RENEWABLE
ENERGY SPECIALISTS

Locogen

MFHCA RCEF Project

Stage 1: Phase 2 Report

For Monk Fryston and Hillam Community Association

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v1.0	22/01/21	Draft for Client review
v2.0	11/02/21	Revised version following feedback from MFHCA
v3.0	19/03/21	Final report including further appendices (requested by Client) and correction to Cricket Club demand profile.

Executive Summary

Monk Fryston and Hillam Community Association (MFHCA) have set ambitious targets for their community to tackle the Climate Emergency, setting an example for neighbouring communities and raising awareness in their own villages. Decarbonising the community buildings is a crucial part of this plan, and therefore the following aims were put together by the group at the beginning of the decarbonisation project:

1. *To make our Community Buildings carbon neutral by 2022.*
2. *To use our learning and investment in renewable energy technologies as 'working examples' to encourage village residents to adopt more environmental beneficial behaviours including investing in sustainable energy in their homes.*
3. *To share with other communities in Selby District and North Yorkshire our learning in order to encourage them to work on their Community Buildings.*

MFHCA have been working with Locogen to refine options to decarbonise five community sites across the two villages. The sites include buildings found in many similar villages: Church, Primary School, Community Centre and sports facilities, such that MFHCA may be exemplar in demonstrating how communities can proactively decarbonise the operations of their assets. Ultimately, the Client are looking to decarbonise the operations of the buildings, in particular their energy consumption, in order to facilitate financial, environmental and social benefits for the local communities.

From an extensive and detailed Options Appraisal, four distinct projects were chosen for their environmental/social impacts, financial benefits and/or simplicity. They include listed buildings, small community hubs and also the local primary school, all with varying technologies identified as the most effective for the specific site. This resulted in four different projects being taken forward to a detailed feasibility study, by which only one of the projects were deemed infeasible. The resulting portfolio therefore presents three distinct and innovative projects utilising a variety of renewable technologies.

In all cases, operating costs are reduced and the projects have a positive net annual income, providing opportunity for each site to invest in further energy saving measures or to support further projects in the community. Several of the options pay back even without the awarding of grant funding. All projects represent employment opportunities for local contractors to design and install the systems. Annual maintenance could also be carried out by a local contractor.

All projects have positive environmental benefits, reducing or removing fossil fuel use significantly for the respective site. The heat pump options immediately decrease the localised pollution from the existing boilers, helping to raise the air quality in the area.

The Church project in particular would be exemplar in highlighting the potential to develop renewables on, or near to, historic assets discretely and considerately. This is a challenge regularly faced by historic building owners, users and operators, as often the required consents are too challenging and costly, deeming most renewables projects unviable. The Diocese, by allowing this development, will set a new standard for historic retrofits and supporting future applications.

Another key benefit is the opportunity for the local community to gain an understanding of renewable technology and how it can be used to replace fossil fuel sources. The installation of heat pumps, solar PV and energy storage represents an educational opportunity for the community, whereby the system can act as a demonstrator project for similar buildings in the community and as an exemplar project for other small-scale installations locally. For pupils in the local schools, the installation will act as an opportunity for school visits and will tie into curriculum work relating to climate change and energy generation. The transition to a net zero society is one that will take place over the next few decades, and it is extremely important to educate people on the subject and the solutions available.

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1. Project background

The Monk Fryston and Hillam Community Association (MFHCA or 'The Client') are seeking to develop on-site renewable generation and heat technologies at five of their community sites. These sites include: St Wilfrid's Church and Church Hall; MFHCA Community Centre; Monk Fryston Primary School; and the community Cricket Club and Football Pitches.

Outcomes from Phase 1 Project

Prior to the detailed investigation within this document, Locogen conducted Phase 1 of this project and provided an Options Appraisal report to MFHCA, presenting a longlist of potential opportunities at all of the sites. This concluded with numerous prospective projects, as highlighted in the table below.

Phase 1 findings	Suitable	To be considered further	Unsuitable
Symbol	✓	?	✗

	RMPV	GMPV	PV canopies	Battery	ASHP	GSHP	Shared loop	Heat battery
St Wilfrid's Church	✗	✗	✗	✓	✓	✓	✗	?
Church Hall	✓	✗	✗	✓	✓	✓	✗	?
Community Association	✗	✓	✓	✓	✓	✓	?	?
Primary School	✓	✗	✓	✓	✓	✓	?	?
Cricket Club	✓	✓	✓	✓	✓	✓	✗	?
Football Pitches	✗	✓	✓	✗	✗	✗	✗	✗

Table 1: Outcomes from Phase 1

Following several discussions with The Client and relevant stakeholders, it was agreed that Locogen would investigate the following options further:

1. Solar PV on the roof of the Church Hall, including thermal or electrical storage, with intentions to offset an air-to-air heat pump system without removal of the existing gas heating system.
2. Ground-source Heat Pump via a borehole array at the Primary School to supply existing underfloor heating, with potential to upgrade to the whole heating circuit.
3. Air-source Heat Pump installations at Community Centre and Cricket Club, the former to be combined with roof-mounted PV, the latter as below. While not identified as an option in this study, the Client has advised that there should be sufficient space on the Community Centre roof for a small-scale PV installation which will be confirmed by a site visit.
4. Ground-mounted Solar PV at the Football Fields to provide income to a community benefit fund, and offset electricity at the Cricket Club (including demand from an ASHP or thermal battery, prospective floodlights and/or Sports Barn). The potential of a roof-mounted solar opportunity on the prospective Sports Barn will also be investigated, based on agreed structure location and dimensions. If found to be unfavourable, roof mounted PV or Solar Carports at the Cricket Club with Energy Storage will be revisited.

Phase 2 study

This document presents the findings in the Phase 2 of the Stage 1 works for the MFHCA project, in line with RCEF project guidelines. Locogen have investigated each site in further detail, presenting more detailed equipment outlines; updated financial costs and analysis, and identified risks, constraints and additional benefits beyond those presented in the Phase 1 report.

This project has wholly been carried out during the COVID-19 pandemic. It has therefore not been possible for Locogen to conduct site surveys which would usually be key to better informing the business case. As an alternative action, Locogen put together a detailed (but not exhaustive) *Site Survey Checklist* which the Client generously arranged to carry out, taking measurements, notes, photographs and videos to best communicate the site context to Locogen. While this was a very worthwhile exercise, and did significantly impact the outcomes and improve on previous assumptions, this is not a sufficient replacement for a formal site survey and thus we cannot guarantee that each system will perform as stated.

The remaining body of this document is divided into sections for each of the four projects outlined above. Locogen have also provided a non-exhaustive list of funding opportunities for which the projects may be eligible, as an appendix.

2. St Wilfrid's Church & Church Hall

2.1. Overview of project

St Wilfrid's Church and Church Hall is owned by the Diocese of York. Phase 1 identified a number of heating solutions and a potential solar PV location on the Church Hall Roof. Given the potential risks and difficulties associated with changing the existing wet heating system, and its shortcomings, The Client has chosen to move forward with an air-to-air heat pump system, potentially with the addition of PV to offset the existing and additional electricity usage.

2.2. Roof Mounted PV System

2.2.1. Equipment location

The initially identified location of the Church Hall's south facing roof has been confirmed as the ideal location for this project. There are several factors which validated this decision realised in the Client's site visit. Images provided by the client highlight that the roof is suitable for a PV installation, as a slate roof with appropriate orientation and slope, and no clear damage nor weaknesses. There is an accessible loft space which is ideal for locating an inverter and ancillary equipment, and also a large storage area if for any reason the loft is considered inappropriate.

Locogen discussed this further with Historic England (HE), given the Church's listed building status, and location within the Monk Fryston Conservation Area. HE confirmed that the church was exempt from the requirements for listed building consent, given its ownership. Furthermore, it was agreed that as the PV array faces south, away from the conservation area, and is unlikely to be visible from any public space within the conservation area, it can be classed as permitted development.

Therefore, it can be concluded that this location is the optimal option for solar and will only require the permission of the Diocese. The Client has advised that this is unlikely to be of concern and the cost of making the request is negligible.

Risks at this location include access to the rooftop. Survey photographs show limited space between the Church Hall roof and a stone wall indicating the property boundary. This has been raised with an experienced installation team and they have confirmed that there appears to be sufficient space for scaffolding, however, this may require temporary removal of the existing sheds currently in the space. Alternatively, there is an option to over-scaffold the sheds. This may incur a slight cost increase, but the given contingency should be sufficient to cover this. This is not uncommon in PV installations.

2.2.2. Scale

The site inspection by the Client highlighted that the current electricity supply is single phase. Northern Power Grid (NPG) state that the maximum that could be connected on single-phase anywhere in their network is 17kW, however this is subject to their agreement. In a call with NPG, it was advised that the electricity grid is highly constrained in Monk Fryston and Hillam, and no conclusions can be drawn regarding addition of more than 4kW to the existing connection.

However, if the heat pump installation was to go ahead it is advised that neither of the heat pump sizes (described below) could be accommodated by the single-phase existing connection from a demand perspective. A new, three-phase supply would need to be connected to the church and/or Church Hall. Locogen have assessed options for the new connection with NPG's network engineer and there is noted to be an appropriate line under the road to the north of the Church. The most cost-effective route would be to track a wire through the church grounds to this connection point, and this is estimated to cost in the region of £10,400. This would accommodate the heat pump and the maximum scale of PV – 6.8kW, and would also mean only a single grid application fee would be required. This cost is estimated following discussions with NPG and based on their Auto Budget Cost Estimate feature. They advise that, if the connection were to incur grid upgrades, there may be additional significant costs. However, the cable on which the church would connect (on the main road to the north) is indicated as being in the lowest risk category. Locogen have included in all projects the cost of retrieving a formal Budget Cost Estimate (BCE) from NPG. This would include all the technologies and determine the impacts of their interactivity, providing the basis for a formal grid application (if this is required).

The proposed solar array options are illustrated and detailed below:

Peak capacity	**4.08kWp**	**6.8kWp**
Orientation	190° (SW)	
Slope of panels	30°	
Shading losses	0.1% /year	0.1% /year
Annual yield	3,738 kWh	6,278 kWh
Specific yield	916.2 kWh/kWp	923.2kWh/kWp

Table 2: Church Hall PV System Specs & Performance

Given the requirement for an improved grid connection for heat pump installation, the 6.8kWp option has been taken forward for the detailed financial modelling.

2.2.3. Ancillaries

Key ancillary equipment for a roof-mounted solar array include:

- Mounting – Inappropriate roof fixings can lead to roof leakages or a requirement for roof replacement. This can be from drilling through the roof and using sealant which wears over time (so may not be obvious at first), or from structural movement, for example due to high winds moving the panels, effectively destroying the external roof material. We therefore recommend mounting systems that are non-penetrative (to avoid leakage) but also respective of load impacts.
  The slate roof at the Church Hall requires specialist fixing such as Genius Roof Solutions flash fixings (which Locogen has utilised previously, though other similar models are available). These are specifically designed to not rest any load on the slates (which could lead to breakages) and fix directly onto the rafters for sufficient load bearing.
  The Client also expressed an interest in removing slates and installingan in-roof system (such as that by Viridian). This would indeed be beneficial when it comes to wind loading effect and is also likely to be preferred from a planning perspective, but are likely to cost in the range of £2-2.5k per kWp, wit han additional c. £200 per kWp for stripping the current slate and sealing the edges.
- Inverter(s) – The solar panels are connected in strings, which are then connected to inverters which convert the DC generated electricity to AC electricity, as is required for local use and grid connection.
- Isolations – there will be two isolators, one on the DC side and one on the AC side of the inverter. These are ultimately safety features to ensure.
- Grid connection & metering equipment – electricity will then pass through a generation meter (to keep track of how much electricity is being generated) before supplying the consumer unit. The DNO will also require protection devices to ensure that the increased generation will not adversely affect the grid.

2.2.4. Associated risks & additional costs

In the solar yield model for the Church, Locogen included the building to the south of the property, as there appears to be shading impacts based on photographs provided by The Client. Given the time of the year in which the survey was taken, it is likely these impacts will not be significant. Best attempts have been made to accurately represent the adjacent property in the 3D model, however it may be that there is a further decrease in yield. We do not expect this to be in excess of an additional 5% loss.

In addition to the aforementioned grid cost, Locogen would recommend also carrying out a structural survey at an early stage to ensure the roof is capable of hosting the PV without reinforcement. Generally, truss roofs are suitable for PV, especially when relatively new. However, the combination of truss and slates may be cause for concern. A structural survey for PV from our experience costs in the region of £100 and will minimise risk going forward. If the survey proves the roof to be unstable, then the costs of reinforcement should be incorporated into the capital cost to allow a financial re-evaluation.

Historic England have advised that there is no requirement for listed building consent. The site is within a conservation area, which may incur a requirement for planning permission. However, general guidance suggests that as long as the commercial rooftop PV is sited such that it is not clearly visible from the public spaces in the conservation area, the project could be considered permitted development. Therefore, as the system is located appropriately (facing south, away from the Conservation Area) to *not* require planning permission due to the conservation area, only a pre-app cost has been included for. This is essentially the cost of formally retrieving a statement from the Local Authority validating that Planning Permission is not required. Locogen would recommend having these formal discussions prior to installation to ensure there are no additional planning costs.

Finally, the financial model has also included for an inverter replacement after 10 years, estimated at £950 including install and anticipated inflation on the current cost.

2.3. Air-to-Air Heat Pump System

Locogen have explored two options for the installation of an air-to-air heat pump system at the Church and Church Hall, as follows:

- One 70kW ASHP with two branch circuit (BC) Controllers (one within the Church and one within the Church Hall to draw heat for the relevant building as required) and internal units; or
- Two ASHP units – one 16kW domestic size ASHP for the Church Hall and one 54kW ASHP for the Church, with internal units.

There are a number of advantages and disadvantages, to both options, as follows. It is important to highlight that these are examples sized to meet the heat demands of the buildings entirely through low-carbon technology and that an alternative strategy may be preferred. MFHCA have highlighted that they may consider installing a 16kW ASHP to meet the demands of the Church Hall, but when there is no requirement for heating in the Church Hall, the ASHP could be used to provide background heat for the Church, with the retained gas boiler used to top up the heat as required. In this case, the costs set out in Section 2.4.2 would be revised to reduce the cost of the heat pump (likely to c.£6000), while the costs of the heat emitters would remain the same (as the number of these would not change) and the cost of installation and M&E is unlikely to be affected (as the system complexities for installation and operation set out in the section '**Single ASHP system**' below would still apply).

Single ASHP system

The installation of a single ASHP would require the construction of one single concrete base, upon which a large 70kW ASHP would be installed, and the installation and commissioning of one outdoor unit, which will help to reduce capital expenditure.

However, as the Church and Church Hall are two separate buildings, refrigerant pipework would then have to be run from the ASHP to one building, either utilising the underside of the covered walkway that connects the buildings, or underground, which would require excavation and the installation of safety pipe, which the refrigerant pipework would run within. Excavation, installation, backfilling and resurfacing of an underground trench would introduce additional capital cost to the project; however, as refrigerant pipework within an ASHP system has a limited maximum length, it may be the only feasible solution, depending on the preferred point of entry of the refrigerant pipework into the two buildings.

Due to the limitations on maximum length of refrigerant pipework, it is likely that the single ASHP unit would have to be installed centrally between the two buildings and would likely be visible by users of both buildings.

One single ASHP system would also require the installation of two BC Controllers – one in each building – in order to 'request' heat from the ASHP as required. The installation of additional components will increase capital expenditure.

