate the project results.

Technical Assessment of the three wells on the KMA well site

In addition to the technical summary outlined in Section 5 above a full technical report is available from CEL and can be obtained on request from ilse.bermudez@ceraphi.com.

Economic Assessment of a proposed geothermal heat network

Section 4 sets out the demands that would be put on any deployed network and Section 6 summarises the network equipment and infrastructure that would be deployed. The economic assessment is then summarised in Section 8. All of these areas are explored in more detail in the CEL Technical Report.

Estimate of up-front connection costs for customers

Section 7 above sets out the connection costs for individual heat off-takers and at the end of Section 8 this is compared with future savings to provide an individual pay-back period for residential customers.

Estimate of carbon emission savings (by type of user)

The two largest off-takers, Dewars and the Rectory Office, could reduce their carbon emissions by 78% and 79% respectively, a combined annual saving of 76.1 tonnes CO_2e and 3,041 tonnes CO_2e over the 40 year life of the project (see Table X below). The church and a typical residential property would have lower savings by quantity but this would still represent reductions of 78% in each case. It is likely that some properties in the village are using tanked oil rather than gas grid in which case the potential carbon savings are greater.

Assuming a successfully converted KM8 well can provide 400kW and is fully utilized, compared to a grid gas heating solution, the geothermal solution would provide carbon emissions savings of 8,885 tCO_2e over the project lifetime of 40 years.

	Dewars	Rectory Office	St Laurence Church	Typical Residential Property
Annual Heat Demand (kWh)	208,469	194,072	20,659	13,800
Annual Gas Consumption (kWh)	245,258	228,320	24,305	16,235
Current Emissions CO2e (tonnes)*	50.2	46.7	5.0	3.3
Heat Pump Consumption for geothermal system (kWh)	52,117	48,518	5,165	4,747
Projected Emissions CO2e (tonnes)**	10.8	10.0	1.1	1.0
Annual Carbon Savings (tonnes)	39.4	36.7	3.9	2.3
Project Lifetime Carbon Savings (tonnes)	1,575	1,466	156	94

* Using CO2e factor of 0.204542

** Using CO2e factor of 0.20705

Table X: Carbon emission savings by off-taker

10. Summary and Next steps

This study has validated the feasibility of using the wells at the KMA well site to heat a community heating network that would provide all the heat needs of the village including the Dewars Hotel, Rectory Office, St Laurence Church, the Village Hall and all the residential properties within the main village. Unfortunately, the proximity of the permanent residents of FL was not such that it was possible to connect them to the same network but an alterative solution, that of a new geothermal well within the boundary of FL, is very viable.

The financial viability of phase 1 (to include Dewars, Rectory Office, the church and at least 17 residential properties) depends upon finding grant funding for the up-front capex due to the innovative nature of the project and the reluctance of private investors to take on the risk. Once phase 1 is deployed, phase 2 (and subsequent phases) will have been derisked, enabling the additional capex to be privately funded. During the course of this project, a suitable grant fund has been launched by the YNYCA for projects to be delivered before October 2027. In March 2025, CEL submitted an application for a 60% grant to fund the deployment of phase 1, the deadline for this fund being March 21st 2025. The application included all costs associated with planning, design, engineering and deployment of the network. This application has passed the initial review process and a full application was submitted on May 31st 2025 with the result of the application expected in August or September 2025. Therefore, the next steps should be:

- For CEL/TE to engage with the key off-takers to secure in-principle long-term commitment to purchase heat on terms similar to those summarised in this report;
- CEL/TE and the Parish Council should engage further with the village residents in order to secure similar in-principle commitment from as many residents as possible; and
- Using such long-term commitments and subject to the successful award of the YNYCA grant, CEL will secure the remaining finance requirement from private sources.