RENEWABLE
ENERGY SPECIALISTS

Locogen

MFHCA RCEF Project

Stage 1: Phase 1 report

For Monk Fryston and Hillam Community Association

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v1.0	30/10/20	Draft report
V2.0	10/11/20	Final version
V3.0	09/12/20	Update to Ph2 objectives following interim meeting and provision of additional information.
V4.0	09/12/20	Further update to Ph2 objectives.

Executive Summary

The Monk Fryston and Hillam Community Association (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.

This report (Stage 1: Phase 1) is primarily to aid the Client in deciding which opportunities, if any, to progress to Phase 2 of the Feasibility Study. The methods for conducting the high-level assessment of sites and identification of opportunities is set out; the local constraints are detailed, and technology options are presented to the Client to ensure a well-rounded understanding of the practicalities of each option. The sites are then presented individually, with the merits and challenges discussed for a number of renewable energy options. Finally, options which include multiple sites or more complex business models are investigated. A high-level cost-benefit analysis is included to aid the Client in decision making.

A draft version of this report was submitted to the Client on October 30, 2020. This allowed for the Client and stakeholders to familiarise themselves with the work done prior to an Interim Meeting, which was held virtually on November 4, 2020. At this meeting, each site was discussed and most of the submitted queries and clarifications were addressed. Nevertheless, all comments and outcomes have been included in this final version of the report for completeness.

Following discussions, the following options are likely be taken forward to Phase 2 of the Feasibility Assessment:

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.

Locogen intends to undertake a site visit, but whether this will be virtual or live will depend on COVID restrictions on travel. The Client has suggested their input via video streaming and photographs, which we believe will be sufficient if it is not possible for Locogen to travel to the site. Locogen will utilise information from the discussions and site visit to further determine project viability, with regular input from the Client where required. This will be followed by detailed half-hourly energy modelling to further inform financial and carbon analysis. Locogen will then provide a draft specification for the preferred energy systems, accompanied by a detailed risk assessment, review of funding options and review of suppliers.

Ultimately, the outcome of the feasibility study will be a comprehensive business case that allows viable energy system options to move forward towards development and meeting the community's development objectives. Locogen also intend to support MFHCA in procurement phase, and will assist MFHCA with funding applications under Stage 2 of the RCEF.

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1. Introduction

1.1. Background

Having been appointed as framework partner, Locogen are undertaking a feasibility project on behalf of the MFHCA. This Project is supported by the BEIS funded Rural Community Energy Fund (RCEF) which is managed by the North East Yorkshire and Humber Energy Hub and administered by Tees Valley Combined Authority.

MFHCA have identified five potential renewable sites between the two villages, namely: St Wilfrid's Church and Church Hall; Monk Fryston Community Centre; Monk Fryston Primary School; Monk Fryston Cricket Club, and its adjacent Football Pitches. Opportunities identified and assessed may include renewable electricity and/or heat generation at any of the sites to supply any of the sites. The sites are mapped in Figure 1 below.

Figure 1 - Location plan

The focus of this project is to determine the feasibility of implementing a range of renewable energy technologies – specifically solar PV, energy storage and renewable heat – across the buildings that are associated with MFHCA.

1.2. Phase 1

To meet the requirements of the community, the feasibility project has been divided into two phases. This report details the work completed in Phase 1, which has involved a desktop assessment of the project location to assess the local requirements, opportunities, and constraints. This has allowed viable energy technologies to be identified and matched with local demands. This Phase 1 feasibility report presents the most technically, economically, and environmentally feasible options for MFHCA as a whole and for each of the buildings under consideration.

Following the issue of this report, Locogen will continue to work alongside MFHCA to select the energy systems to take forward for detailed assessment in Phase 2 of the project, which is also funded by the RCEF.

1.2.1. Objectives

In order to help the Monk Fryston and Hillam community achieve their goals for this project, Locogen will assess the feasibility of implementing various renewable energy technologies to meet the energy demands of the five community buildings. Phase 1 entails a review of options for standalone and shared heat pumps and biomass systems for heating, as well as solar PV and battery systems for electricity generation. Small wind and hydro generation will also be considered, but based on information provided by the client, it is acknowledged that these are unlikely to be feasible. As well as individual systems, options for shared heating systems will be considered.

1.2.2. Report structure

This report is divided into the following sections:

1. **Methodology** – outlining the processes used in the development of Phase 1, and key assumptions made in the initial stages of the project;
2. **Constraints analysis** – High level introduction to developmental constraints, such as grid connections and planning requirements;
3. **Technology overview** – Details of the potential options available for the provision of renewable space heating, reduction of heat requirements, renewably heated hot water, and onsite electricity generation;
4. **Properties under consideration** – Property-by-property analysis of potential energy/carbon saving opportunities for space heating, hot water and electricity generation;
5. **Other opportunities** – Additional potential energy or resource saving options, options to combine systems; and
6. **Summary and recommendations**

1.3. Phase 2

Following an interim meeting (anticipate w/c 2 November), selected projects will be taken forward to a Focussed Assessment (Phase 2). This will commence with a site visit to further determine project viability, followed by detailed half-hourly energy modelling to further inform financial and carbon analysis. Locogen will then provide a detailed specification for the preferred energy systems, accompanied by a detailed risk assessment, review of funding options and review of suppliers.

Within Phase 2, Locogen also intend to support MFHCA in procurement phase. Ultimately, the outcome of the feasibility study will be a comprehensive business case that allows viable energy system options to move forward towards development and meeting the community's development objectives.

2. Methodology

2.1. Constraints analysis

Locogen utilised our dedicated GIS database to assess the planning risk to development in the area. This includes data from Natural England; Historic England; the Civil Aviation Authority; BEIS, and local DNOs. The satellite base-map imagery was utilised to build spatial models representing residential amenity, and to assess the likely visual impact of any development.

From satellite imagery, likely impacts from noise, glare (from solar) and shadow flicker (from wind) have been assessed qualitatively, utilising Locogen's development experience to identify opportunities with minimal planning risk. GIS was also used to map public footpaths, overhead transmission and distribution lines, watercourses and other water bodies, woodland, and land boundaries to maximise contextual understanding of the site.

In addition to this, proposals maps from the Selby District Council Local development plan were overlaid with the GIS model to ensure none of the intended development areas impacted proposals, nor were impacted by impending developments.

2.2. Demand analysis

Half-hourly electrical demand profiles were built for each site, the assumptions behind which are included within the report on a site-by-site basis. These profiles were scaled according to real annual demand figures provided by the Client for each site, to ensure an accurate kWh/year consumption and, in some cases, seasonally matched with monthly data. Furthermore, where timetables of usage were provided, the profile was altered to include for higher demands during occupancy times.

Annual heat demand figures were provided by the Client for all sites. Where floorplans were provided, these were utilised to model the buildings heat losses through the year based on MCS approved methods, notably the MCS room-by-room heat calculation tool. The MCS tool bases it's calculations on locational climate data and degree days; target room temperatures; ventilation; building fabric and dimensions; window fabric and dimensions, and occupancy. Each of these variables are assessed on a room-by-room basis (rather than, for example, assuming the same temperature throughout the building) to accurately estimate annual and peak heat and hot water demands. This is especially useful when gas is used for cooking, as this is generally included in annual gas bills and often leads to overestimation of heat requirements.