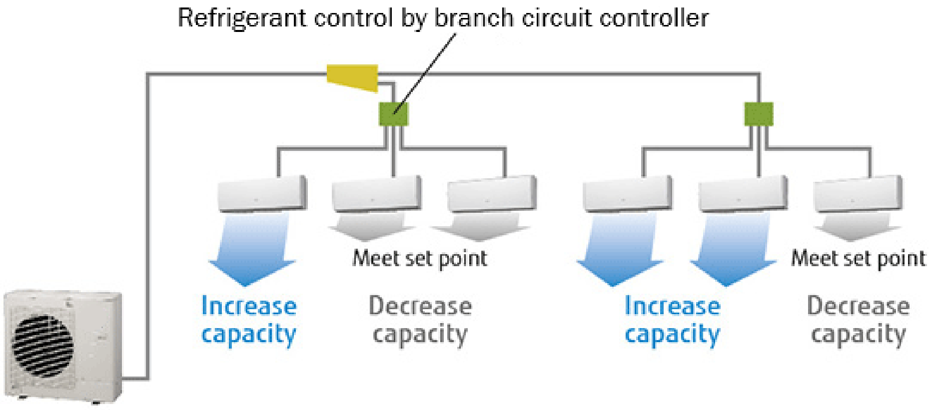

Figure 1: Simplified schematic of ASHP system with one external ASHP supplying two buildings.

It is also pertinent to highlight that should heating in the Church not be required, the ASHP will only be running at 23% of its capacity to heat the Church Hall. At partial load, a heat pump becomes less efficient and as such, will require more electricity per unit of heat generated. ASHPs like to run continually and work most effectively when sized accurately to the building, or buildings, that they are heating.

Individual ASHPs

Should two, smaller, ASHPs be installed, these could be better located such that refrigerant pipework can be routed directly into the building that each ASHP serves, without the need for trenching or the installation of underground pipework. The ASHPs could each be installed in a less visually obtrusive location, such as to the rear of both buildings (rather than centrally between the two due to restrictions in pipework length).

As the Church Hall comprises one main room and associated storage, a BC Controller would not be required and could instead be replaced with a simple on/off/temperature set point control system, which would reduce capital costs. As the Church is made up of multiple rooms that will likely require different temperatures, a BC Controller would still be required with in the Church.

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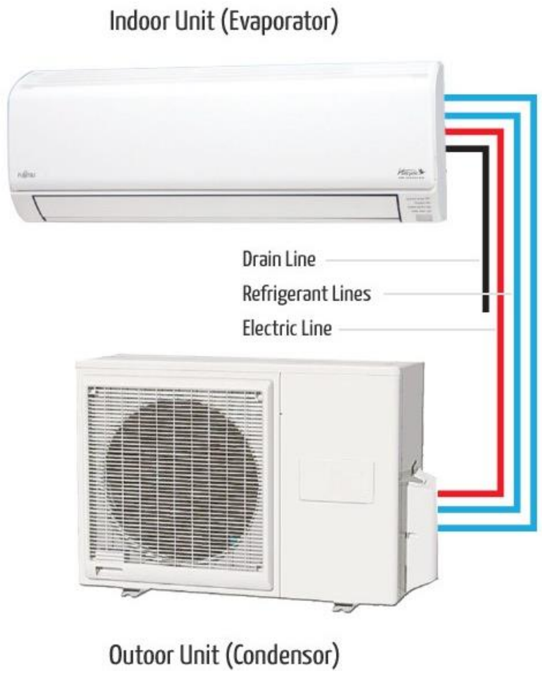


Figure 2: Simplified schematic of ASHP system with one external ASHP supplying the Church Hall (no BC Controller)

Additionally, the ASHP unit required for the Church Hall is likely to have a very low purchase price, as it would be in the realm of a domestic-scale installation. However, as ASHPs increase in size, they tend to be banded into capacity groups (such as a 45-60kW unit), and the savings realised between a larger 70kW unit and a smaller 54kW unit for the Church may not be particularly significant in size.

The installation of two ASHPs could, however, require the construction of two concrete plinths (depending on the location identified for installation and the existing ground make up). The installation and commissioning of two units would also be required, increasing the cost of installation.

For the purposes of this study, Locogen have calculated that there will not be a significant difference between the two options with regards to the capital cost of the system; however, this will be confirmed if the project progresses to detailed design and costing stage with an ASHP Contractor, who will be able to formally price both options once a detailed design package (including equipment schedules and specifications) has been produced.

2.3.1. Equipment location and scale

Where a decision is made to install one larger ASHP, the outdoor unit will need to be installed centrally between the two buildings in order to minimise the length of refrigerant pipework between the outdoor unit and the indoor units. As such, Figure 3 below shows the two most appropriate locations for the installation of the outdoor unit. This is either:

- Alongside the Church Hall, behind the covered walkway, with refrigerant pipework run to the BC Controller in the Church either through an underground safety pipe or at high level underneath the covered walkway, entering the Church within the entrance lobby; or
- In the space between the Church and the retaining wall, beside the below ground room located directly beneath the vestry, where refrigerant pipework could be run to the Church Hall underground, entering the Church Hall at the far left hand side of the building.

It is important to highlight that ASHPs do require some free space around them in order to draw in fresh air from their surroundings. The space between the Church and the retraining wall has not been measured and as such, may prove unsuitable as a proposed location.

Figure 3: Proposed ASHP location where one 70kW unit is installed to supply both buildings.

If instead, the decision is made to install two, smaller ASHPs, there are a number of less visually obtrusive locations where these could be located. For the Church Hall, this is likely to be to the rear of the building, as defined by the red square in Figure 4 below. This location offers plenty of free area for installation and maintenance of the ASHP, and refrigerant pipework can be run directly into the building.

For the Church, the opportunities identified are shown as yellow squares in the figure below. The opportunity to install the ASHP in the space between the Church and the retaining wall below the vestry remains feasible, bearing in mind the discussion above regarding the free area required for air inlet. Alternatively, there is potential for the ASHP to be installed beneath the tower at the rear of the building where it would be hidden from many users of the Church, but understanding that the tower is one of the oldest parts of the Church and that siting the ASHP in this area must be done sensitively. Both options are shown in Figure 4 below, whereby the final decision regarding the position of the Church ASHP to be determined in later stages of design.

Figure 4: Proposed ASHP locations where two units are installed to supply buildings (red for Church Hall, yellow for Church (two options identified))

In either case, it would not be recommended to site any ASHPs to the south of the Church Hall, as access to this area is severely restricted, particularly for the installation of the heat pump. It would also not be recommended to locate the ASHP to the north of the Church as the unit would be visually obtrusive to users of the graveyard and would not be in line with the character of the Church and its surroundings.

2.3.2. Ancillaries

There are various ancillary items required for the system which have been included in the capital cost estimates. These include controls, temperature sensors, valves, pipework, insulation, amongst other items which will be specified at the detailed design stage.

An air-to-air heat pump was chosen as it is the best way to heat a large, open space such as a Church, without the longer warm up time typically required in radiator-heated spaces. With air-heating, heat can be directed towards occupants to heat up the space around them, without using energy to heat the entire room.

In order to introduce heat into the Church and Church Hall, it is necessary to install indoor units which take in air from the internal space, heat it and blow it back out into the room. These indoor units come in multiple forms, as shown in Figure 5 and Figure 6 below.

Figure 5: Wall mounted indoor unit

Figure 6: Floor mounted indoor unit

It is understood that the existing heating system, which incorporates a gas boiler and cast iron radiators will be retained to supplement the air source heat pump system. As such, the cost for removal of the existing system has not been included in the capital costs set out in Section 2.4 below.

2.3.3. Associated risks & additional costs

The cost for the grid connection is shared with the PV generation, estimated at £10,400. This is ultimately the cost of a new 3 phase connection, which would replace the single phase meters in the Church and Church Hall.

While there are no planning costs, due to the location of the equipment and the Diocese's ownership, there is a fee to be paid to the Diocese – estimated at £300. This may be absorbed as a single fee for the whole project but has been included separately for PV and ASHP to ensure all costs are captured.

2.4. Project costs & Financial projections

Project costs have been estimated based on prior experience and, where possible, have been verified by input from suppliers; discussions with NPG; discussions with planners, and further information provided by The Client. These are detailed below, separated into Development, Capital and Operational costs.

As discussed in Section 2.3, there will not be a significant difference between the two options with regards to the capital cost of the system. As such, costs presented here are representative of both options.

2.4.1. Developments Costs

Table 3 below illustrates the estimated development costs associated with the project, assuming a 6.8kWp PV system is installed in tandem with the air-to-air (A2A) heat pump system:

System	Item	Cost

PV	Planning application fee (to Diocese)	£300
A2A	Planning application fee (to Diocese)	£300
PV & A2A	Pre-application discussion with Local Planning Authority	£330
PV	Notification to Local Planning Authority	£96
PV	Grid Budget Cost Estimate Fee	£150
PV	Grid application fee	£350
PV	Structural Survey	£100
PV & A2A	Estimated grid connection cost	£10,400
Total		**£12,026**

Table 3: Estimated development costs for Church and Church Hall projects

2.4.2. Capital Costs

Table 4 below illustrates the estimated capital costs associated with the project:

System	Item	Cost
PV	Panels	£2,040
PV	Ancillary Equipment (inverters, cables, mounting)	£1,170
PV	Install	£1,890
A2AHP	Heat pump	£12,500
A2AHP	Heat emitters	£7,500
A2AHP	Mechanical & Electrical (M&E) equipment, accessories and installation	£30,000
Total		**£55,100**

Table 4: Estimated capital costs for Church and Church Hall projects

2.4.3. Operational Costs

Table 5 below illustrates the estimated operational costs associated with the project. These costs exclude the cost of electricity for the air source heat pump system, which are included in the financial analysis in comparison with the current heating fuel costs, offset from PV and incentives to represent a 'net annual income'.

System	Item	Cost/year
PV	Maintenance (cleaning, visual inspection)	£250
A2AHP	Maintenance	£1,200
Total		**£1,450**

Table 5: Estimated annual operational costs for Church and Church Hall projects

2.4.4. Financial Modelling outcomes

Table 6 below highlights the key financial outcomes of the project. The capital costs include a contingency of 5%. Net income is the sum of:

- Income/savings (Electricity savings from PV usage; Income from export of excess electricity (SEG); Heating fuel cost savings; Old system maintenance cost savings, and Income from Renewable Heat Incentive (RHI, where applicable);

- Less the additional costs (increased electricity spend (due to addition of heat pump, for example); New system maintenance costs, and additional lifetime costs (equipment replacements).

The Net Present Value (NPV) and Internal Rate of Return (IRR) at year 20 are also included, alongside carbon offset estimations.

System	Whole System
Whole system CAPEX (incl. 5% contingency)	£70,482
Whole system OPEX	£1,450
Net income Y1	£3,044
Y20 NPV	-£21,644
Y20 IRR	0%
Payback years	21.3
Carbon offset Y1	25.8 T
Carbon offset Y20	553.1 T

Table 6: Financial outcomes for 6.8kWp solar PV system with 70kWp ASHP system

System	4kW PV	6.8kW PV
Whole system CAPEX (incl. 5% contingency)	£5,082	£17,567
Whole system OPEX	£250	£250
Net income Y1	£74	£210
Y20 NPV	-£4,477	-£14,501
Y20 IRR	-12%	-11%
Payback years	No payback	No payback
Carbon offset Y1	0.5 T	0.8 T
Carbon offset Y20	5.5 T	9.3 T

Figure 7: Financial outcomes varying scales of PV system, no ASHP

2.5. Impact of project on local community

Installation of a heat pump has demonstrated significant energy (and subsequently, cost) savings against the existing gas boiler system. Reducing operating costs for the Church and Church Hall introduces opportunities for the Church to invest in further energy saving measures (such as LED lighting or additional insulation) or to support further projects within the community.

Construction of the air source heat pump system could represent an employment opportunity for local Contractors, if they were to be approached by the Community Association to design and install the system. Depending on the manufacturer and model of the heat pump chosen, annual maintenance could either be undertaken by the manufacturer or by a local Contractor.

Minimal operational interference and maintenance will be required for the heat pump system outside of the annual service. This will largely comprise ensuring that the outdoor unit is free from debris, such as leaves, and changing filters within the indoor units (if required by the manufacturer). As such, a negligible additional input from the Church Warden will be required to ensure smooth operation of the system.

The siting of the rooftop PV would be exemplar in highlighting the potential to develop renewables on, or near to, historic assets discretely and considerately. This is a challenge regularly faced by historic building owners, users and operators, as often the required consents are too challenging and costly, deeming most renewables projects unviable. The Diocese, by allowing this development, will set a new standard for historic retrofits and supporting future applications.

3. Primary School

3.1. Overview of project

The primary school has approximately 200 pupils and is currently partially heated by an under-floor heating (UFH) system and partially by gas boilers connected to radiators, along with some electric heaters.

Outcomes from Site Visit

The pictures and site visit survey form completed by the client provided more detailed information on the current heating system, the details of the electrical grid connection, and allowed Locogen to refine their thermal modelling of the site.

3.2. Ground-Source Heat Pump

In the phase 1 report various options for a replacement heat source were assessed, however the client has decided to pursue the option of a Ground-Source Heat Pump (GSHP) for more detailed investigation in this phase 2 report. Two GSHP options have been assessed in more detail:

- A 38kW GSHP connected to a borehole array in the playing fields, which will connect to the existing Under Floor Heating (UFH) system and supply heat to the areas of the school currently served by this system.
- A 60kW GSHP connected to a borehole array in the playing fields which will completely replace the existing heating system and supply heat and hot water to the whole school.

In the initial report a ground-loop option was also considered however this has not been investigated further after discussions with the client where it was indicated that digging up the entire playing field to install the ground loops would not be favourable.

The modelling of each option has been carried out based on heat loss calculations for the primary school building. The demand profile for the heat pumps was estimated on the basis of the UFH system running constantly when the school is in use and then dropping the temperature back to a lower set point when it is not in use (i.e. on weekends and school holidays).

3.2.1. Location & Scale

It is envisaged that for both options the best location for the heat pump units would be in the existing plant room.

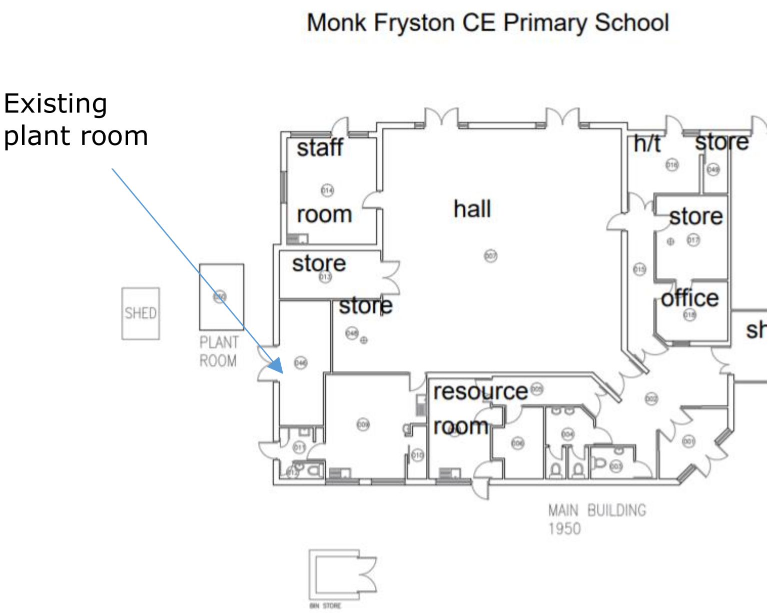


Figure 8: Proposed GSHP location

In both cases the heat pump unit would replace one of the existing gas boilers as shown below:

Figure 9: Proposed location of GSHP within plant room

For the 60kW GSHP option, the other gas boiler would be kept as a backup system in the event of a breakdown or if the GSHP needed to be shut off for maintenance at any point.

A 60kW heat pump unit would measure approximately 600mm x 620mm x 1800mm and would fit comfortably in this space with additional room for ancillary equipment and maintenance access. Given the plant room door measures 840mm x 2070mm there would be no issues with getting the heat pump unit into the room.

The school has ample ground available for locating the borehole array in the playing fields. Unfortunately, the plant room is at the other end of the school from the playing field so the pipework to reach the plant room must be trenched and it is anticipated that the most convenient route will be as shown in Figure 10 below.

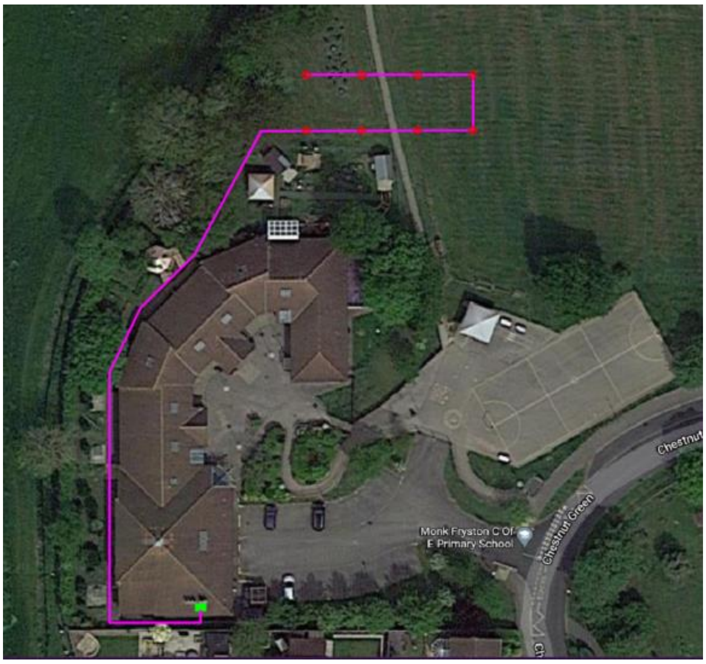


Figure 10: Proposed pipe route and borehole array for 60kW GSHP

There is potential for the boreholes to be located along the back of the school which would reduce the length of underground pipework required, however from the pictures supplied it is unclear what space is available here and a more detailed survey would need to be undertaken at the design stage to assess the suitability.

From the modelling carried out it has been estimated that 8 boreholes would be required for the 60kW GSHP option as shown in Figure 10. For the 38kW GSHP it is estimated that only 6 boreholes would be required which would be located in a similar position as shown in Figure 11. A standard spacing of 8m has been assumed, however this is dependent on ground conditions and could increase or decrease slightly at the detailed design stage.

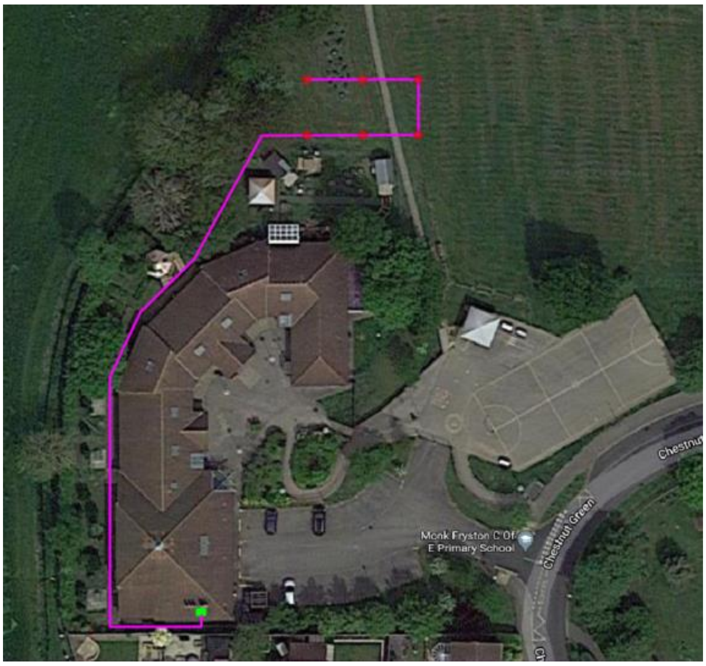


Figure 11: Proposed pipe route and borehole array for 38kW GSHP

3.2.2. Ancillaries

There are various ancillary items required for the system which have been included in the capital cost estimates. These include controls, temperature sensors, valves, pipework, insulation, amongst other items which will be specified at the detailed design stage.

In order to ensure the building is heated sufficiently with the 60kW GSHP option, it is necessary to replace the existing radiators in the parts of the school where there is not UFH. This is so that the radiators can operate properly at the lower flow temperatures produced by the GSHP (old radiators operate at 70-80 degrees, whereas the flow temperature of the ground source heat pump would be 45 degrees). As the survey did not detail how many radiators there were, Locogen estimated that 20 radiators would need to be replaced throughout the school and have priced accordingly.

Approximately 100m of trenching for pipework will be required to reach the borehole array as shown in Figure 10. This has been included in the capital cost estimations, however should a detailed survey of the site reveal that it is possible to locate the boreholes behind the building to the West then this cost may be mitigated. It should be noted that the boreholes make up the large majority of this cost, so savings would be in the region of £2,000-£3,000.

3.2.3. Associated risks & additional costs

As both ground arrays are less than 0.5 hectares, this can be classed as permitted development. However, Locogen recommend having pre-app discussions with the Local Planning Authority to confirm that this is the case. Furthermore, it will need to be provided in writing (at no cost) that there is the intention to remove the array whenever it becomes redundant (such as at the end of its lifetime, or if the school were to close or relocate).

The site survey highlighted that the site currently has an existing, three-phase 100A electricity connection. It is therefore unlikely that the existing supply will need to be upgraded to accommodate either heat pump. If a new connection is deemed to be required, for any reason, this has been estimated by NPG at £2,500.

If the client intends to pursue either of the GSHP options, they would be required to inform the local planning officer of this. It is our experience that these projects now require permission in most cases. Planning permission will also be required for the boreholes, however from our experience it is rare that this is not granted and there are no particular reasons that this may be a problem for this site.

There are also some technical risks associated with boreholes. The number of boreholes required is dependent on the thermal conductivity of the ground, and without drilling a test borehole and testing the thermal conductivity of the ground on site the number cannot be confirmed. Best estimates based on geological surveys have been used however geology can vary substantially locally and this may lead to better/worse conductivity. The local geology can also have imperfections such as cracks/fissures which can limit the depth that boreholes can be drilled to, in some cases meaning a higher number of shallow boreholes may be required. The school has ample room for a larger borehole array however the cost would likely increase if this were the case. The depth of borehole that is achievable at the site would also be confirmed by drilling a test borehole first.

3.3. Project costs & Financial projections

3.3.1. Developments Costs

Table 7 below illustrates the estimated development costs associated with the project.

System	Item	Cost
GSHP	Pre-planning advice	£330
TOTAL		**£330**

Table 7: Estimated development costs for GSHP project

3.3.2. Capital Costs

Table 8 and Table 9 below illustrates the estimated capital costs associated with the project:

System	Item	Cost
GSHP	Heat pump unit	£7,000
GSHP	Ancillary M&E items (accessories, buffer vessel, pipework etc)	£3,000
GSHP	Borehole array and groundworks	£33,500
GSHP	Collector system materials	£2,500
GSHP	Installation (Labour, management etc)	£18,000
TOTAL		**£64,000**

Table 8: Capital costs for 38kW GSHP system

System	Item	Cost
GSHP	Heat pump unit	£14,000
GSHP	Ancillary M&E items (accessories, buffer vessel, pipework etc)	£3,000
GSHP	Replacement of existing radiators	£6,000
GSHP	Borehole array and groundworks	£43,500
GSHP	Collector system materials	£3,500
GSHP	Installation (Labour, management etc)	£26,000
TOTAL		**£96,000**

Table 9: Capital costs for 60kW GSHP system

3.3.3. Operational Costs

Table 10 below illustrates the estimated operational costs associated with the project:

System	Item	Cost
GSHP	Maintenance	£200
TOTAL		**£200**

Table 10: Operational costs for GSHP system

GSHP systems are relatively low maintenance and apart from any unexpected system repairs/breakdowns an annual servicing is all that is required.

3.3.4. Financial Modelling outcomes

Table 11 and Table 12 below highlights the key financial outcomes of the project for each option. The capital costs include a contingency of 5%. Net income is the sum of:

- Income/savings (Electricity savings from PV usage; Income from export of excess electricity (SEG); Heating fuel cost savings; Old system maintenance cost savings, and Income from Renewable Heat Incentive (RHI, where applicable);
- Less the additional costs (increased electricity spend (due to addition of heat pump, for example); New system maintenance costs, and additional lifetime costs (equipment replacements).

The Net Present Value (NPV) and Internal Rate of Return (IRR) at year 20 are also included, alongside carbon offset estimations.

System	38kW GSHP
Whole system CAPEX (incl. 5% contingency)	£67,547
Whole system OPEX	£300
Net annual income	£235
Y20 NPV	-£61,615
Y20 IRR	-16%
Payback years	no payback
Carbon offset Y1	10.5 T
Carbon offset Y20	286.5 T

Table 11: Financial outcomes for 38kW GSHP connected to UFH system

System	60kW GSHP
Whole system CAPEX (incl. 5% contingency)	£101,147
Whole system OPEX	£400
Net annual income	£947
Y20 NPV	-£83,025
Y20 IRR	-11%
Payback years	no payback
Carbon offset Y1	16.9 T
Carbon offset Y20	378.6 T

Table 12: Financial outcomes for 60kW GSHP supplying heat for the whole school

The financial modelling shows that neither of the proposed systems will produce a positive return on the investment, and this is quite common with GSHP systems that are unable to obtain the RHI payments as the capital cost is relatively high compared to the annual savings. The modelling does show that the system operating costs would result in a net annual savings compared to the business-as-usual case. This is represented as ‘Net annual income’ in the table.

The whole system OPEX represents the maintenance costs required for the new system. This does not account for the maintenance of the existing gas boilers, and as both of the options involve retaining one of the gas boilers there are only marginal savings to be made here as the retained boiler will still require annual servicing.

3.4. Impact of project on local community

Although neither of the options will provide a good return on investment, there are many other benefits associated with the proposed solutions. The carbon modelling in Table 11 and Table 12 show that both options will save substantial amounts of carbon emissions, with the 60kW option offering 378.6 T of CO_2 savings over 20 years. This would significantly lower the school's carbon footprint and brings it in line with the governments aims of achieving Net Zero emissions by 2050.

By replacing gas boilers with a GSHP unit this immediately decreases or eliminates (depending on which option is selected) the localised pollution from the system and will help to raise the air quality in the area. This effects not only the children and the staff at the school but the wider community as well.

Another associated benefit is the opportunity for the children at the school as well as the local community to gain an understanding of renewable heating technology and how it can be used to replace fossil fuel sources. The transition to a net zero society is one that will take place over the next few decades, and it is important to educate people on the subject and the solutions available to us at a young age.

4. Air-Source Heat Pumps at Community Association and Cricket Club

4.1. Overview of project

Both the Community Association and the Cricket Club have relatively low heat loads, calculated at 13.3 kW and 6.9 kW, respectively. ASHP systems have been considered as the ideal solution for decarbonising the heating system at these sites. Furthermore, both have opportunities for on-side generation by PVs. This chapter presents the impact of the heating systems alone, and then the financial implications of offsetting the resultant increased electricity load with local PV.

There are several projects to be further investigated at the football pitches and cricket club. In the first instance, this site has the largest renewable electricity generation potential, and various options for utilising this potential have been investigated. Phase 1 highlighted the space available could host c. 100kW of PV generation, which initially was thought appropriate to supply the increased demand requirements. However, discussions with NPG have highlighted that connecting 100kW behind-the-meter at this site will require a new connection. Furthermore, the site's demand is sufficiently low that a much smaller array would be sufficient to service the site. The larger PV array option has therefore been considered as a separate entity in the next section.

There is also some on-site demand which is anticipated to increase in the near future (as described subsequently). Therefore, a suitable scale of PV to supply the new demand has been investigated in this section.

4.2. Outcomes from Site Visit

Community Association

Community centre heat and hot water demand had no significant changes from the demand calculated in Phase 1. These values were 27,600kWh/year for heating and hot water and a peak heating load of 13.3kW.

The Community Centre saw little variation from the electricity demand profile built in Phase 1 (though the centre meter reading were trending lower, this is assumed to be due to the ongoing COVID19 restrictions reducing use). For PV calculations and recommendations, the predicted electricity demand profile of the proposed heat pump has been incorporated into the electricity demand model to better understand the impact of installing PV alongside the heat pump.

Cricket Club

The Cricket Club heat demand profile has been significantly revised, as follows:

1. Annual combined heat demand and peak heating load remained the same as the ones calculated in Phase 1 with values of 17,502kW/year and 6.9 kW, respectively.
2. Based on the information supplied by the Client in relation to the use of the Cricket Club, Locogen developed a heat demand model that assumed high occupancy periods of the Cricket Club to be between 7am and 10pm on weekdays and between 10am-4pm on weekend days. This was to mirror the Client's stated usage (as detailed below), allowing sufficient 'warm up' time for the building.

The Cricket Club electrical demand profile has been significantly revised, as follows:

1. The Client has advised that additional usage of the Clubhouse is c. 2.5kW per hour for three hours per weekend day from May to August inclusive, which has been assumed to be from 12pm-3pm per weekend day. This has been incorporated into the demand profile, which had already assumed a 75% weekday use (for the Nursery) between 7am and 6pm, and adjusted to retain total yearly kWh/year as indicated by the electricity bills provided (4,500kWh/year).

2. There has been an addition to this load of a bio-digestor, which is intended to replace the current effluent removal system for the site. Based on the previous project, Locogen has assumed this to consume c. 900kWh/year, and this has been added to the original load profile.
3. The base-case also now includes for an ASHP installed at the cricket club. The predicted electrical profile indicates a total electricity consumption of 6,400kWh/year if the existing radiators are retrofitted with a high temperature heat pump, or 4,570kWh/year if the radiators are replaced and a low temperature heat pump is used.
4. A further addition has been the inclusion of 12 proposed floodlights, each with a power rating of 300W (total of 3.6kW). These are assumed to be utilised for 2 hours per weekday between 6-8pm from October to March inclusive.
5. Locogen also modelled a demand scenario in which the Floodlights are replaced by a *Sports Barn*, which is anticipated to also use 3.6kW/h but will operate from 6pm-10pm on weekdays from August to May inclusive.

Demand profiles 1, 2 and 3 are included in all scenarios. These correlate to a total yearly demand of 11,850kWh and 13,110kWh for the Floodlights scenario and Sports Barn scenario respectively. With regards to the existing electrical system, the photographs taken in the site visit confirmed that both sites were on single phase supplies.

4.3. Air-source Heat Pumps

4.3.1. Location & Scale

Community Centre

The recommended location for the heat pump unit would be in the existing boiler cupboard that is located in the kitchen and where the gas boiler is currently located.