This provided a peak demand (kW) from which a renewable heating system could be sized whilst considering future building use changes. These peak demand figures will be re-examined as the building fabric of each site is assessed following the site visit if progressed to Phase 2.

Where floorplans were not provided, peak heat demand was estimated using the yearly demand figures and estimated Full Load Equivalent running hours of the system which were approximated based on Locogen's experience with similar sites and the expected usage patterns provided by the Client. This is a high-level estimate and exact building dimensions, and fabrics would need to be confirmed to reduce any uncertainty if progressing any of these projects to Phase 2.

2.3. Solar PV options

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:

Maximum generation for each PV technology

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.

G98 compliance

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 of 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.

75% consumed on site

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.

2.4. Heat options

From the information provided for each site in combination with aerial images and general information available online, Locogen were able to assess the heat options suitable for each site. For each of the technologies in Section 4 a high level assessment was carried out to determine whether the plant equipment spatial requirements could be met which was the first criteria. Then by using the annual demand and estimated peak demand figures, the resource availability was assessed for each technology (e.g. fuel availability for biomass, and ground area requirements for GSHP collector systems) to determine whether the technology could be used successfully. This, combined with Locogen's experience of each technologies suitability for different buildings depending on their usage and design, enabled a list of feasible heat options for each site.

Where electricity-powered heat options (such as direct electric heating or heat pumps) have been considered, the electrical load has not been added to the demand profile at this stage, but will be included in whole-system energy flow modelling in Phase 2 as required.

2.5. Carbon analysis

The carbon offset for each PV array has been estimated and presented for Y1 and Y20. PV generation is assumed to decrease by 0.7% per year as the installation ages, and the annual generation is compared with the estimated average grid carbon content for that year. The assumed carbon regression profile of the UK grid is included in Appendix A.

3. Constraints analysis

3.1. National/international designations

Natural England

Locogen investigated the following Natural England designations:

- Special Protection Areas (& Potential Special Protection Areas)
- Special Areas of Conservation (& Possible Special Areas of Conservation)
- Sites of Special Scientific Interest
- RAMSAR sites
- National Parks
- National Nature Reserves
- Areas of Outstanding Natural Beauty
- England Coastal Path
- Conservation and Enhancement Scheme Agreements
- Biosphere Reserves
- Ancient Woodland
- Local Nature Reserves
- Country Parks

The only designations within 5km of Monk Fryston and Hillam are SSSI designations, all of which are over 3.5km from the site. This distance is considered sufficient to be a low risk to any solar or renewable heat development, but should be reassessed if considering wind development at any site.

Historic England

Locogen also investigated historic designations, including:

- World Heritage Sites
- Parks and Gardens
- Historic Battlefields
- Scheduled Monuments
- Listed Buildings

The only designations within 5km of Monk Fryston and Hillam are Scheduled Monuments and Listed Buildings.

Such historical assets not only need fundamentally conserved in their own structures, but there is also a risk that altering their setting (i.e. surroundings) may have significant adverse impact in the cultural appreciation of the asset. Objection to development regarding the setting of historic assets is most common in large-scale developments with significant visual impact, such as industrial or wind development, but there is also ground for objection to solar.

Figure 2 and Figure 3 below show the locations of listed buildings within 1km of the potential development sites at Monk Fryston and Hillam respectively. While there are also Scheduled Monuments within 5km of the site, it is extremely unlikely that (given their positions >2km from the site) there will be any objection to the likely scale of development at the MFHCA sites.

![Loco2gen logo]

Figure 2: Monk Fryston Listed Buildings **Figure 3: Hillam Listed Buildings**

<u>St Wilfrid's Church and Church Hall</u>

St Wilfrid's Church itself is a listed building. This means that any significant alterations to either the interior or exterior of the building would usually require planning permission and Listed Building Consent, adding significant time and cost to the project. This includes energy efficiency measures, alterations to the heating system, and any works within the curtilage of the designated building (which includes all grounds and the Church Hall). The Church Hall itself is not listed, and so it's unclear whether this would usually require listed building consent or only planning permission.

However, the Client advises that as the Church is owned by the Diocese, these restrictions do not apply. The consenting process would instead be via Church faculties.

A further listed building (Prebendal House) is located to the south of the Church Hall, and the setting of this may be just reason for objecting to alterations to the external faces of the Church Hall (for example, south-facing roof mounted PV). The Client advises that there are three modern houses in Prebendal Close, one of which is between Prebendal House and the Church Hall. It is therefore considered unlikely that Historic England would object to development at the Church Hall on these grounds.

Glint & Glare impacts

Wind and solar developments can have significant impact on operation of airports, airfields en-route air traffic, as well as road traffic and transit. In the case of solar development, this is mostly from Glint and Glare. Glint and glare generally occurs when the sun is lowest in the sky (i.e. sunrise and sunset) and reflects off the panels, impacting in the east/west direction. It is important to consider glint and glare impact on any transit routes within 1km of the development, and ensure sufficient screening is in place.

All potential PV sites are well screened from roads. The potential development sites in Monkfryston and Hillam are <1km south-southwest of Sherburn-in-Elmet Airfield. The runway for this airfield is directed west-southwest, c. 35 degrees from the nearest potential site (the Church), which may be considered sufficiently offset to be a low risk. A larger >1MW solar array may prove a higher risk. The client advises that the airfield is used by light aircraft and helicopters, but Monk Fryston itself is a designated no-fly zone, so it is unlikely there will be aircraft flying at low altitude. Leeds Bradford airport to the south is sufficiently distant to not be impacted by development and is extremely unlikely to object in planning.

Glint and glare can also impact adjacent residential receptors and there have been instances where local residents have objected even to small-scale rooftop developments. It is rare that this leads to planning refusal but should be considered a risk when there are nearby, taller buildings and no screening in place.

3.2. Local authority constraints

The Selby District Local Plan and Interactive Planning Policy Map was used to assess any local plans that may impact development. Items which may impact local renewables development were overlaid with the potential sites, and are reviewed below:

- Significant Residential Permissions – does not impact any of the potential sites.
- Safeguarded Land – To east of Beteras Hill Road to Lumby Hill, does not impact any of the potential sites.
- Proposed Recreational Open Space – includes Primary School playground and area to east of Chestnut Green, limiting options for GMPV development.
- Existing Recreational Open Space – includes Primary School playground and Community Centre grounds. May object to GMPV development at Community Centre, medium risk.
- Historic Park and Garden (Local) – to North of Main St, Monk Fryston Hall and grounds extending to Ingthorne Ln. Setting may be impacted by development at the Church.
- Green Belt – Most of surroundings are designated green belt. This is high risk to large developments but given that new developments are intended to be at existing sites, likely to be lower risk. Acceptability of development in greenbelt varies between local authorities. See Figure 4 below for extent (greenbelt in hatched green).
- Historic Conservation Area (Local) – The villages of Monk Fryston and Hillam are designated Historic Conservation Areas. This means that any solar development is likely to require planning permission, even if usually considered permitted development. Satellite imagery indicates a property with rooftop PV c. 50m east of the Church, suggesting that the Local Authority is supportive of renewable developments despite the designation. Nevertheless, it is best to consult early with the LPA and Historic England. See Figure 5 below for extent (conservation area shaded orange).