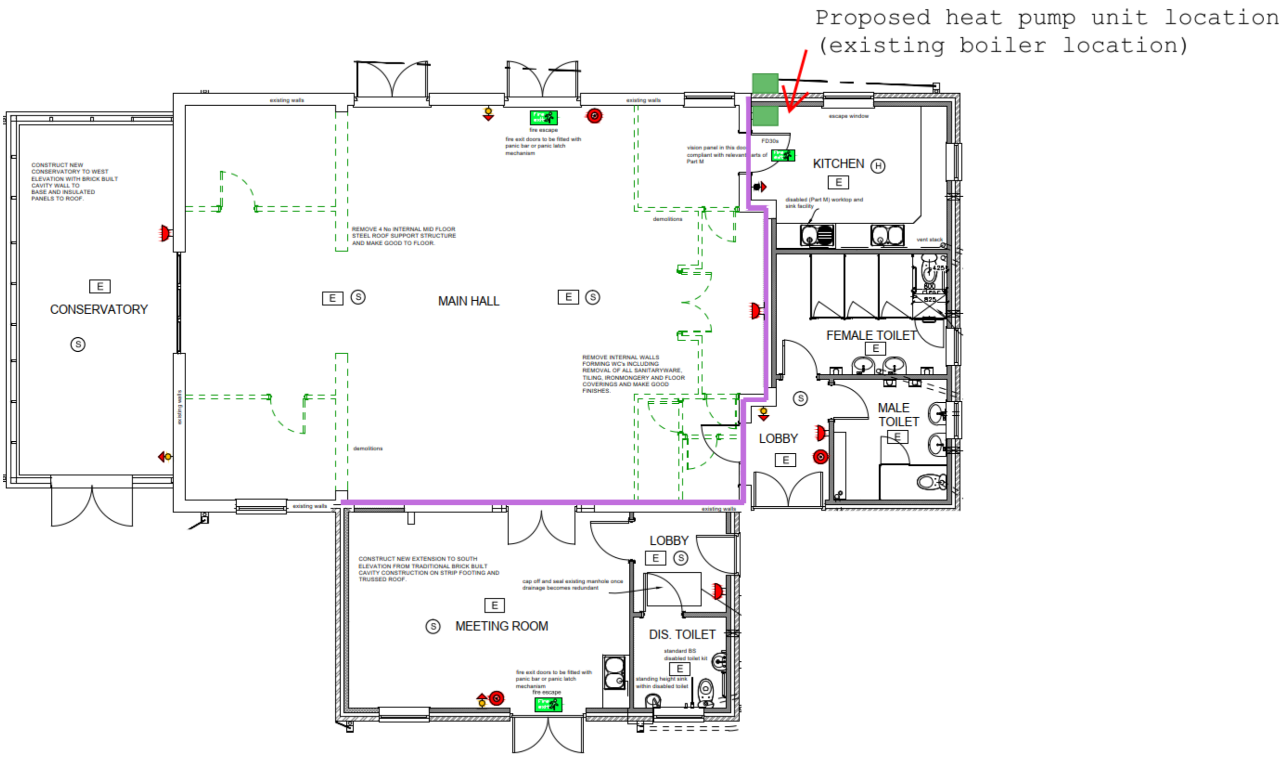


Figure 12: Proposed ASHP location at Community Centre

The external heat pump unit would be located on the exterior side of the cupboard's wall and would measure approximately 950mm x 1380mm x 330mm. The internal unit would measure approximately 490mm x 850mm x 315mm and would fit in the space the existing boiler is occupying, whilst leaving enough room for ancillaries and maintenance access. There may be an additional challenge, given the size of the boiler's cupboard door, and additional work might be required to provide space to exchange the systems. This should be addressed with the contractor at an early stage to mitigate the potential issue.

Cricket Club

The external heat pump unit would be best located on exterior side of the wall and would measure approximately 950mm x 834mm x 330mm. The best location for the internal unit would be in the storage room where the gas boiler is currently located.

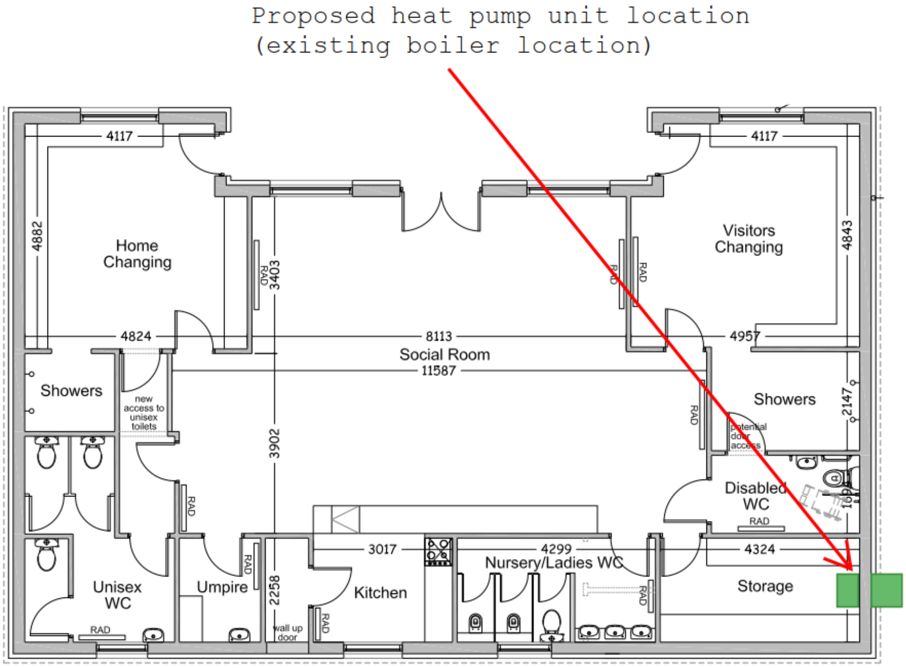


Figure 13: Proposed ASHP location at Cricket Club

A 7kW low temperature indoor unit would measure approximately 490mm x 850mm x 315mm and would fit in the space the existing boiler is occupying and leave enough room for ancillaries and maintenance access.

If the existing radiators were to be retrofitted with a high temperature unit, the indoor heat pump unit would measure approximately 520mm x 1080mm x 330mm and the outdoor unit approximately 950mm x 1380mm x 330mm.

4.3.2. Ancillaries

There are various ancillary items required for the system which have been included in the capital cost estimates. These include controls, temperature sensors, valves, pipework, insulation, amongst other items which will be specified at the detailed design stage.

In the detailed design stage, it is necessary to evaluate the viability of retrofitting the existing radiators in the Cricket Club with a high temperature heat pump. This will depend on the size and number of the current radiators and on the heat pump output temperature. In the case that retrofitting the existing radiators was not possible, the radiators would need to be replaced. Locogen estimated from the provided floorplans that 10 radiators would need to be replaced throughout the Cricket Club and have priced accordingly.

4.3.3. Associated risks & additional costs

Given the scale of the projects, there is not anticipated to be any grid connection cost. Both scales of heat pump are anticipated to be connectable to the existing electricity supply.

Installations of air source heat pumps on non-domestic properties are likely to require an application for planning permission to the LPA. The associated planning application fees are unclear, so are assumed to be the minimum planning cost for erection of plant/machinery, estimated at £256 per site. A pre-application discussion with the local planning authority will determine the requirements of this application, but it is likely they will simply need assurance that the ASHP is sited appropriately to a) not impact nearby conservation areas, and b) comply with noise regulations (i.e. is not sited near to a neighbouring property, window or entrance). It is anticipated that a single pre-application consultation will provide sufficient guidance for both projects.

4.4. Addition of Rooftop Solar PV

Both properties are suitably orientated, and the roofs appear to have no obstruction or defects that may render them unsuitable for a rooftop PV installation. Several scales of PV have been investigated, taking into account the new electricity loads, as detailed below.

Community Association

There are several areas of south-facing roof on the community centre. The Client has advised that a solar contracting company has already carried out a site inspection and expects the roof is sufficient for an install of 7.2kW. This is assumed to be equivalent to 24 x 300W panels. Locogen used PVSOL to simulate this, with the assumption that 6 panels are located in the extruding, entrance section of the roof, and the remaining 18 panels on the south face of the main building roof. Some shading losses are seen and are expected to be from the main 18 panels.

Given the grid constraints in the area, NPG has indicated that an addition of 7.2kW electricity load is likely to exceed the capacity of the existing electricity supply. There would therefore need to be an upgrade. The most cost-effective means of upgrading would be to replace the existing single-phase supply and connect a three-phase supply to the site, which is estimated to cost in the region of £20-22k. This has been included for in the financial analysis.

Table 13 below highlights the performance of the two potential systems.

Peak capacity	**4.08 kW**	**7.2 kWp**
Orientation	195° (SW)	
Slope of panels	30°	
Shading losses	0.8%	1.9%
Annual yield	3,695 kWh	6,501 kWh
Specific yield	905.6 kWh/kWp	902.9 kWh/kWp

Table 13: Community Association PV System Specs & Performance

Cricket Club

There is one south-facing roof on the Cricket Club. 3D modelling of the building highlighted that this is capable of hosting in the region of 10kWp. However, given the low demand and the strain on the existing connection, Locogen again recommends installing an array in the region of 4.08kW to avoid grid upgrades and costs associated with the G99 application.

Peak capacity	4.08 kW
Orientation	184° (SW)
Slope of panels	30°
Shading losses	17.9%
Annual yield	3,067 kWh
Specific yield	751.79 kWh/kWp

Table 14: Cricket Club PV System Specs & Performance

It is seen that there are significant shading losses at this site. This is due to the surrounding treeline, and perhaps justifies the alternative PV location near to the football fields, as discussed in the proceeding section.

4.4.1. Ancillaries

Key ancillary equipment for roof-mounted solar arrays include:

- Mounting – Both buildings appear to have relatively modern tiled roofs, with no apparent damage or defects observed in the site surveys. There are plenty of tried-and-tested options for tiled roofs, so this is considered relatively low cost and low risk.
- Inverter(s) – The solar panels are connected in *strings*, which are then connected to inverters which convert the DC generated electricity to AC electricity, as is required for local use and grid connection. Construction phase photos from the Community centre show a sufficiently large, accessible attic space that is likely to be a suitable inverter location. Similarly, the Cricket Club attic space is accessible via ladder, and looks like a suitable Inverter location.
- Isolations – there will be two isolators, one on the DC side and one on the AC side of the inverter. These are ultimately safety features and are required in any major electrical installation.
- Grid connection & metering equipment – Locogen have included costs for generation and export meters, as well as required grid protection devices. These costs are consistent between PV array options. The existing electrical cupboard at the Community Centre should be sufficient for inverter location (as an alternative) and for generation/export meter.
  It is noted that the electricity meter for the Cricket Club is c. 100m from the pavilion, located in an external box. Any export metering equipment will require an internet connection, thus it is advised that these meters and the inverter will need to be stored inside the building.

4.4.2. Associated risks & additional costs

The 4kW PV options are permissible under the G98 recommendations, such that there is only a requirement to notify NPG of the works with no associated costs.

The Community Association has a single-phase, 100A commercial supply. Locogen investigated the cost of replacing the existing connection with a 3-phase supply which would allow for larger PV arrays to be installed. The associated cost was estimated to be in the region of £12,600 for the community centre. This is considered excessive, given that the scale of the demand at the community centre is relatively low.

The Cricket Club also appears to have a single phase, 100A commercial supply. Given the distance from any appropriate connection point, upgrading this to a 3-phase commercial supply is estimated to cost in the region of £25,500. This outweighs any benefit in installing a larger PV array behind-the-meter at the site.

When PV has been included, the cost of an inverter replacement in year 10 has been included in the financial model, estimated at £580 for a 4kW system and £1,150 for a 7kW system, taking into account inflation.

4.5. Project costs & Financial projections

The costs, as described in the preceding sections, are detailed in the tables below.

4.5.1. Developments Costs

Table 15 below illustrates the estimated development costs associated with the project:

System	Item	Community Centre	Cricket Club
ASHP + PV	Pre-Planning advice fee	£330*	£330*
ASHP	Planning application fee	£256	£256
PV	Planning notification fee	£96	£96
TOTAL		**£682**	**£682**
PV (>4kW)	BCE	£150	n/a
PV (>4kW)	Application cost	£350	n/a
PV (>4kW)	Estimated cost of connection	£22,000	n/a
TOTAL (for PV >4kW + ASHP)		**£23,182**	**n/a**

Table 15: Development costs for various aspects of ASHP/PV hybrid project

4.5.2. Capital Costs

Table 16 and Table 17 below illustrate the estimated capital costs associated with the project:

System	Item	Community Centre	Cricket Club (existing radiators)	Cricket Club (replace radiators)
ASHP	Heat pump unit	£4,420.55	£5,427.68	£2,825.69
ASHP	Ancillary M&E items (accessories, buffer vessel, pipework etc)	£3,567.11	£4,523.38	£4,523.38
ASHP	Replacement of existing radiators	£0.00	£0.00	£4,000.50
ASHP	Installation (Labour, management etc)	£1,082.81	£1,082.81	£1,082.81
ASHP Total		**£9,070**	**£11,033**	**£12,432**

Table 16: Capital costs for ASHP installation at each site

System	Item	7.2kW	4kW
PV	Panels	£2,142.00	£1,224.00
PV	Ancillary Equipment (inverters, cables, mounting)	£1,351	£955
PV	Install	£2,106	£1,890
PV Total		**£5,559**	**£4,069**

Table 17: Capital costs associated with varying scales of PV at either site.

4.5.3. Operational Costs

Table 18 below illustrates the estimated annual operational costs associated with the project:

System	Item	Community Centre	Cricket Club
PV	Maintenance (cleaning, visual inspection)	£250	£250
ASHP	Maintenance	£200	£200
Total		**£450**	**£450**

Table 18: Operational costs by technology at each site

4.5.4. Financial Modelling outcomes

Below the financial performance of each site is illustrated. Note that discounts may be available if continuing with multiple projects at once, and this has not been taken into account. Given the simplicity of these projects and what can be achieved in the short timescales required, RHI has been considered possible at these sites.

The tables include a contingency of 5% within the capital costs. Net income is the sum of:

- Income/savings (Electricity savings from PV usage; Income from export of excess electricity (SEG); Heating fuel cost savings; Old system maintenance cost savings, and Income from Renewable Heat Incentive (RHI, where applicable);
- Less the additional costs (increased electricity spend (due to addition of heat pump, for example); New system maintenance costs, and additional lifetime costs (equipment replacements).

The Net Present Value (NPV) and Internal Rate of Return (IRR) at year 20 are also included, alongside carbon offset estimations.

Community Centre

An initial exercise to assess the individual impact of PV scales highlighted that, while there is no payback from either project (based on no demand increase), the trade-off between capacity and CAPEX does not pay off. This is ultimately due to the inflated grid connection cost for the 7.2kWp system.

System	Community Centre	
PV Scale	**4.08kW**	**7.2kW**
Whole system CAPEX (incl. 5% contingency)	£4,989	£30,894
Capex per kWp	£1,223	£4,291
Capex per kWh	£1.35	£4.75
Whole system OPEX	£250	£250
Net income Y1	£119	£270
Y20 NPV	-£3,446	-£26,584
Y20 IRR	-7%	-12%
Payback years	no payback	no payback
Carbon offset Y1	0.4 T	0.7 T
Carbon offset Y20	5.4 T	9.6 T

Table 19: Financial performance of PV installation only at the Community centre (for comparative purposes)

While there is sufficient space to install up to 7.2kW of PV, the benefits of installing the additional 3.2kW above the G98 recommendations is unlikely to outweigh the cost of the new connection and additional application fees. Therefore, the 4kW PV system has been included in further modelling.