Figure 4: Extent of greenbelt designation

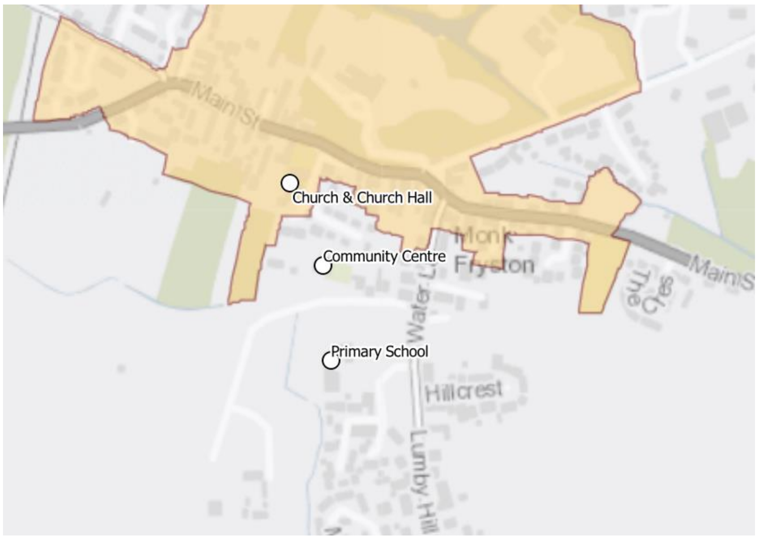

Figure 5: Extent of Conservation Area designation

Furthermore, the map indicated the extent and location of the proposed Monk Fryston Bypass, which currently appears to pass through the school grounds. There is limited information available on the proposals See Figure 6 below for current proposed bypass route, shaded dark grey.

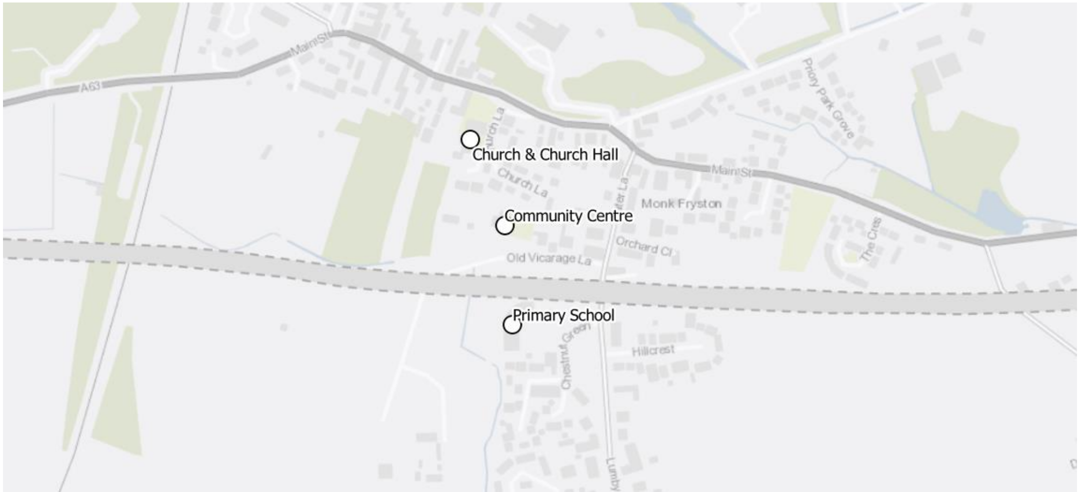

Figure 6: Proposed Monk Fryston Bypass route

It was confirmed by the Client in the Interim Meeting that the bypass line was repealed c. 10 years ago, and is not of concern.

4. Technology overview

4.1. Renewable electricity generation

4.1.1. Solar PV

The primary opportunity for electricity generation for use in buildings across the site is through the use of Solar PV systems – either standalone, RMPV systems which directly supply the building on which they are installed; or larger, GMPV systems which could supply a number of buildings at any one time. Solar canopy options were also investigated to maximise retainment of recreational greenspace. These three systems are illustrated in Figure 7 - Figure 9 below.

Figure 7: RMPV

Figure 8: GMPV

Figure 9: Solar canopies

Recently, PV has been acknowledged as the best value per kWp renewable generation to install. This is especially apparent at <1MW scale, which is most appropriate for the MFHCA project. As a proven technology, it is a reliable, low-risk and versatile option for renewable generation, thus it is the focus for this project.

What must be considered in solar installations is its seasonal and daily variation in output. Figure 10 below illustrates an average daily generation profile of a 1MW solar array in summer and in winter. This is complimentary to commercial consumers, as they are generally more active in daylight hours, but is often not ideal when paired with residential consumers. Furthermore, these variable profiles highlight the unlikeliness of 100% of a site's demand being met in real time with PV. This can be bettered with the installation of energy storage technologies, discussed subsequently.

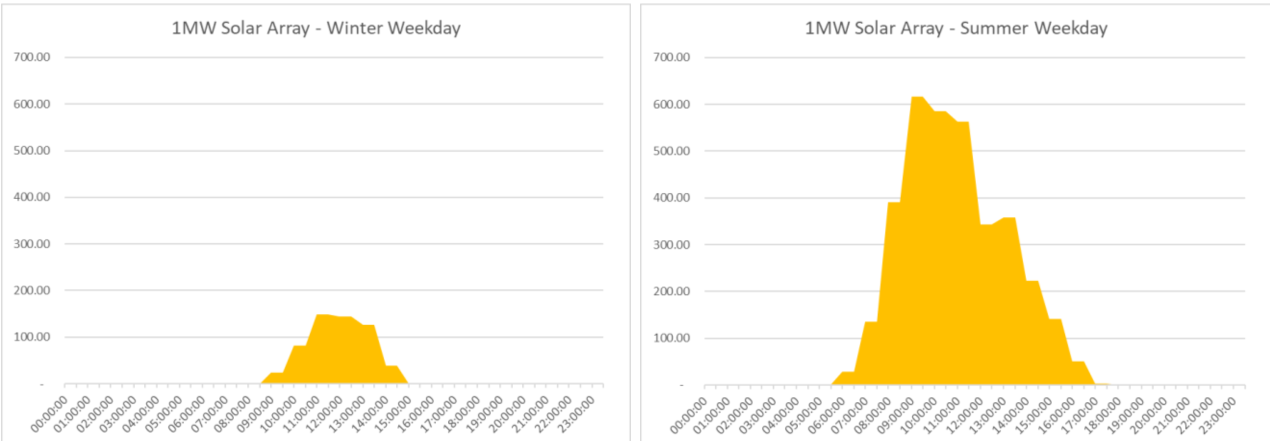

Figure 10: Summer vs Winter PV generation

Where roof-mounted Solar PV systems are being considered, a structural engineer will need to ensure that the roof can take the additional weight and loadings that would be imposed by its installation. Where ground mount systems are being considered the ground type/conditions and location of underground services need to be considered.

Any PV system will also require the installation of an inverter, or inverters, to convert the DC electricity generated by the panels into AC electricity which can be fed directly to a building, exported to the grid or used to charge battery or thermal storage, as appropriate. The lifetime of any PV installation is anticipated to be 25-30 years, with the inverter replaced c. year 10.

4.1.2. Wind

As outlined in the previous section, there are a number of spatial constraints which greatly limits opportunities for wind development within this area at the present time. Specifically, visual and noise impacts are key challenges for any scale of wind development, especially when sited <1km from conservation areas.

Small wind turbines, in the scale of 5-20kW were considered, although the economics of such turbines are generally very hard to balance, largely owing to high capital costs, lengthy planning approval periods and low generation outputs. Smaller turbines are most suitable for locations with an average annual wind speed of 8m/s, which are generally coastal or at higher elevations.

While a small 5kW wind turbine can cost in the region of £32,500 and is capable of generating up to 9,167kWh (at an annual average wind speed of 5m/s), a solar PV installation capable of generating a similar annual energy yield, would cost in the region of £10,000. Small turbines also generally have a very short warranty period and tend to operate with a low capacity factor (the average power generated, divided by the rated peak power of the turbine).

The Client highlighted there was a nearby wind turbine, and stated their interest in perhaps purchasing energy from this or another community-led turbine project. As it stands, the existing turbine is likely to already have purchase agreements in place, if it is not receiving financial incentives for its sale of energy to the grid. It is unlikely that even combining the demand from all buildings would merit a large >1MW scale turbine.

Locogen supports MFHCA's interest in developing, owning and operating their own turbine for community benefit. This route does not directly impact the electricity bills, but a community benefit fund fed by income from the turbine would have a positive financial impact, and the energy produced would offset the net carbon emissions of MFHCA sites. Locogen have worked on a number of community owned wind projects, all made possible through the FIT incentive. While this is not directly within the scope of this project, which aims to offset carbon emissions from the existing sites directly, Locogen are happy to investigate the viability of a community owned wind turbine on behalf of the Client. This could be as a separate project, or as an amendment to the Phase 2 scope.

Ultimately, the installation of a wind turbine(s) at MFHCA for the buildings considered has been deemed unfeasible owing to planning, financial and technical constraints and as such, it would not be recommended to pursue this option further.

4.1.3. Energy storage

Now that the government's Feed-in Tariff scheme, established to reward export of localised generation to the electricity grid, has ended, it is generally much more economical to utilise as much energy onsite as opposed to selling surplus electricity to the grid. Incorporating batteries can further reduce dependency on grid electricity imports and increase the operational savings of PV by an additional 10-20%, depending on the battery's storage capacity and onsite usage profile.

The capital costs of batteries are relatively high, starting at £2,000-£3,000 for domestic-scale systems, meaning that they do not always guarantee a return on investment over a reasonable period. Where battery storage is identified for further consideration throughout this report, a recommendation will be made for the optimum battery size using energy flow modelling as part of the Phase 2 works.

The implementation of energy storage technologies also opens up the possibility of accessing other benefits, such as flexible pricing arrangements and grid services. The opportunities for this are complicated to assess and are highly capacity and location specific. They are also subject to market opportunities bid on either week, day or hour ahead basis that are typically obtained by a 3rd party service provider. This makes it harder to provide a firm indication of the value of these installations, as the opportunities and benefits have varied (and are likely to continue to do so in the future). However, these can be a significant benefit to the system economics, as long as it is understood that the incomes and benefits are variable and not guaranteed. The Phase 2 analysis of the storage options will therefore provide a range of possible benefits from these systems to provide a clearer understanding of the opportunity and scale of potential variance, that can then be used to make a balanced appraisal of the projects willingness to engage with these technologies and systems as part of the development options.

4.2. Renewable heating systems

4.2.1. Overview

In addition to investigation renewable electricity generation options, there is a requirement to investigate means of decarbonising the heating systems at the MFHCA sites.

4.2.2. Heat Pumps

Heat pumps involve a heat exchanger unit, essentially amplifying the difference between the ambient source and the heat emitter temperature within the building, with electricity as the controllable energy input. Heat pumps can be air, ground or water sourced. The key consideration in heat pump technology is the heat pump's coefficient of performance (COP). The COP varies depending on the heat pump make and model; the outside temperature through the year, and the temperature required for the building's heating circuit. As an example, a COP of 3 would mean that for every 1kW of electricity input to a heat pump, there will be 3kW of heat output. Therefore, there are significant fuel savings compared with electric heating options. The carbon footprint of a heat pump is therefore proportionate to the carbon intensity of the electricity input. In theory, a wholly renewable system can therefore be accomplished by pairing a heat pump system with PV and a battery. Similarly, direct electric heating options, when combined with PV and potentially energy storage, are also considered means of decarbonise an existing heating system.

The type of heat pump is defined by where the ambient heat for the system is gathered. This can be from either the air, taken from the ground (through either a direct or indirect collector system) or from a water source (such as a river, lake or sea). From an practical perspective, various warranties are available depending on the brand of heat pump selected, some can be around 5-7 years, however Locogen expects that the realistic lifespan of a heat pump which is used as specified could be up to 20 years.

4.2.2.1. Air Source Heat Pumps (ASHP)

ASHPs provide a simple and relatively inexpensive renewable heating system. An ASHP essentially involves an exchanger unit, usually in a box outside the property, which will use electricity to heat up an internal wet heating system (radiators or underfloor heating) as well as for hot water. ASHPs are very common in Scandinavian countries and are becoming increasingly popular in the UK especially when gas is not available. For newbuilds in rural locations, ASHPs are usually the first choice for heat and hot water.

Where ASHPs are considered within villages, care will be needed in relation to the siting of the external ASHP unit(s), as units emit some noise when they are running (usually in the region of 40-60dB from 1m). Key considerations therefore should be given to the final position to ensure that the noise does not become a nuisance to anyone both internally and externally to the building. There is an MCS methodology for assessing noise impacts, and this will be used to choose location if ASHP is progressed to Phase 2. If no location can be within industry standard noise limits, it will no longer be considered an option.

A typical ASHP is likely to have an average COP of 3.5, as has been used in this study. This may be refined further in Phase 2.

4.2.3. Air-to-Air (A2A) Heat Pumps

A2A heat pumps are similar to traditional ASHPs in that they extract the heat from ambient air via an external unit and heat exchanger system. However, they differ in that the heat collected is not transferred to a wet heat distribution system, but directly to the air within a room - essentially resembling an air conditioner operating in reverse. Due to the lack of an intermediate step between the heat pump and the air to be heated, the efficiency of the units is higher. However, the A2A units are not able to provide hot water, so a further system is required to provide this. They can be cheaper and easier to install as there is no requirement to connect them to new or existing wet heating systems. They can also be utilised where there is an existing wet heating system, where additional space heating is required. This option will not have a requirement for new radiators, but either new pipework or ducting will need to be installed in the property between the outdoor unit and the indoor units.

4.2.3.1. Ground Source Heat Pumps (GSHP)

GSHP systems are generally more complicated and expensive to install than ASHP systems; however, the benefits of these systems are the consistent heat output they can produce due to the stable ground temperature that they are drawing heat from and that plant equipment can all be installed internally within a larger building, or adjacent to a building in a packaged plant room.

In order to draw heat from the ground, the heat pump utilises a ground collector loop with can be installed vertically (using boreholes) or horizontally (using loops of plastic pipe). In this situation it would be recommended to use boreholes as these require a significantly smaller ground area to be set aside for the installation and requires less civils works. In addition to these factors, boreholes tend to provide a more efficient collector system as they are extracting heat from a greater depth where the temperature is slightly higher and more stable. The installation of boreholes would require testing to be completed of the ground where the system was to be installed, in order to determine the thermal performance of the type of ground, which would then be used to produce a final design of a ground collector system.