Table 20 below highlights the key financial outcomes of the project, including the case with the 4kW PV installation included.

System	**Community Centre**		
Incentive	**No RHI**	**RHI**	**RHI + 4kW PV**
Whole system CAPEX	£9,070	£9,070	£14,308
Whole system OPEX	£200	£200	£450
Net income Y1	£5	£1,990	£2,129
Y20 NPV	-£8,681	£22,839	£19,465
Y20 IRR	No return	23%	15%
Payback years	No payback	4.4	6.4
Carbon offset Y1	4.2 T		4.6 T
Carbon offset Y20	118.3 T		124.4 T

Table 20: Financial performance of ASHP installation at Community Centre

Cricket Club

Note that these scenarios include electrical demand profiles for the Clubhouse, ASHP, Biodigestor and floodlights system.

System	**Cricket Club (existing radiators)**			**Cricket Club (replace radiators)**		
Incentive	**No RHI**	**RHI**	**RHI + 4kW PV**	**No RHI**	**RHI**	**RHI + 4kW PV**
Whole system CAPEX	£11,033	£11,033	£16,023	£12,432	£12,432	£17,421
Whole system OPEX	£200	£200	£450	£200	£200	£450
Net income Y1	-£310	£768	£862	-£81	£1,007	£1,093
Y20 NPV	-£15,465	£1,659	-£2,174	-£13,268	£3,998	£70
Y20 IRR	No return	5%	2%	No return	7%	4%
Payback years	No payback	12.8	16.7	No payback	11.3	14.7
Carbon offset Y1	1.9 T		2.2 T	2.2 T		2.3 T
Carbon offset Y20	60.8 T		65.8 T	65.8 T		66.8 T

Table 21: Financial performance of ASHP installations at the Cricket Club

It is clear from this analysis that the most cost-effective option is to replace the radiators at the Cricket Club to suit the low-temp ASHP, as the increase in electricity required to power the high-temp ASHP is not cost effective Unfortunately, the PV does not compliment the electricity profile well seasonally. This is illustrated graphically in below.

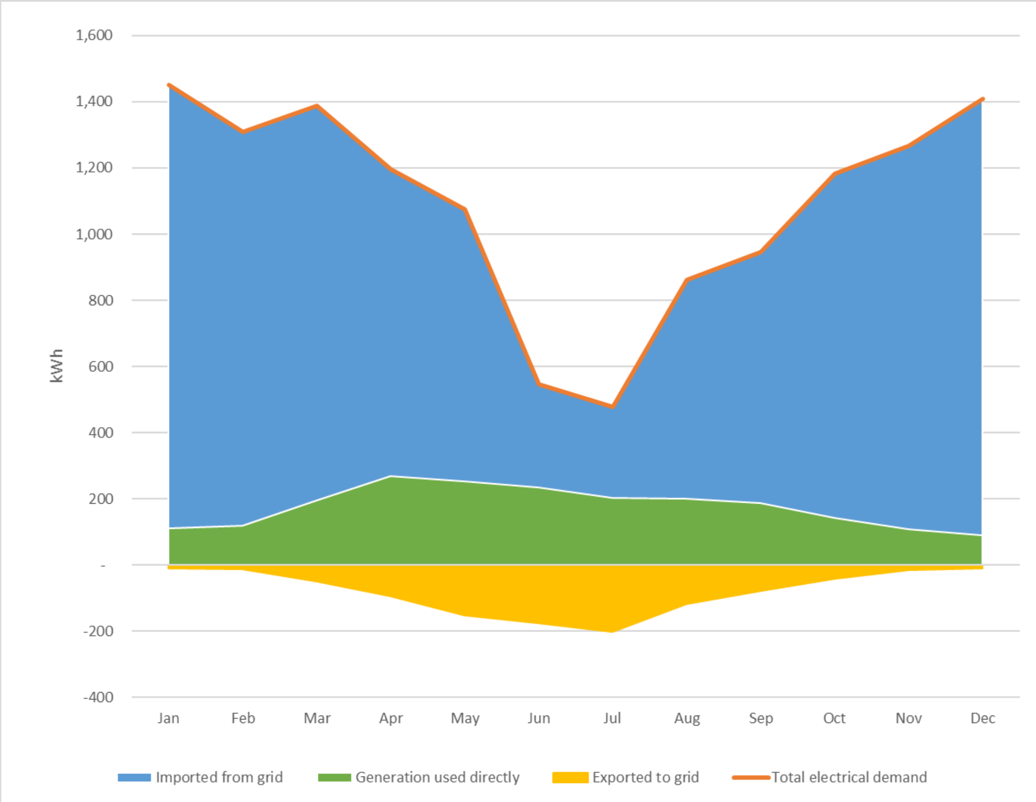


Figure 14: Energy distribution of Cricket Club ASHP & PV installation

This, in some cases, presents a good opportunity to investigate energy storage (ES). Locogen therefore added to this model, a 5.8kWh electrical battery with the sole purpose of maximising the use of the generation on-site. The cost of this addition is estimated to be an additional c. £2,500 including all ancillaries (some of which assumed to be shared by PV costs already accounted for), with a battery replacement in Year 10. The results of this financial analysis and the corresponding energy distribution are illustrated below.

System	**Cricket Club (replace radiators)**			
Incentive	**No RHI**	**RHI**	**RHI + 4kW PV**	**RHI + 4kW PV + ES**
Whole system CAPEX	£12,432	£12,432	£17,421	£20,046
Whole system OPEX	£200	£200	£450	£450
Net income Y1	-£81	£1,007	£1,093	£1,128
Y20 NPV	-£13,268	£3,998	£70	-£3,597
Y20 IRR	no return	7%	4%	1%
Payback years	no payback	11.3	14.7	17.8
Carbon offset Y1	2.1 T		2.3 T	
Carbon offset Y20	63.9 T		66.8 T	

Table 22: Financial performance of ASHP installations at the Cricket Club, incl. ES

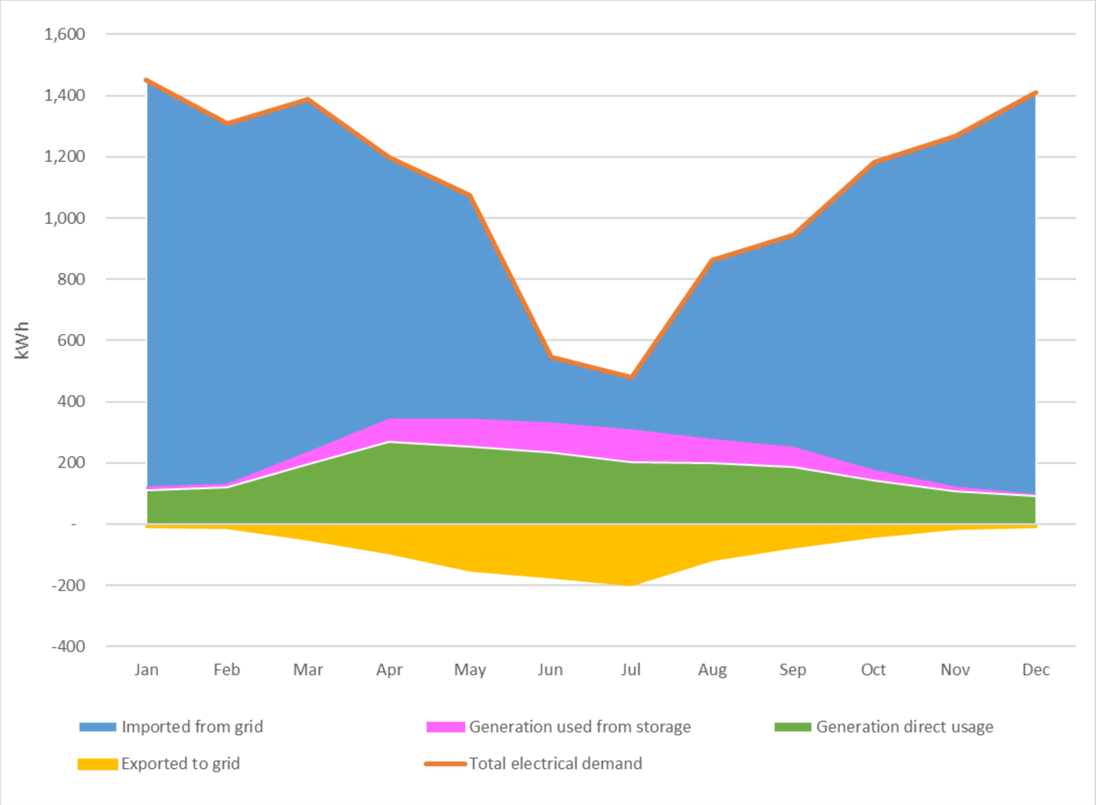


Figure 15: Energy distribution of Cricket Club ASHP, PV & ES installation

It can be seen that the addition of energy storage does indeed increase the amount of generation utilised on-site, but the financial impacts are marginal, equating to only an additional £35 per year.

If the heat pump can be commissioned before the RHI deadline, it will provide a net income which will mean that it will pay for itself over time and later on provide a small source of income to the cricket club. At this moment, the addition of energy storage doesn't positively impact the buildings sufficiently to justify its capital costs. However, if battery prices drop or if the commercial energy storage market becomes more accessible to small organisations/buildings, battery storage may become a worthwhile addition to the project.

4.6. Impact of project on local community

The installation of heat pumps, solar PV and energy storage represents an educational opportunity for the community, whereby the system can act as a demonstrator project for similar buildings in the community and as an exemplar project for other small-scale installations locally. For pupils in the local schools, the installation will act as an opportunity for school visits and will tie into curriculum work relating to climate change and energy generation.

5. Stand-alone PV Array at Football Fields

5.1. Overview of project

On further investigation following Phase 1, it has been realised that the Cricket Club and Football Fields' demand does not require a large PV array as has been identified. The difficulties associated with splitting this demand up to several meters is currently impossible due to grid regulations, not to mention the distance from Hillam (where the array would be) to the other community buildings in Monk Fryston is such that a private wire arrangement would be unviable.

The options at this site are therefore to:

- Develop the site as an export-only project, with revenues only from the sale of electricity to the grid; or
- Sell the electricity via private wire to a nearby consumer for a higher price than could be achieved by export only, connecting behind-the-meter at the consumer's site, with any excess sold to the grid.

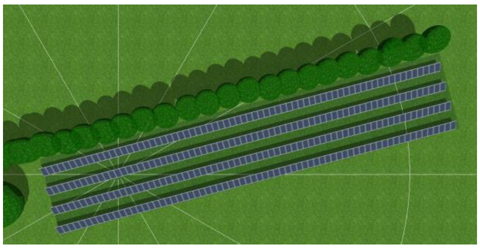
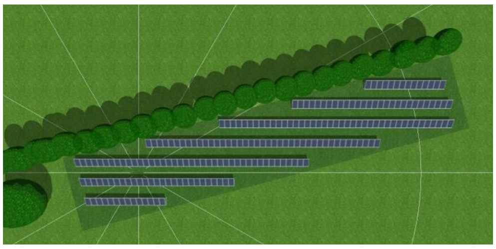
The project proposed here consists of static, ground-mounted solar panels. Standard sizes for individual panels are ~340 Watt and each of these will measure 1.6m x 0.9m. These are arranged in such a way as to generate the maximum amount of energy with minimal losses.

5.1.1. Location

The allocated area for the ground-mounted PV was measured from satellite imagery to be a rectangle of 71m x 13.5m. A variety of array layouts were simulated for the area, and the model included the treelines to the north and east of the site. The land is assumed to be flat, and the treelines confining the space are seen to be offset c. 15° from the E-W and N-W planes.

5.1.2. Scale

Discussions with NPG highlighted that the grid connection cost is unlikely to vary between the scale of 50kW and 100kW at the site, and it is therefore best value (due to economies of scale) to maximise the scale of the installation in the available area. However, there are other variables which have been considered. Locogen has investigated the trade-offs between installing an array which maximises use of space vs optimally orientating the panels, and this is detailed in the table below:

Option	Maximum installed capacity	Optimal orientation (south)
Layout		
PV Panels	280 x 330W	206 x 330W
Capacity	92.4 kW	67.98 kW
Slope	30°	30°
Orientation	165° (SE)	180° (S)
Annual generation	72,968 kWh	52,087 kWh

Specific Yield	789.7 kWh/kWp	766.2 kWh/kWp
shading losses	14.20%	14.20%

Table 23: Football Fields' PV System Specs & Performance

5.1.3. Grid connection

The grid connection is ultimately the cable connecting the solar array to the proposed grid connection point. Generally, this connection will be buried underground, where possible, to minimise visual impacts. In a call, the DNO has suggested that a 100kWp system could very simply be connected to the 11kV network via a single 100kVA pole-mounted transformer. This would cost in the region of £25-30k, not including the cost of routing the wire to the connection point. At this site, the 'connection point' would be a pylon or wooden pole on the existing 11kV line.

Open data maps indicate there is an overhead line only 350m to the south which services the adjacent Sewage works and pumping station. It is estimated that easement across this land would be c. £1,000 per year. An alternative 11kV line is c. 300m northeast, but tracking the wire to the point of connection requires a more complex route and as several land packets are crossed, easement costs would be higher.

It should be noted that the adjacent Waste Water Treatment Works (WWTW) are ideal off-takers for this energy. It is likely that they may wish to buy the electricity at a higher price than it can be sold to the grid. Given the scale and nature of the sewage works, it is possible that they may consume over 90% of the energy produced by the 100kWp array. We have included a scenario with an increased sale value of the energy generated, based on the existing grid connection cost (as the site connection is to the same line as the estimated cost provided by NPG).

Both cable route options require the use of third party land and therefore a first step would be to contact the landowner and gauge their interest in the project. See the two options illustrated below, it is most cost-effective ot bury the cables underground, which will therefore impact the land use options for the future.

Figure 16: Cable route optons to South

5.1.4. Ancillaries

Other key ancillary equipment for a ground-mounted solar array include:

- Ground anchors and frames – The panels are mounted on metal frames with appropriate ground anchoring, which could be screw anchors, piled foundations or ballast systems. Ballast foundations would add ~10% on to the total capital cost of a screw anchor option (assuming no other works are required to allow for the screw anchor option). The frames set the panels at an optimal angle to collect the most energy from the sun. They must also be capable of withstanding environmental conditions for the anticipated 20-year project lifetime. As the Client has advised this is a relatively wet site, a generous capital cost has been given to foundation and anchors.
- Inverter kiosk(s) –The solar panels are connected in strings which are then connected to inverters to convert the electricity to grid quality AC power. These are located at intervals within the solar array, to minimise cabling distances.
- Electrical substation building –This infrastructure will be required if the site is a stand-alone project that will export straight back to the grid. Typically, this will be a brick or Glass Reinforced Plastic ('GRP') building that houses the transformer, switchgear and protection equipment for the scheme. This building would also have space for the Distribution Network Operator's ('DNO') electrical equipment.
- Construction compound –This is typically required for larger stand-alone projects. An area of hardstanding may be installed for the safe delivery and assembly of the solar array equipment. The size of this area will depend on the scale of scheme installed and for large schemes (5-10MW) would normally comprise of a compacted area of hardcore measuring approx. 500m2. During operation, the area would generally be retained and used for any maintenance works that may be required.
- Fencing –In order to provide suitable security a 2.5 metre fence (e.g. weldmesh) would be proposed around the full perimeter of the array.
- Security –In addition to the above fence it is recommended to install an infrared detection system and a remote camera surveillance system. Using infrared technology would avoid the need for security lighting to minimise the potential for complaints from residents.