Consideration should be given to available plant room space and the plant equipment required to form a GSHP system. An additional consideration would be in relation to the refrigerant gases used within the heat pump and that the planned plant room space has sufficient volume and ventilation for the gas used. A specialist heat pump installer can advise further on the specific installation requirements and on the most suitable heat pump model.

A typical GSHP is likely to have an average COP of 4, as has been used in this study. This may be refined further in Phase 2.

4.2.3.2. Shared Loop System

A shared loop GSHP system utilises a ground source collector system which is shared by heat pumps installed in multiple buildings within a close geographic location. Header pipes would run between the buildings delivering heat that has been captured via boreholes which will be connected to the header pipework. This method provides a cost saving on installing individual heat pump systems as construction costs are shared and therefore reduced.

4.2.4. Biomass

Biomass is also considered to be a carbon-neutral (or renewable) option for providing heat. This relied on the sustainable production and transport of wood fuel. Biomass boilers are widely installed as low-carbon heating system alternatives in large commercial applications, where there is a consistent high demand for heat

Generally, biomass heating systems utilise wood as a fuel. For automated systems, this is normally either wood pellets or wood chips, however in this study only pellet would be considered suitable as it is a much more consistent and higher density fuel than wood chip and therefore better suited to smaller scale installations. Biomass boiler systems are large pieces of machinery, requiring a fuel store and space for associated plant equipment. They also require regular fuel handling for refilling of the fuel store and regular maintenance. Therefore, they tend to be installed in a stand-alone boiler house with associated fuel store.

Biomass installations generally involve considerable additional expense and permitting requirements, and work most effectively where there is a consistent, high demand for heat, rather than variable heating profiles. Furthermore, biomass is not recommended in urban settings or settlements due to potential impact on air quality. For these reasons, biomass has not been considered suitable for any of the sites in this study.

4.2.5. Direct electric

Electric radiators are a simple option for both commercial and domestic use. The dimensions and volume of the property is the key determiner of the number and size of radiators needed to heat the space. Electric heaters are easily controlled individually and so the cost of heating is directly related to how often and for how long they are used. They are suited most to small buildings with inconsistent use. For buildings with consistent or large heat loads, electric heating would be the most expensive system to run. Costs are unlikely to be offset with PV due to contrasting demand and generation profiles, but this may be supplemented by electrical storage.

Using electric room heaters at any site will also mean that hot water demand will require further technology. This is traditionally an electric boiler or point-of-use electric water heating, but alternatives such as Sunamp and hot water dedicated heat pumps are considered more efficient.

4.2.6. Heat batteries

Heat batteries are a new technology which allow heat to be stored via a phase change material (a similar principal to which hand warmers work). The leading manufacturer and supplier of heat batteries in the UK is Sunamp. These can be 'charged' by a thermal source, such as a heat pump, or by electricity, to provide space heating and/or hot water. The batteries are compact, requiring zero maintenance over a 50-year lifetime (according to manufacturers of the technology) and can replace domestic hot water cylinders, with which they are cost comparable whilst being more energy efficient.

In the same way as an electricity battery, heat batteries can harness surplus electricity generated from PV to offset heat and/or hot water costs. Whether to choose a heat battery or electric battery would depend on the Client's needs, quantity of excess electricity, availability of capital funding, and the technologies in the existing heating system.

4.3. Note on the Renewable Heat Incentive (RHI)

Currently, the above technologies (excluding heat batteries) are eligible for payments under the Government's RHI scheme, provided they are installed and by Microgeneration Certification Scheme (MCS) accredited installer where rated <50kW, which is most domestic and small commercial applications. The scheme provides payments based on the amount renewable heat generated by the installation as measured via a heat meter.

For commercial properties, the scheme is due to end on 31st March 2021[1], and it is important to note that this date may be challenging for some buildings across the site to meet, particularly for ground source heat pumps. An extension to this scheme (as a result of delays caused by Covid-19) has been announced for schemes where a Tariff Guarantee is already in place. The Department for Business, Energy and Industrial Strategy (BEIS) are currently in consultation regarding an extension for schemes which are still at design stage and do not have a Tariff Guarantee in place (such as in the case of MFHCA), but that have made an investment in the design or installation of an RHI-eligible technology. We would therefore recommend that investment decisions are made exclusive of any potential RHI benefits.

[1] Although a 6 month extension has been announced for schemes that have already commenced and can demonstrate they are already progressing.

5. Site assessments

5.1. St Wilfrid’s Church and Church Hall

5.1.1. Overview

St Wilfrid’s Church and Church Hall is the northernmost building in the study. The Church’s history dates from c. 1070, with the last major known works in the 15th century. The Church was again restored in 1891, and the rood and stonework most recently repaired in 2013. The Church Hall addition was constructed in 1970 and extended in the late 1990s, with a children’s play area added in 2010. Figure 11 below shows an elevation of the property.

Figure 11: St Wilfrid's Church

The Client highlighted that renewable heat would be a priority option for the Church, given its high demand. In terms of renewable heat options, it is considered that either ASHP or GSHP systems are suitable for the building. Both of these systems are eligible for payments via the RHI scheme, if commissioned before the scheme closes. We would not recommend installing a biomass system due to the large associated capital cost and ongoing maintenance requirements, and there is no resource available nearby to utilise a water-source heat pump (WSHP) so this is not considered to be an option.

Figure 12 below outlines the assumed land ownership of the Church. The Church is seen in the centre of the site, with the Church Hall adjoined to the South. While there appears to be ample space for a ground installation, the listed status and the historical nature of the site means any development which includes ground excavation has a high risk of uncovering historical assets which may be a showstopper for the project. Furthermore, these historical designations mean that any alteration to the Church interior, or the exterior of any structure within its curtilage, is likely to face objection at planning stage due to the impact on the setting of the Church and surrounding historical conservation area. These constraints could also be a barrier to the installation of an ASHP as the heat pump unit would likely be positioned adjacent to the Church building, and planning permission for this could be very difficult to obtain.

Figure 12: St Wilfrid's Land Boundary

5.1.2. Energy demand

The Church and Church Hall share one electricity meter, and have their heating supplied by two separate gas boilers with radiators as the emitters. A previous energy audit highlighted that the combined electrical demand of the site is 4,336kWh. For the purposes of this study, it has been assumed that 75% of the site demand is between the hours of 8am and 7pm, seven days per week.

The energy audit provided annual consumption figures of 35,314kWh for the Church and 29,296kWh for the Church hall and as there was no consumption data available for comparison these were taken forwards. The annual carbon impacts were estimated at 6,503kg for the Church and 5,395kg for the Church hall. As there was not enough information available for the Church/Church Hall to comprehensively model the heat losses, Locogen utilised the annual consumption figures along with the client's indications of how frequently the buildings are used to estimate a peak heat demand. By dividing the annual consumption figures by the expected Full Load Equivalent hours (FLEQ) this gives an approximate peak heat demand. These are very high-level demand estimates which would require refining in the next stage of the project upon receipt of more detailed information on the buildings. The electricity and heat demands, and carbon footprint, are illustrated in Table 1 below.