5.1.5. Additional risks

This project has several significant risks that may impact the proceeding costs. While we have accounted for the planning discussions, application fee and some support, the pre-application discussions may highlight where additional works need to be carried out. For example, while there are no ecological habitats identified in the Local Development Guidance nor on Natural England's databases, the Client has highlighted that there are occasions where there is minor flooding in the area. This may require an assessment by the Environment Protection Agency (EPA) to ensure that there will be no impact on water quality or aquaculture in the surrounding area.

Another risk highlighted by the client was the right-of-way passing through (or near to) the location of the prospective PV array. This may be sufficient ground for rejection of the application by the planning department, and an alternative route may need to be proposed and constructed if this is not accommodated into the array design, all of which could be at a cost.

Furthermore, a solar planning application is usually supported by enhancement plans for the local natural environment. Given the scale and nature of the development, this is unlikely to be at significant cost.

5.2. Project costs & financial projections

5.2.1. Developments Costs

Table 24 below illustrates the estimated development costs associated with the project:

Item	Cost

Pre-planning advice	£330
Planning application fee	£739
Planning application support	£800
BCE	£190
Grid application fee	£430
Estimated grid connection cost	£25,000
Total	**£26,669**

Table 24: PV System Development Costs

5.2.2. Capital Costs

Table 25 below illustrates the estimated capital costs associated with the project:

Item	Max– 92.4kWp	South – 68kWp
Panels	£28,560	£20,400
Ancillary Equipment (inverters, cables, mounting)	£43,770	£33,270
Install	£6,000	£6,500
TOTAL	**£78,330**	**£60,170**
Inverter replacement Y10	£5,280	£5,870

Table 25: PV system estimated capital costs

5.2.3. Operational Costs

Table 26 below illustrates the estimated operational costs associated with the project:

Item	Cost
Annual maintenance/inspection & cleaning	£450
Lease for cable route	£1,000
Total	**£1,450**

Table 26: PV System operational cost

5.2.4. Financial Modelling outcomes

Table 27 and Table 28 below highlight the key financial outcomes of the project.

System	**Football Fields – 4.5p/kWh**	
PV Scale	**Max– 92.4kWp**	**South – 68kWp**
Whole system CAPEX (incl. 5% contingency)	£110,249	£91,181
Capex per kWp	£1,900	£1,450
Capex per kWh	£1,193	£1,341
Whole system OPEX	£1.51	£1.75
Net income Y1	£812	£322
Y20 NPV	-£99,223	-£88,271
Y20 IRR	-15%	no return

Payback years	no payback	no payback
Carbon offset Y1	8.8 T	6.4 T
Carbon offset Y20	126.7 T	92.7 T

Table 27: PV performance exporting all energy directly to grid

System	Football Fields – 8p/kWh	
PV Scale	**Max– 92.4kWp**	**South – 68kWp**
Whole system CAPEX (incl. 5% contingency)	£110,249	£91,181
Capex per kWp	£1,900	£1,450
Capex per kWh	£1,193	£1,341
Whole system OPEX	£1.51	£1.75
Net income Y1	£3,366	£2,146
Y20 NPV	-£60,996	-£60,984
Y20 IRR	-4%	-6%
Payback years	no payback	no payback
Carbon offset Y1	8.8 T	6.4 T
Carbon offset Y20	126.7 T	92.7 T

Table 28: PV Performance providing 90% of generation to WWTW, and remaining 10% to grid

5.3. Impact of project on local community

A key benefit of the stand-alone PV project on the local community is that it would help to meet the ambitious climate targets of the villages, which were the driving force behind this RCEF study. Over time, the renewable generation from the PV system would make a modest but important contribution to the decarbonisation of the national grid (or to the WWTW). Provided that essential grant funding can be secured for the PV system, it could generate a long-term income steam for the community association, which could be put towards meeting its charitable aims and therefore benefit the whole community.

Acquiring grant funding itself carries the benefit of raising the profile of the community and providing good publicity. Similarly, providing cheaper electricity to the WWTW would create a good relationship between the community and this organisation, which may carry or lead to other soft benefits.

Some potential grant funding options are outlined in Appendix A.

Appendix A. List of Abbreviations

A2A	Air-to-air Heat Pump
AC	Alternating Current
ASHP	Air Source Heat Pump
BEIS	Department for Business, Energy & Industrial Strategy
CAPEX	Capital Expenditure
COP	Coefficient of performance (re. Heat Pumps)
COVID	Coronavirus-19 Pandemic
DC	Direct Current
EV	Electric Vehicle Chargepoint
EVCP	Electric Vehicle Chargepoint
FLEQ	Full Load Equivalent hours
GIS	Geographic Information Systems
GMPV	Ground-mounted PV
GSHP	Ground Source Heat Pump
HMFCC	Hillam and Monk Fryston Cricket Club
HP	Heat Pump
LPA	Local Planning Authority (Selby District)
LPG	Liquefied Petroleum Gas
MCS	Microgeneration Certification Scheme
MFHCA	Monk Fryston and Hillam Community Association
OLEV	Office for Low Emission Vehicles
OPEX	Operational Expenditure
PV	Photovoltaic (Solar panel)
PVGIS	PV generation database (industry software tool to estimate Solar Yield)
RAMSAR	Wetlands of International Importance Especially as Waterfowl Habitat (EU designation)
RCEF	Rural Community Energy Fund
RHI	Renewable Heat Incentive
RMPV	Roof-mounted PV
SEG	Smart Export Guarantee
SSSI	Sites of Special Scientific Interest (Natural England designation)
STA	Solar Trade Association
STAR-MAT	Sherburn, Tadcaster and Rural Multi-Academy Trust
UFH	Underfloor Heating
WSHP	Water-source Heat Pump

Appendix B. Potential Funding Sources

Currently, the UK government is incentivising the uptake of small-scale renewable energy installations through the Sustainable Export Guarantee (SEG) and the Renewable Heat Incentives (RHI). Both of these provide an income proportional to the volume of renewable energy exported, but the RHI is due to close shortly and will likely be replaced by the Clean Heat Grant (which is expected to offer up to £4,000 for renewable heating). The SEG is administered by energy companies, who are able to set their own tariff rates. A list of SEG suppliers can be found on Ofgem's website.

Regardless of these incentives, capital funding is key to realising renewables projects, especially for community groups who tend not to have large cash reserves. Locogen has identified the following funding pots which the client may be eligible to apply to. This a non-exhaustive list, and further lists are available on the Community Energy England and Centre for Sustainable Energy websites.

Grants

- **The National Lottery Awards for All:** £300 and £10,000 for community projects including refurbishments and equipment: https://www.tnlcommunityfund.org.uk/funding/programmes/national-lottery-awards-for-all-england
- **Reaching Communities England:** £10,000+ for community projects including refurbishments and equipment: https://www.tnlcommunityfund.org.uk/funding/programmes/reaching-communities-england
- **People and communities:** £10,001 to £500,000 for community projects including systems and equipment: https://www.tnlcommunityfund.org.uk/funding/programmes/people-and-communities
- **Tesco Bags of Help**: small grants for community projects including environmental improvements: https://tescobagsofhelp.org.uk/home/community-apply-bags-help-grant/
- **Energy Redress Scheme**: large grants for charities conducting emissions reductions projects: https://energyredress.org.uk/apply-funding
- **Aviva Community Fund**: Up to £50,000 for community resilience projects:https://www.avivacommunityfund.co.uk/uploads/terms/aviva-community-fund-eligibility.pdf

Many grants including some of those listed above do not fund projects for religious groups or activities, therefore specific grants for churches are listed below:

Grants for churches:

- **Churches and Community Fund:** grants to community projects run by parish churches, deaneries, dioceses and other bodies connected to or working in partnership with the Church of England: www.churchandcommunityfund.org.uk
- **National Churches Trust:** several grants for churches, chapels and meeting houses throughout the UK: www.nationalchurchestrust.org

Loans

- **Rural Community Buildings Loan Fund:** Loans of up to £20,000 for energy efficiency in community buildings: https://acre.org.uk/our-work/rural-community-buildings-loan-fund.php
- **Social and Sustainable Fund:** Loans of £250,000+ for community projects including those addressing fuel poverty and energy efficiency: https://www.socialandsustainable.com/community-investment-fund/

Appendix C. Financial model assumptions

Other than costs stated, the following standard assumptions are consistently used in the financial modelling for each project.

Variable	Value	Notes
Solar yield degradation	0.4%	
Cost of electricity	12.5 p/kWh	
SEG	4.5 p/kWh	
RPI	1.00%	Applies to electric/gas/oil prices, SEG, OPEX
CPI	1.70%	for RHI
Discount rate	3.5%	
Gas boiler efficiency	89%	
Fuel cost Y1 (p/kWh)	3.46p/kWh	
Oil boiler efficiency	85%	
Fuel cost Y1 (p/kWh)	3.20 p/kWh	

Carbon projections – from BEIS

Appendix D. Target room temperatures

Church		School	
Room	**Target Temp**	**Room**	**Target Temp**
Main church hall	19	Staff room	21
Side wing (left)	19	Hall	21
Side wing (right)	19	Kitchen	18
Room underneath tower	16	Resource room	21
Entrance lobby	18	Lobby 1	18
Lecturn area	19	Cloaks/WC 1	18
Organ	18	Office	21
Hallway adjacent to organ	18	Year 6 classroom	21
Vestry	18	Year 5 classroom	21
		Cloaks/WC 2, 3	18
Church Hall		Year 4 classroom	21
Room	**Target Temp**	Year 3 classroom	21
Main room	21	Cloaks/WC 4, 5	18
Storage	16	Lobby 2	18
Toilets	18	Year 1 classroom	21
		Year 2 classroom	21
Cricket Club		Reception	21
Room	**Target Temp**		
Shower	22	**Community Association**	
Dining	21	**Room**	**Target Temp**
Shower 2	22	Lounge	21
Toilet 1	21	Hall	18
Store	16	Kitchen	18
Toilet 2	21	Toilet 1	18
Kitchen	21	Toilet 2	18
Dressing	21	Hall 2	18
Toilet 3	21	Study	21
Hall	21	Hall 3	18
		Toilet 3	18

Appendix E. Primary School Solar PV Options

This appendix was prepared by Ray Newton based on information provided in Locogen's MFHCA Phase 1 report (6693-FEAS-REP-0001-MFHCA-v4.0.pdf).

Solar PV options – Phase 1 methodology

Estimation software *PVGIS* was used to estimate the annual generation potential of solar development at each of the sites. This utilises COSMO irradiation data, providing a Specific Yield (kWh/kWp installed) for each location. All sites were assessed with the specific orientation of the opportunity included. All arrays were sized using a nominal 300Wp PV module. Three potential solar installation options have been investigated: Ground-mounted PV (GMPV), Roof-mounted PV (RMPV) and Solar canopies (carports). The Client highlighted the option to erect PV canopies in areas that are not carparks. This was considered on a case-by-case basis, but generally the advice is to erect a structure (such as school or sports shelter) and place PV on the rooftop. It is likely this would be more functional and more cost effective given the high capital cost of carport structures, which are designed specifically to minimise contact with the ground for ease of parking, and balancing this with structural strength to cope with wind and snow. The Client also highlighted a risk that children may attempt to climb on the structures, indicating the solar canopies may not be the most appropriate choice.

The potential scale of GMPV is generally based on a conservative estimate of 0.75MWp/hectare. This accounts for presence of security fencing, access, and ancillaries. RMPV system scales have been estimated based on available roof area, with an assumed safety margin of ~1m from all roof edges and based on panel dimensions of 0.9x1.6m (orientation of panels optimised to roof shape). The peak capacity installed in solar carports has been estimated based on the number of car parking spaces available, with an estimated capacity of 1kW per canopy. The capital cost of a PV array has been estimated at £850/ kWp for a roof mounted system; £1000/kWp for a ground mounted system, and £1800/kWp for solar carport canopies.

For each site, the following options have been presented:

<u>Maximum generation for each PV technology</u>

This option investigates the impact of installing the maximum scale of PV that can realistically fit in the area provided. Where this significantly exceeds on-site demand, it provides a basis for assessing potential export to adjacent sites or third parties.

<u>G98 compliance</u>

In terms of array size, a 3.9kWp (or 13 panel) array was considered to represent the maximum size allowed under the G98 grid connection. Effectively, the G98 recommendation is the connection standard which allows a 'simple' connection from the inverter of up to 3.68kW (AC, single phase supply) without having to consider grid supply upgrade costs. Essentially, it is likely to be more cost effective and simpler to install a 3.9kWp system as opposed to a 4kWp system. This is not necessarily true of larger developments due to economies of scale.

In the instance where any site has a three-phase electricity supply, this should be flagged as it is likely that additional capacity could be installed under the G98, up to a maximum of 11.7kWp.

<u>75% consumed on site</u>

This option essentially investigated the optimum size of PV required to ensure 75% on-site consumption. 75% is generally accepted as an 'acceptable' target for on-site consumption to maximise revenue from a PV system without compromising on scale. This required matching half-hourly PV generation data with the half-hourly profiles created in the Demand Analysis.

The latter two options have been based on the lowest risk PV technology for the specific site.

While electricity storage opportunities have not been modelled at this stage, opportunities which may be complimented by battery storage have been identified for further investigation if taken to Phase 2.

Revenue from a PV installation is considered to be from either electricity cost savings, or (where there is a significant amount of energy exported) from the Smart Export Guarantee ('SEG' – refer to Section 6.5 for further details). The potential income from the SEG for the MFHCA has been calculated using a conservative SEG rate of 5p/kWh. In the instance where solar does not offset local demands (and therefore has no electricity cost savings included in the financial model) a sensitivity analysis presenting the impact of various SEG rates has been included. Justification for these rates is detailed in Section 6.5. Where local demand is offset, savings are based on a cost of electricity per kWh which varies per site, as supplied by the Client.

The School Electricity demand and PV options

Energy demand

The Client provided monthly electricity data from April 2018 – Dec 2019. This indicated that for 2019 the total annual demand was 59,485kWh of electricity, and this value is mirrored in the energy audit. Extrapolating this data allowed Locogen to estimate a total 2018 demand of 60,926kWh. Averaging between both years, Locogen has utilised an estimate of 60,200kWh per year for electricity demand modelling. The Client also provided a cost per kWh of electricity, notably a 12.185p/kWh flat rate, which corresponds to an average annual current spend on electricity of £7,335.

To better refine the electricity demand profile, the Client provided electricity demand data taken for 10 September to 24 September, which suggests a weekend daily demand of 100-120kWh, increasing to 250-390kWh/day during the week. The generated demand profile therefore assumes that 85% of the weekly electricity demand is used on weekdays during term time. In addition to this, it is assumed that 75% of said demand is consumed during the hours of 0700-1900.

		Primary School
Elec.	Annual kWh demand	60,200
Heat	Annual kWh demand	127,290
	Peak demand (kW)	50-55

Table 11: Demand analysis results for the Primary School

Energy opportunities

Options for Solar PV generation are outlined in Figure 19 below.

Figure 19: PV options at Primary School (RMPV: yellow; Solar canopies: green)

There are no clear options for GMPV at the school as all ground area is currently used for either recreation or carpark space. Generally, planning would favour options which do not remove recreational outdoor space. In addition to this, the complexity of the roof space limits options for RMPV, specifically due to the varying orientation with minimal south-facing surfaces, in addition to the frequent rooflights. The identified location for RMPV is estimated to be capable of hosting c. 9kWp of PV; the canopies are estimated to be able to host 10kWp.

Factor	RMPV1	Solar Canopies
Array size	9 kWp (max)	10 kWp (max)
# panels/canopies	30	2 x 5 ports
Orientation	South 0°	
Annual generation	8730 kWh	9710 kWh
Capital cost	£7,650	£18,000
% generation estimated to be used on site	92%	90%
Annual savings from on-site consumption	£969	£1,054
Simple payback without SEG	7.9 years	17.1 years
% of generated electricity exported to grid	8%	10%
Annual income from SEG	£33	£46
Annual combined income/savings	£1,002	£1,101
Simple payback incl. SEG	7.7 years	16.4 years
Y1 CO_2 offset (kg)	1,993	2,217
Y20 CO_2 offset (kg)	16,122	17,931

Table 12: Impact of maximum PV generation on Primary School

This exercise highlights that there is sufficiently high demand to utilise sufficient PV generation onsite to provide decent paybacks. The low cost of roof mounted PV paired with the high on-site consumption makes for a low -risk option for decarbonising. Limiting the installation to the G98 limit has the impact illustrated in Table 13 below.

Summary

While the school has the highest electricity demand of all sites, it has limited opportunities for PV generation. Any PV install is likely to be viable, with >90% generation used on site in all cases.

Table 15 below presents the relative economic and planning risks for each potential renewable development. Annual savings/income takes into account the increase or decrease in the cost of fuel, and any income (such as SEG) for the relevant system. SEG is assumed to be at a rate of 5p/kWh.

Option	CAPEX payback years	OPEX benefit	£/Tonne Carbon offset	Planning risk
RMPV1	7.7	+£1,002	£475	Low
RMPV2	7.3	+£454	£475	Low
Solar canopies	16.4	+£1,101	£100	Low
ASHP	25+	-£546	£1,614	Low
GSHP	25+	£147	£3,742	Low

Table 15: Economic and planning risk of options

Going Forward assessment prepared by Ray Newton

The School appears to have a 3 phase 100A supply which gives it a G98 maximum permitted development of 11.8kWp. Therefore, it is recommended to stay within this maximum PV generation capacity, although it is possible to install greater capacity but mechanically limit the maximum Power export to 11.8kWp.

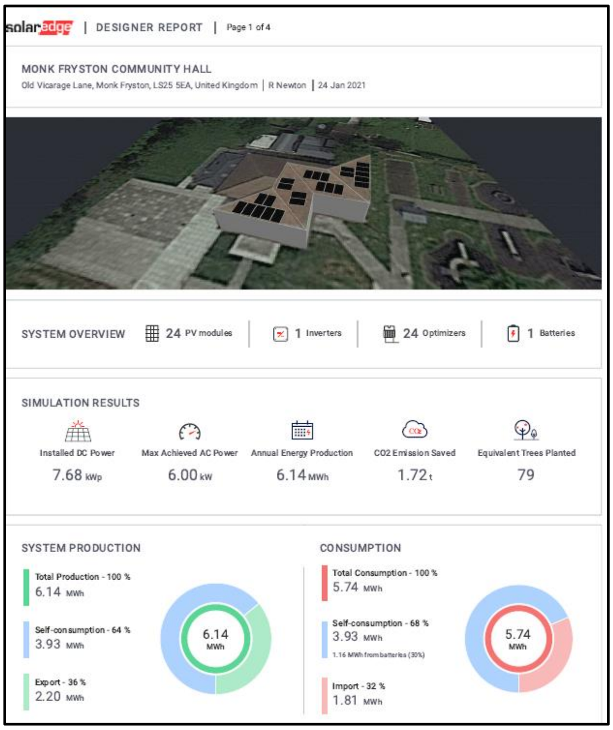
1. Conclusions which can be drawn from the Phase 1 report include:
    a. Options in Table 12 for either RMPV or Solar Canopies remain valid with very little shading to minimise potential generation if the solar canopy was located at the east (top end of the car park).
    b. The demand model used in phase 1 included for three key 'target' values:
        i. weekday daytime: 13.5kW;
        ii. weekday evening-time: 4.51kW;
        iii. weekend anytime: 3.9kW;
    - The 'evening' is essentially a four hour period on weekdays in which there may be extra curricular activities or late workers.The 'weekend anytime' value is also used for holiday periods. There is also a smooth curve applied to transition periods.
    c. The information provided indicates an average underlying consumption level of 3.9kWh per hour (taken from the 24-hr weekend consumption date) it would mean at least 50% of the energy generated would be consumed in these periods – and throughout the normal working school day. The balance being either diverted and stored as hot water or fed back into the grid at SEG rates.
    - Note that to divert excess electricity to the Hot Water, an extra piece of equipment would be required called a Solar Diverter. Some heat pump cylinders have this kind of control included or as an optional add-on. The additional cost is likely to be negligible, c. £500.
    d. Alternatively, Energy storage batteries could be purchased and drawn from for non-generation periods to offset energy purchases. Locogen state in the Phase 2 Final report, '*This, in some cases, presents a good opportunity to investigate energy*

storage (ES). A 5.8kWh electrical battery could be installed with the sole purpose of maximising the use of the generation on-site. The cost of this addition is estimated to be an additional c. £2,500 including all ancillaries (some of which assumed to be shared by PV costs already accounted for), with a battery replacement in Year 10.'

- Furthermore, it is possible to negotiate a dual tariff electricity supply which ES batteries could be topped up at off peak times – but given the school is part of a wider purchasing contract this is unlikely to happen.

e. Any potential PV supplier will model the exact detail of anticipated generation - see the Community Centre example below.

2. On-going Maintenance and other costs – Locogen quote in examples in the Feasibility study that: -
    a. Solar array – an estimated cost of £250 for annual maintenance (cleaning, visual inspection);
    b. 'The cost of an inverter replacement in year 10 is estimated at £580 for a 4kW system and £1,150 for a 7kW system, taking into account inflation', although some can be guaranteed for longer periods.



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Business Plan

Decarbonisation of Community Buildings

For Monk Fryston and Hillam Community Association

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v1.0	18/02/2021	Original document
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v3.0	19/03/2021	Amended report following further client feedback; update to cricket club demand profile.

Executive Summary

Monk Fryston and Hillam Community Association (MFHCA) have set ambitious targets for their community to tackle the Climate Emergency, setting an example for neighbouring communities and raising awareness in their own villages. Decarbonising the community buildings is a crucial part of this plan, and therefore the following aims were put together by the group at the beginning of the decarbonisation project:

4. *To make our Community Buildings carbon neutral by 2022.*
5. *To use our learning and investment in renewable energy technologies as 'working examples' to encourage village residents to adopt more environmental beneficial behaviours including investing in sustainable energy in their homes.*
6. *To share with other communities in Selby District and North Yorkshire our learning in order to encourage them to work on their Community Buildings.*

MFHCA have been working with Locogen to refine options to decarbonise five community sites across the two villages. The sites include buildings found in many similar villages: Church, Primary School, Community Centre and sports facilities, such that MFHCA may be exemplar in demonstrating how communities can proactively decarbonise the operations of their assets. Ultimately, the Client are looking to decarbonise the operations of the buildings, in particular their energy consumption, in order to facilitate financial, environmental and social benefits for the local communities.

From an extensive and detailed Options Appraisal, four distinct projects were chosen for their environmental/social impacts, financial benefits and/or simplicity. They include listed buildings, small community hubs and also the local primary school, all with varying technologies identified as the most effective for the specific site. This resulted in four different projects being taken forward to a detailed feasibility study, by which only one of the projects were deemed infeasible. The resulting portfolio therefore presents three distinct and innovative projects utilising a variety of renewable technologies.

In all cases, operating costs are reduced and the projects have a positive net annual income, providing opportunity for each site to invest in further energy saving measures or to support further projects in the community. Several of the options pay back even without the awarding of grant funding. All projects represent employment opportunities for local contractors to design and install the systems. Annual maintenance could also be carried out by a local contractor.

All projects have positive environmental benefits, reducing or removing fossil fuel use significantly for the respective site. The heat pump options immediately decrease the localised pollution from the existing boilers, helping to raise the air quality in the area.

The Church project in particular would be exemplar in highlighting the potential to develop renewables on, or near to, historic assets discretely and considerately. This is a challenge regularly faced by historic building owners, users and operators, as often the required consents are too challenging and costly, deeming most renewables projects unviable. The Diocese, by allowing this development, will set a new standard for historic retrofits and supporting future applications.

Another key benefit is the opportunity for the local community to gain an understanding of renewable technology and how it can be used to replace fossil fuel sources. The installation of heat pumps, solar PV and energy storage represents an educational opportunity for the community, whereby the system can act as a demonstrator project for similar buildings in the community and as an exemplar project for other small-scale installations locally. For pupils in the local schools, the installation will act as an opportunity for school visits and will tie into curriculum work relating to climate change and energy generation. The transition to a net zero society is one that will take place over the next few decades, and it is extremely important to educate people on the subject and the solutions available.

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1. Case

This document presents the business plan for implementation of a range of renewable technologies by Monk Fryston and Hillam Community Association (MFHCA). To date, MFHCA have commissioned an Options Appraisal, in the interest of identifying renewable energy opportunities that will allow the community buildings to draw at least 75% of their energy demand from sustainable sources. This was followed up by a Feasibility Study, detailing the preferred options. They have also carried out a significant amount of their own research and resourcing to further support the development of the project.

The current project portfolio is detailed further in the proceeding section, and includes:

5. Solar PV on the roof of the Church Hall, including thermal or electrical storage, with intentions to offset an air-to-air heat pump system without removal of the existing gas heating system.
6. A Ground-source Heat Pump system via a borehole array at the Primary School to supply existing underfloor heating, with potential to upgrade to the whole heating circuit.
7. Air-source Heat Pump installations at Community Centre and Cricket Club, the former to be combined with roof-mounted PV, the latter as below. While not identified as an option in this study, the Client has advised that there should be sufficient space on the Community Centre roof for a small-scale PV installation which will be confirmed by a site visit.
8. Ground-mounted Solar PV at the Football Fields to provide income to a community benefit fund, and offset electricity at the Cricket Club (including demand from an ASHP or thermal battery, prospective floodlights and/or Sports Barn). The potential of a roof-mounted solar opportunity on the prospective Sports Barn will also be investigated, based on agreed structure location and dimensions. If found to be unfavourable, roof mounted PV or Solar Carports at the Cricket Club with Energy Storage will be revisited.

There are numerous benefits in developing community renewables projects. Inherently, developing renewable project at any scale make a positive contribution to carbon reduction targets and ultimately the battle against climate change. Generating and using electricity at a local level is one of the key solutions identified by the UK Government. This ultimately minimises transmission losses and strain on the national electricity grid, and this is especially the case in rural communities such as Monk Fryston and Hillam.

Beyond the positive impact on the environment, such projects empower communities. Renewable developments bring opportunity for education, resilience and economic income. By generating a sustainable income (or offsetting current electricity costs) funds can be used to further benefit the community on other projects. The installations can be exhibited to school and youth groups to aid education, or to raise awareness generally in the community and influencing the residents to be environmentally responsible. Furthermore, involvement in renewable projects strengthens the community's connections, making further projects easier as technology and markets advance, and further projects are sought. Furthermore, as more local renewable projects are developed these become exemplar for neighbouring communities, by setting a standard and proving the business case.

2. Project Portfolio

The section sets out a summary of each of the renewables projects in the portfolio that are currently being investigated by MFHCA.

2.1. St Wilfrid's Church and Church Hall

The Church and Church Hall project looks to install rooftop solar PV, or perhaps combining this with heat provision through an air-to-air heat pump system. To install PV on its own, the most cost-effective option would be to install 4kWp of PV, as this can be installed using the existing supply to the building. The Church would require a new 3-phase supply to run the heat pumps, and this improves the case for PV. If both systems are to be installed, the PV could be increased to c. 6.8kW of PV (the maximum that can fit on the appropriate roof structure). This results in a total carbon saving of c. 553T – the largest of the proposed projects.

2.2. The Primary School

The Primary School is ultimately looking to decarbonise it's heating system, and is benefitted from an existing under-floor heating (UFH) system in part of the building which is well suited to renewable heat options. The proposed project looks, in the first instance, to replace the supply for the UFH section with a ground-source heat pump, which would require minimal building upgrades. This system would be c. 38kWp and is estimated to require drilling of only 6 boreholes.

A larger system looks to replace the heating emitters in the rest of the building such that the whole school's heat can be supplied by GSHP. This would require a 60kW heat pump and an estimated 8 boreholes. Neither system demonstrates a positive IRR, but if grant funding could be acquired then both systems provide an annual net income for the school. Carbon savings are estimated to be in the region of 117T and 379T for the 38kW and 60kW systems respectively.

2.3. Air-source Heat pumps on smaller community buildings

The introduction of small ASHP units in tandem with solar PV is proposed for the Community Centre and Cricket Club. Both these buildings are relatively small and new, making them very suitable for ASHP installations. PV was also included to compensate for the increased electricity load given the ASHP installation, but in both cases this did not appear to compliment the electricity demand well due to the mismatch between generation and demand.

What is an important consideration for both these properties is that, due to their small scale and relative simplicity, they could benefit from the Non-domestic Renewable Heat Incentive (RHI). At time of writing, Locogen considered the timescales for installation made it possible for the projects to receive RHI payments. However, the Client suggested in the concluding meetings that this is unlikely. Similar to the Church project, both sites have a significant net income from the installation of solar panels which, given grant funding is acquired, would be beneficial to the community.

2.3.1. MFHCA Community Centre

The ASHP project alone, including income from RHI, sees substantial income for the community centre with an IRR at year 20 of 23% and a net annual income of almost £2000. The excellent return is likely due to the existing heating system again using UFH, which means it's unlikely the internal system will need to be retrofitted. The carbon offset is also substantial, at 250T for the ASHP alone. Both the carbon offset and net income are slightly bettered by the inclusion of Solar, though the returns are marginally lower. The carbon savings for the whole system is c. 124T.

2.3.2. The Cricket Club

Similarly, the ASHP installation at the Cricket Club with the inclusion of RHI is a very cost-effective means of decarbonising the building. However, in this case an internal retrofit is required so IRRs are in the region of 7%. While the addition of PV, this again is worsened while the net annual income increases. Lifetime carbon savings at this site with both systems installed is c. 67T.

2.4. Stand-alone solar at the Football Fields

The community group were enthusiastic about the development of a larger-scale renewable project at the football fields, either as a ground-mounted system or as a roof-mounted system on a prospective 'sports barn' sheltered area. This would be in the region of 80-100kWp installed, providing significant carbon offset and helping decarbonise the local electricity grid.

The opportunity for development of medium-scale solar at the football fields was not taken further, given poor financial prospects (primarily due to grid connection costs). However, if the landscape changes and the value of exported energy increases, Locogen would recommend revisiting this option. This would also be true if more land were to become available near to a large industrial consumer, ultimately taking advantage of economies of scale.

3. Summary of Financials

Below is a summary of each project's estimated financial performance.

- Costs specific to each system are detailed in Appendix A;
- Net income is the sum of:
  - Income/savings (Electricity savings from PV usage; Income from export of excess electricity (SEG); Heating fuel cost savings; Old system maintenance cost savings, and Income from Renewable Heat Incentive (RHI, where applicable);
  - Less the additional costs (increased electricity spend (due to addition of heat pump, for example); New system maintenance costs, and additional lifetime costs (equipment replacements).