		Church	Church hall
Elec.	Annual kWh demand	4,366	
Heat	Annual kWh demand	31,783	26,366
	Estimated Peak demand (kW)	51	22

Table 1: Demand analysis for the Church and Church hall

From experience with other buildings it is likely that the Church's actual peak demand could be higher than the high level estimation of 51kW as it is likely that the heating system currently in place does not heat the Church to the comfort levels desired as is common with many old heating systems in Churches. However, without building dimensions and building fabric details etc it is very difficult to model this accurately.

5.1.3. Energy opportunities

Solar PV generation

Given the historical nature of the site and the risks associated with groundworks, the only identified option for PV generation at the Church is on the Church Hall's South facing roof. This location is least likely to impact the Church aesthetic from key viewpoints and is also facing away from the conservation area.

Figure 13 below indicates the potential location of a PV installation on the Church Hall roof.

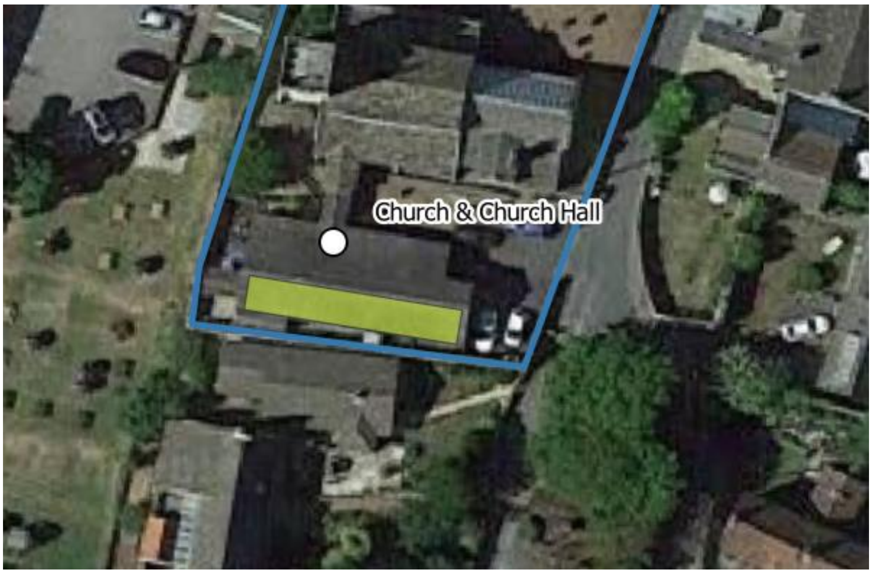

Figure 13: RMPV option (yellow) on Church Hall roof

This area is estimated to be c. 110m^2. Taking into account necessary setbacks from roof edges, this is sufficient for c. 44 panels, with a total peak generation capacity of 13.2kW (assuming 300W panels). Climate data indicates a specific yield for this array would be in the region of 968kWh/kWp, resulting in an annual generation of 12,784kWh.

The combined electrical demand of the site is 4,336kWh, c. 1/3 of what can be generated annually. Furthermore, this utilisation is not necessarily reflected in the daily solar generation profile (illustrated in Section 4.1.1). Therefore, even a smaller system is unlikely to have 100% of the solar energy consumed on site.

Table 2 below sets out several options for PV.

Location	RMPV1	RMPV2	RMPV3
Array size	13.2 kWp (Max)	3.9 kWp (G98)	2.1 kWp (optimum)
# panels	44	13	7
Orientation	5° from South		
Annual generation	12790 kWh	3770 kWh	2030 kWh
Capital cost	£11,220	£3,315	£1,785
% generation estimated to be used on site	19%	51%	75%
Annual savings from on-site consumption	£288	£231	£183
Simple payback without SEG	25+ years	14.4 years	9.8 years
% of generated electricity exported to grid	81%	49%	25%

Annual income from SEG	£520	£93	£25
Annual combined income/savings	£807	£324	£209
Simple payback incl. SEG	13.9 years	10.3 years	8.6 years
Y1 CO2 offset (kg)	2,921	861	464
Y20 CO2 offset (kg)	23,619	6,962	3,749

Table 2: Impact of RMPV generation at St Wilfrid's Church & Church Hall

In the case of the Church, the optimum scale of PV for maximising on-site use is less that the limits of the G98. This project would have a reasonable payback and may be a good low-capital option for increasing renewable generation for MFHCA. This however is entirely dependent on the likelihood of planning permission being granted. It would be recommended, before pursuing this project, to engage with Historic England and the Local Planning Authority to better understand the extent of the planning risk.

Installing the maximum amount of PV does not necessarily provide good returns. This is due to the low value of exported energy and is bettered significantly with the SEG. Given the 25-year lifetime of the PV installation, any savings/income after the payback period may be considered profit. Ideally, the excess generation could be shared with other community assets. However, there are several obstructions between the Church and the nearest asset (the community centre) such that this option is only feasible as a stand-alone system.

Given the Church's operating hours and relatively low electricity demand, energy storage is unlikely to be beneficial to this project from the perspective of maximising on-site consumption. Furthermore, utilising thermal storage to absorb excess electricity for use in heating/hot water systems is not cost competitive with gas, and is unlikely to benefit MFHCA at this time.

Renewable heat generation

Replacing the existing gas boilers is the clearest route to decarbonising the heating systems in the Church and Church hall. Unfortunately for biomass boilers the plant equipment would likely require an external plant room to be built along with a fuel storage facility on the exterior of the Church which is highly unlikely to be granted planning permission given the listed building status. Biomass has therefore not been taken further for this site. Although the Church Hall may not be subject to the same planning challenges, given the additional space requirement for fuel storage and the additional maintenance requirements in operating the pellet boiler, it is not regarded as a viable heating option for this project.

Direct electric radiators/boilers have also been ruled out as they are extremely expensive to run and the high annual heat demand figures of both the Church and the Church Hall would result in extremely large electricity bills. Even if these were to offset by PV generation and storage, this would require a PV system c. five times the maximum that can be installed.

ASHPs, A2A HPs and GSHPs could be installed at each building, however the heat demands of both buildings means that a large area of ground would be required for a GSHP surface collector system. The majority of the grounds host the Church cemetery, as well as being within historic designation curtilage, and so it is assumed that this would not be suitable for installing a surface collector system.

There is potential for drilling a borehole GSHP system on the ground immediately surrounding the Church, or the ground behind the Church, but still presents a high risk given the historic nature of the site. Details of the exact ground area required and consultation with Historic England would need to be investigated further during Phase 2 if the option is carried forwards.

Table 4 and Table 3 below indicate the approximate cost and carbon impacts of replacing the existing gas boilers with low carbon heating systems. The capex values given do not include for any changes to the existing wet heating systems, which may be required to accommodate heat pumps. This is likely to include larger radiators to maintain temperature set-points within the building space and upsized pipework. The A2A HP options would not require wet heating systems but instead a number of indoor units would need to be installed at height and connected to the outdoor unit. In the case of the Church, any of these options would again present a high risk to planning, as the internal aesthetic must also be conserved.

Factor	ASHP	A2A HP	GSHP
Capex	£38,250	£ 16,000	£89,250
Running costs	£1,734	£ 1,641	£1,518
Savings vs gas	-£210	-£117	£6
Simple payback	-	-	-
Y1 CO_2 offset (kg)	4,420	4,532	4,679
Y20 CO_2 offset (kg)	6,172	6,189	6,212

Table 3: Cost benefits of current Church heating options

Factor	ASHP	A2A HP	GSHP
Capex	£16,500	£ 8,000	£55,000
Running costs	£1,439	£ 1,361	£1,259
Savings vs gas	-£186	-£108	-£6
Simple payback	-	-	-
Y1 CO_2 offset (kg)	3,667	3,760	3,882
Y20 CO_2 offset (kg)	5,120	5,134	5,153

Table 4: Cost benefits of current Church hall heating options

In short, directly replacing the heating system with a renewable alternative source is not cost competitive with the existing gas system. Both ASHPs and A2A HPs do not offer any savings compared to gas. The low CAPEX costs of the A2A HPs means that it should be considered as an option, however the running costs need to be kept in mind and a more detailed investigation into whether this is feasible with the planning restrictions on the building would be required. The better performance of the GSHP systems means that the annual variation in fuel costs is minimal, but there is therefore no means of system payback. The only means of making this project viable would be to obtain grant funding for GSHP installation CAPEX. While this would provide no economic benefit to the community, carbon savings are apparent, and further benefit could be gained from installation of solar PV.

A further option is to add thermal battery storage into the system, reducing the need for the gas boiler, and warranting a larger PV installation. The thermal battery would effectively store the excess electricity from the solar panels, and convert this to heat energy to be used on-demand, offsetting the use of the gas boiler for heat and/or hot water thus offsetting the carbon footprint of the whole system. Locogen would recommend investigating this in Phase 2, with an aim to achieve 75% on-site usage while maximising the amount of PV which can be installed in line with the G98 (i.e. RMPV2).

The thermal battery could also be used alongside a heat pump system during peak heat demand if installed in the future. If both a heating system replacement and PV are considered for the Church and/or Church hall, detailed energy modelling will determine whether installing thermal storage would be beneficial to this particular project, and whether it is worthwhile increasing the PV array size beyond the G98.

5.1.4. Summary

If the local planning authority responds positively to the proposed PV on the Church Hall's south-facing roof, Locogen recommends pursuing this option with a view to offset the electricity and heat demand using thermal battery storage (without installation of a heat pump). The Client has highlighted that a structural survey of the Church Hall roof would be a priority if progressing this option to Phase 2.

While there was no economic benefit to installing a heat pump system, there are carbon benefits. If there is an opportunity to get the CAPEX of a heat pump installation grant funded, these options would be worth pursuing further in Phase 2. One key consideration is that the A2A option does not require removal of the gas system, but that the gas system can remain in place to act as a back-up heating system in the unlikely event of heat pump failure or increased heating demand. As such, the gas consumption may be considerably reduced.

Table 5 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	Payback years	Annual savings/income	£/Tonne Carbon offset	Planning risk
RMPV1	13.9	+£807	£476	Medium
RMPV2	10.3	+£324	£476	Medium
RMPV3	8.6	+£209	£476	Medium
Church ASHP	25+	-£210	£1,021	High
Church A2A HP	25+	-£117	£2,585	High
Church GSHP	25+	+£6	£3,622	High
Church Hall ASHP	25+	-£186	£957	Medium
Church Hall A2A HP	25+	-£108	£1,558	Medium
Church Hall GSHP	25+	-£6	£3,396	High

Table 5: Economic and planning risk of options

5.2. MFHCA Community Association (Community Centre)

5.2.1. Overview

The MFHCA Community Centre is also located in Monk Fryston, adjacent to the Primary School. The site contains the Community Centre Hall, playground, recreation area and car-park with recycling facility. The centre is generally occupied 7 days a week, with key operating hours between 7:30am and 10:30pm on weekdays, and 9am-5pm on weekends. They host a range of community activities including before- and after-school clubs, group fitness classes, cubs, scouts and community meetings. The Client has noted a specific interest in getting uniformed groups (such as scouts, cubs, guides etc) involved in the project to further involve the community, which may be reason to prioritise development at the Community Centre. Figure 14 below shows an elevation of the property.

Figure 14: MFHCA Community Centre

Figure 15 below outlines the assumed land ownership of the Community Centre. There is limited space for Solar PV, and the areas available are subject to significant shading. As previously noted, the area available to the south is earmarked for recreational use. Nevertheless, Locogen have included anticipated impact and cost of GMPV and GSHP systems here. There is also the option to install carports over the existing carpark, which (while more expensive) will be less subject to shading losses and maximise space available for recreational activities. Furthermore, solar carports could link well with future installation of EVCPs, which may in turn lead to an opportunity for an electric community car club – another interest identified by the client.

Figure 15: MFHCA Community Centre land boundary

5.2.2. Energy demand

The client provided monthly electricity meter readings from January 2018 – December 2019. Where there was missing data in this period, estimations of monthly usage were made from meter readings for proceeding/preceding months. Averaging across both years, annual electricity consumptions was calculated to be 5,321kWh. Generally, both datasets were within 20% of the average, with the exception of December which varied considerably between years. This is likely due to the timing of meter readings across the Christmas period.

This estimated demand is within 1% of the demand figure of 5,358kWh given in the energy audit. It was therefore decided that it would be appropriate to use the energy benchmarking figure going forwards. A demand profile was developed which reflected the operating hours provided by the client, namely from 7:30am-10:30 pm on weekdays, and 9am-5pm on weekends. It is assumed that during these operating periods, three times as much energy is used per hour than when the centre is closed. Furthermore, the demand profile was manipulated to demonstrate three seasonal tiers, with higher demands in November and December, and lower demands in April-July. The profile was then scaled to match the benchmark figure of 5,358kWh/year,

The Client also provided a cost of 15.48p/kWh for electricity from their previous electricity contract that expired in 2019. The energy benchmarking summary gave a figure of 14.74p/kWh for the electricity. As it is unclear where this price has come from, Locogen have used 15.48p/kWh to be conservative. This corresponds roughly to an annual cost of £895 when the standing daily charge of 18p is included.

Heat provision is currently via underfloor heating and a gas boiler. The Client provided monthly gas consumption data from meter readings from February 2018 – December 2019. For analysis purposes, Locogen extrapolated this data to represent two, full*, business as usual* years, from January – December 2018 and 2019. This indicated a yearly gas consumption of 26,257kWh and 27,626kWh respectively. Averaging this provides an estimated usage of 26,942kWh per year. The Client advised the cost of gas is 5.483p/kWh and although the standing charge has not been provided this has been estimated at 26.08p/day based on EDFs figures for the area online. Therefore, the heat and hot water gas consumption costs in the region of £1,572 per year which is slightly less than the cost provided in the energy benchmarking summary which was £1,623. Assuming a gas boiler efficiency of 90%, this gas consumption provides a high-level estimated heat and hot water demand of c. 24,248kWh/year.

To accurately estimate the peak heat demand of the community centre, Locogen utilised the industry standard MCS room-by-room heat load calculator. The degree days for the site were assumed to be 2307. Heating degree days are a measure of how much (in degrees), and for how long (in days), the outside air temperature is expected to be below a certain level. They are industry standard values, used in calculations relating to the energy consumption required to heat buildings. The model utilised floorplans provided by the Client and u-values based on the floor insulation details that were also provided, however Locogen used standard building U-values for the rest of the building which information was not available for. The annual demand for heat and hot water was calculated 27,601 kWh/year which is within 15% of the consumption figures provided by the client. It is likely that the discrepancy is due to the limited information available on building fabrics and hot water usage.