A full list of assumptions made in the cashflow models is included in the Phase 2 Report.

Site	**Church & Church Hall**			**School**		**Community Centre**		**Cricket Club**	
Option	**1a**	**1b**	**1c**	**2a**	**2b**	**3a**	**3b**	**4a**	**4b**
System (s)	**PV only (4kW)**	**PV only (6.8kW)**	**PV (6.8kW) + A2AHP**	**38kW GSHP**	**60kW GSHP**	**ASHP***	**ASHP + PV***	**ASHP***	**ASHP + PV***
Whole system CAPEX	£5,082	£17,567	£70,482	£67,547	£101,147	£9,070	£14,308	£12,432	£17,421
Whole system OPEX	£250	£250	£1,450	£300	£400	£200	£450	£200	£450
Net income Y1	£74	£210	£3,044	£235	£947	£1,990	£2,129	£1,007	£1,093
Y20 NPV	-£4,477	-£14,501	-£21,644	-£61,615	-£83,025	£22,839	£19,465	£3,998	£70
Y20 IRR	-12%	-11%	0%	-16%	-11%	23%	15%	7%	4%
Payback years	No payback	No payback	21.3	No payback	No payback	4.4	6.4	11.3	14.7
Carbon offset Y1	0.5 T	0.8 T	25.8 T	10.5 T	16.9 T	4.2 T	4.6 T	2.1 T	2.3 T
Carbon offset Y20	5.5 T	9.3 T	553.1 T	286.5 T	378.6 T	118.3 T	124.4 T	63.9 T	66.8 T

**These systems have included for the non-domestic RHI, as it is possible they may be developed within the application deadlines.*

This highlights the best option from a financial perspective (based on IRR) is Option 3a, however the greatest carbon reduction benefits are realised in Option 1c. Given the intentions for the community to obtain grant funding for the projects, however, a better indication of the performance would be the Net yearly income. It can therefore be seen that, in all project where grant funding is achieved, the Client makes a net income and therefore any of these projects could be considered financially viable.

4. SWOT analysis

The below matrix illustrates the Strengths, Weaknesses Opportunities and Threats that generally apply to community renewables projects.

Strengths	Weaknesses
1. The intention to carry out this study demonstrates a level of trust, commitment and pride in MFHCA, and this is reflected in their track record of activities and enterprises. 2. Where fossil fuels are displaced (such as in renewable heat), the community is less vulnerable to fluctuations in fuel prices or increased taxation. In the case of the PV projects, energy generated is ‘free’, so electricity bills are also less influenced by fluctuating markets. With these costs financially benefitting community group, more funds can be allocated to activities and new ventures, further empowering the community group. 3. Community groups often have a variety of backgrounds and experience among their members. While the renewable projects are largely passive technologies that do not require extensive maintenance, often it is that the community group will have enthusiasts in these technologies, giving opportunity for education and engagement with the group and wider community. This also eases the ongoing commitment, as maintaining a level of enthusiasm will ensure there are volunteers when occasional maintenance work is required. 4. Finally, the project will have a net environmental benefit, and the example set will influence nearby and national community groups to take on similar projects, ultimately adding to the environmental benefit of the project.	1. Incentives (or grants) are required for the portfolio to achieve any significant income or to achieve reasonable payback periods. 2. Small-scale projects cannot take advantage of economies of scale and will likely pay more per kW for installations. 3. Benefits are heavily weighted on building usage and ongoing operation. Unfortunately, Community buildings are often used in the evenings or only on the weekends, which does not reflect PV generation daily profiles. Further to This, schools and many other community buildings close in summer months, when PV generation is at it’s peak, resulting in a lot of low-value exported energy. This is very case-specific. 4. Nature of community project means limited operational-phase resource which may lead to complications when maintenance is required. There is a requirement for community group to be involved in arranging ongoing (though occasional) maintenance, and also to manage the decommissioning phase. The intentions for this should be set out at an early stage. 5. Rural communities in particular may face challenges in sourcing skilled labour to carry out maintenance work when required due to remoteness of location. Delayed maintenance means a reduction in annual generation and a loss of revenue.

Opportunities	Threats
1. There has been a significantly increasing awareness of Climate Change and the requirement for renewable heat and power generation. The urgency means it is likely that these projects will gain the attention of external and internal investors in a bid to achieve climate change targets and demonstrate responsibility. 2. Community groups often have access to a wider range of funding sources, including grant funding. 3. Small-scale projects do not require large loans with complex repayment terms that are likely to be influenced by markets. 4. There is often rates relief for community organisations such as amateur sports clubs, religious and educational institutions. 5. It is anticipated that the cost of gas and oil will increase significantly, and therefore the value of installing renewable heating systems is improving, with less vulnerability to fossil fuel cost increases. 6. The small-scale renewable heat projects (ASHPs) may be achievable in the RHI timescales, improving financial case. 7. Demonstrating their capacity to organise and develop a project such as this will empower the community, making it exemplar for neighbouring community groups, and will demonstrate to their local authority the possibilities even in rural communities, ideally influencing policies. 8. Such a project will provide a local educational opportunity, whereby local youth groups and school pupils may visit and learn about the community project, it's impacts and climate change. 9. The project develops local experience in community development, empowering the community to take on further ventures.	1. The future of renewable incentives (i.e. replacements for FIT and RHI) are extremely unclear. There is always a temptation to 'wait it out' to avoid missing out on income opportunities. 2. There is a trending increase in distributed electricity generation across the UK, and each project increases the strain on the existing electricity grid infrastructure. This means that at any point a grid connection may be more expensive to install to the point that is becomes a showstopper for the project. 3. The seasonal performance of solar PV in particular means that a bad/short summer could significantly reduce revenue for that year. 4. The seasonal performance of heat pumps varies seasonally. This means that they do not run as efficiently with colder outdoor temperatures (when they are needed the most). Unfortunately, if electricity becomes more expensive in winter (due to decreased solar production) this may incur an increased running cost. 5. Generally, the voluntary nature of community groups teamed with varying levels of enthusiasm and dedication leads to often difficulties balancing service delivery and advocacy. 6. Adverse weather such as snow, ice and high temperatures can impact renewable equipment. Heat Pumps may need defrosted, and panels may need cleaned of snow. This can be especially challenging if volunteers aren't available to grant access to contracted maintenance workers at short notice.

5. Risk Register

ID	Phase	Section	**Risk** (Description of the risk)	Severity	Likelihood	Risk level	**Required mitigation** (How to reduce the risk)	Comments	Severity	Likelihood	New Risk level	Risk owner
R1	Design and procurement	Financial	Project does not secure grant funding	4	2	8	MFHCA to engage actively with funders and address concerns about the project		4	1	4	MFHCA
R2	Design and procurement	Financial	Project does not have budget available for match funding	4	3	12	MFHCA to seek alternative means of fund raising. Crowd funding or opportunity to invest in project		4	2	8	MFHCA
R3	Consenting	Planning	Consent is not achieved for the project	5	4	20	Locogen have undertaken initial consultation to understand key project barriers (Planning risks e.g. aviation, ecology, etc.)		5	2	10	MFHCA
R4	Consenting	Planning	Grid connection application rejected	5	2	10	MFHCA to engage early with NPG regarding local grid constraints. Applications to increase grid capacity should be submitted early on in the next stage of the project and secured as necessary to mitigate this project risk	Engagement thus far has highlighted estimated costs, as included in report. .	5	2	10	MFHCA
R5	Construction	Business as usual	Power shut down affects the operation of community buildings.	4	3	12	Installation period to be completed at scheduled time - outage to be communicated in advance to stakeholders to minimise impact.	Contractor to provide dates of shut down with notice to site management, if applicable.	2	2	4	Contractor
R6	Construction	Transport	Contractor cannot get equipment to the site.	5	1	5	Traffic management plan to be undertaken showing that the equipment can be delivered to site. The delivery is on standard HGV vehicles.	Contractor to complete study.	2	2	4	Contractor

R7	Design and procurement	Supply	Equipment delivery is held up and delivered late to the project.	3	3	9	Project to allow suitable time for procurement/mobilisation		2	2	4	Contractor
R8	Construction	Programme	Forces beyond our control delay programme (e.g adverse weather, pandemic)	3	2	6	Allow float in the programme to allow for uncontrollable weather delays. If possible, priorities summer period for installation works.	In the example of the Pandemic, such has been experienced in 2020/2021, delay in unavoidable. We would expect that where there are deadlines to mee, these will be extended.	2	2	4	Contractor
R9	Construction	Programme	Contractor takes longer than programmed to undertake the work as identified in their programme	4	2	8	Contractor to confirm their programme and provide weekly updates. Contractor to apply additional resources if required to keep to the project programme.		3	2	6	Contractor
R10	Construction	Programme	Contractor does not follow working practices on site and is stopped from working.	5	5	25	Contractor to include the site rules and procedures in to their own working procedures and ensure this is submitted to the Client for approval prior to starting work on site.		5	2	10	Contractor
R11	Construction	Environmental	Contractor do not follow the environmental controls on site.	4	3	12	Contractor to follow the environmental processes needed on site.		3	2	6	Contractor
R12	Construction	Financial	There is an increase in capital costs	4	3	12	Consultant to actively engage with suppliers at feasibility stage to identify costs. Contingency of 5% capital cost increase has been included, and costs should be agreed upon prior to construction phase.	It should be noted that the cost for renewables installations have been steadily reducing in recent years due to lower equipment prices and more competition for the construction works. However, impacts of Brexit are yet to be realised.	2	2	4	Locogen
R13	Construction	Financial	There is an increase in operational costs	4	3	12	Consultant to actively engage with suppliers at feasibility stage to identify costs.	Contingency should be allowed at an appropriate level (5% highlighted in feasibility study)	2	2	4	Locogen

R14	Operational	Financial	Technology performs poorly compared to expected generation	2	4	8	Financial modelling should include appropriate generation losses to ensure business case is robust.		2	2	4	Locogen
R15	Operational	Programme	Contractors cannot access site due to volunteers being unavailable from community group	1	3	3	The group should agree with the operators at each site a responsible person to be available for any ongoing maintenance work.	It is likely this would be the building's current caretaker, for example.	1	1	1	MFHCA
R16	Operational	Security	Equipment is stolen or damaged	4	4	16	Following site inspection, it may be decided that security measures beyond those anticipated are required.	Through operation there is a risk that the panels could be stolen or damaged, with the panels being particularly vulnerable to being damaged by thrown stones. The array site is currently accessed by public footpath and the fact the site is adjacent to open space increases the potential for security issues which may in turn increase the operational costs.	2	2	4	MFHCA
R17	Decommissioning	Financial	Funds are not available for removal, disposal or repowering the project	4	4	14	These cost should be accounted for early in the project, and some of the revenue should be retained for the end of life of the project.		2	2	4	MFHCA
PVR1	Construction	Programme	Roof is found to be structurally unsuitable for solar installation	5	4	20	A structural survey should be carried out prior to any construction work commencing		5	1	5	MFHCA
HPR1	Construction	Financial	Test borehole for GSHP system has poor results.	4	3	12	Alternative schemes should be considered such as ASHP as an alternative, with the internal retrofit being the same but	The test borehole is to test the system, and if this finds unsuitable ground conditions then an alternative project should be considered, or else the project should end.	3	3	9	

6. Conclusions

Financial analysis has confirmed that this portfolio represents reasonable returns (provided grant funding is achieved) and introduces financial benefits to the community/community building users. The risks identified can be mitigated to an acceptable/negligible levels as outlined in the risk register.

The project portfolio is in line with National Government and Local Government targets and policies with regards to climate change, decarbonisation and energy savings, and can inspire nearby communities to take on similar projects as they are likely to have a similar building set.

Furthermore, the strengths and opportunities identified far outweigh the weaknesses and threats to the projects.

Appendix A. Breakdown of project costs

Below provides a breakdown of development, capital and operational costs extracted from the Phase 1 Stage 2 (Feasibility) report.

St Wilfrid's Church and Church Hall

Phase	System	Item	Cost
Development	PV	Planning application fee (to Diocese)	£300
	A2A	Planning application fee (to Diocese)	£300
	PV & A2A	Pre-application discussion with Local Planning Authority	£330
	PV	Notification to Local Planning Authority	£96
	PV	Grid Budget Cost Estimate Fee	£150
	PV	Grid application fee	£350
	PV	Structural Survey	£100
	PV & A2A	Estimated grid connection cost	£10,400
	Total		**£12,026**
Capital	PV	Panels	£2,040
	PV	Ancillary Equipment (inverters, cables, mounting)	£1,170
	PV	Install	£1,890
	A2AHP	Heat pump	£12,500
	A2AHP	Heat emitters	£7,500
	A2AHP	Mechanical & Electrical (M&E) equipment, accessories and installation	£30,000
	Total		**£55,100**
Operational	PV	Maintenance (cleaning, visual inspection)	£250
	A2AHP	Maintenance	£1,200
	Total		**£1,450**
	Additional	**Inverter replacement (Y10)**	**£950**

Primary School

Phase	System	Item	Cost
Dev.	GSHP	Pre-planning advice	£330
	TOTAL		**£330**
Capital – 38kW	GSHP	Heat pump unit	£7,000
	GSHP	Ancillary M&E items (accessories, buffer vessel, pipework etc)	£3,000
	GSHP	Borehole array and groundworks	£33,500
	GSHP	Collector system materials	£2,500
	GSHP	Installation (Labour, management etc)	£18,000
	TOTAL		**£64,000**
Capital – 60kW	GSHP	Heat pump unit	£14,000
	GSHP	Ancillary M&E items (accessories, buffer vessel, pipework etc)	£3,000
	GSHP	Replacement of existing radiators	£6,000
	GSHP	Borehole array and groundworks	£43,500
	GSHP	Collector system materials	£3,500
	GSHP	Installation (Labour, management etc)	£26,000
	TOTAL		**£96,000**
Op.	GSHP	Maintenance	£200
	TOTAL		**£200**

ASHP Systems

Phase	System	Item	Community Centre	Cricket Club
Development	ASHP + PV	Pre-Planning advice fee	£330*	£330*
	ASHP	Planning application fee	£256	£256
	PV	Planning notification fee	£96	£96
	TOTAL		**£682**	**£682**
	PV (>4kW)	BCE	£150	n/a
	PV (>4kW)	Application cost	£350	n/a
	PV (>4kW)	Estimated cost of connection	£22,000	n/a
	TOTAL (for PV >4kW + ASHP)		**£23,182**	**n/a**
Capital	ASHP	Heat pump unit	£4,420.55	£2,825.69
	ASHP	Ancillary M&E items (accessories, buffer vessel, pipework etc)	£3,567.11	£4,523.38
	ASHP	Replacement of existing radiators	£0.00	£4,000.50
	ASHP	Installation (Labour, management etc)	£1,082.81	£1,082.81
	Total		**£9,070**	**£12,432**
	PV (4kW)	Panels	£1,224.00	£1,224.00
	PV (4kW)	Ancillary Equipment (inverters, cables, mounting)	£955	£955
	PV (4kW)	Install	£1,890	£1,890
	Total		**£4,069**	**£4,069**
	PV (7.2kW)	Panels	£2,142.00	n/a
	PV (7.2kW)	Ancillary Equipment (inverters, cables, mounting)	£1,351	n/a
	PV (7.2kW)	Install	£2,106	n/a
	Total		**£5,559**	n/a
Operational	PV	Maintenance (cleaning, visual inspection)	£250	£250
	ASHP	Maintenance	£200	£200
	Total		**£450**	**£450**
	Additional	Inverter replacement (Y10)	£950	£950