The conclusions from the demand analysis are outlined in Table 6 below and form the basis of the energy flow modelling.

		Community association
Elec.	Annual kWh demand	5,358
Heat	Annual kWh demand	24,248
	Peak demand (kW)	13

Table 6: Demand analysis results for the community centre

5.2.3. Energy opportunities

Solar PV generation

There is very limited space on the south-facing rooftop at the community centre, estimated as capable of hosting only 4 panels. Figure 16 below indicates two potential alternative PV array locations: Ground-mounted PV (GMPV) and Solar carport canopies. The latter is considerably more expensive but have become popular when installed alongside Electric Vehicle Charge Points (EVCPs) and in instances where there are no alternative options.

Figure 16: Solar opportunities at MFHCA Community Centre (GMPV: pink; Solar canopies: green)

Table 7 and Table 8 below illustrate the impact of various PV installations on the demand profile of the community centre.

Location	GMPV1	Solar Canopies
Array size	30 kW (max)	10 kW (max)
# panels/canopies	100	2 x 5 ports
Orientation	14° from South	
Annual generation	28800 kWh	9600 kWh
Capital cost	£30,000	£18,000
% generation estimated to be used on site	9%	24%
Savings from on-site consumption	£318	£281
Simple payback without SEG	-	-
% of generated electricity exported to grid	91%	76%
Annual income from SEG	£1,307	£363
Combined savings	£1,626	£644

Simple payback incl. SEG	18.5 years	28 years
Y1 CO_2 offset (kg)	6,576	2,192
Y20 CO_2 offset (kg)	53,185	17,728

Table 7: Impact of installing maximum scales of PV generation at Community Centre

Location	**GMPV2**	**GMPV3**
Array size	3.9 kW (G98)	1.8 kW (optimum)
# panels/canopies	13	6
Orientation	14° from South	
Annual generation	3740 kWh	1760 kWh
Capital cost	£3,900	£1,834
% generation estimated to be used on site	49%	75%
Savings from on-site consumption	£219	£158
Simple payback without SEG	17.9 years	11.6 years
% of generated electricity exported to grid	51%	25%
Annual income from SEG	£96	£22
Combined savings	£315	£180
Simple payback incl. SEG	12.4 years	10.2 years
Y1 CO2 offset (kg)	854	402
Y20 CO2 offset (kg)	6,907	3,250

Table 8: Impact of installing reduced scales of GMPV at Community Centre

The GMPV option in Table 7 represents the maximum system size at the community centre, 30kW. This is excessive for the site, but highlights an opportunity to provide excess energy to other community assets, such as the Primary School (which has limited space for its own array). The high capital costs of solar carports, paired with the low demand of the community centre, results in a payback greater than the anticipated lifetime of the system, making this an unviable option at this site.

Table 8 highlights that the optimum scale of PV to achieve 75% generation on site is only 2.1kW (7 panels). This presents a low cost, small scale project which is financially viable for MFHCA, but has a small impact. Unlike the Church, this project is comparatively low-risk given the removal of designations at the site.

Discussion with the Client highlighted that the location of the GMPV options would not be considered suitable to take forward due to the requirement of green recreational space. Given the proportional cost of solar canopies, and the relatively low demand, it is unlikely PV will be considered further at this site.

Renewable heat generation

Replacing the existing gas boilers is the clearest route to decarbonising the heating system in the community centre. Although the community centre has the space available for the fuel storage facilities and plant room that would be required for a biomass boiler, the additional maintenance requirements in operating the pellet boiler means it is not regarded as a favourable heating option for this project.

Direct electric radiators/boilers have also been ruled out as they are extremely expensive to run and would result in very large electricity bills in comparison to other solutions. It also fails to make use of the existing wet heating system.

Both ASHPs and GSHPs could be installed in the building grounds, however the heat demand means that a large area of ground would be required for a GSHP surface collector system and the suitable grounds within the land boundary are limited in size due to the car park and the playground so it is likely that this would not be substantial enough for installing a surface collector system. This would need to be clarified after more detailed modelling in phase 2 but from a high level estimate the surface collector would not fit in the space available.

There is potential for drilling a borehole GSHP system on the grassy ground in front of the community centre, or even on the car park/playground if required. Details of the exact ground area required would need to be investigated further during Phase 2 if the site is carried forwards.

Table 9 below indicates the approximate cost and carbon impacts of replacing the existing gas boiler with low carbon heating systems. The capex values given do not include for any changes to the existing wet heating systems, which may be required to accommodate heat pumps. This is likely to include larger radiators to maintain temperature set-points within the building space and upsized pipework.

Factor	ASHP	GSHP
Capex	£12,000	£32,500
Running costs	£1,021	£894
Savings vs gas	£551	£678
Simple payback	22	48
Y1 CO_2 offset (kg)	3,372	3,570
Y20 CO_2 offset (kg)	4,709	4,739

Table 9: Cost benefits of heat options for community centre

5.2.4. Summary

Ultimately, the electrical demand of the community centre does not warrant a large-scale PV development, with the optimum scale being only 6 panels. However, provided there is the option of using the identified ground-mount area, there is a key opportunity here to generate electricity for the Primary School. This has been further investigated in Section 6.1. This option, however, was (understandably) identified by the Client to be unsuitable due to the requirement for green recreational space, and is not to be taken forward to Phase 2.

The demand of the community centre is sufficiently low that a single ASHP unit could provide heat for the building as a standalone install. While there is opportunity for a GSHP installation, the associated paybacks are not financially attractive. Addition of either will impact the electrical demand of the building, and my improve the case for small-scale PV generation.

Table 10 below summarises 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
GMPV1	18.5	+£1,626	£564	Medium
GMPV2	12.4	+£315	£565	Medium

GMPV3	10.2	+£180	£564	Medium
Solar Canopies	25+	+£644	£1,015	Low
ASHP	22	+£551	£2,548	Low
GSHP	25+	+£678	£6,858	Medium

Table 10: Economic and planning risk of options

5.3. Primary School

5.3.1. Overview

Monk Fryston Church of England Primary School hosts c. 200 pupils across 6 years. The School was constructed in 1999 in an C-shaped layout, with a playground to the north and car parking area to the east. Figure 17 below shows an elevation of the property. The Client also states that they receive the feed-in tariff at a rate of 0.642p/kWh, although it is unclear from provided data what this applies to.

Figure 17: Monk Fryston CofE Primary School

The school is occupied from 0730-1800 Monday-Friday, with extracurricular activities taking place Monday & Thursday from 1900-2100. There is minimal energy use during school holidays, which include 2 weeks at Christmas, 2 weeks at Easter, and 6 weeks in summer. This has been reflected in the electricity profile used for the energy modelling. Gas is used primarily for the UFH between 0600-1400 from Monday to Friday, and also for cooking from 1000-1200.

As a CofE School, the Ownership is that of the Diocese, with a lease to the Sherburn, Tadcaster and Rural Multi-Academy Trust (STAR MAT). The STAR MAT also own the playing fields (playground to north). This ownership is illustrated in Figure 18: Primary School land ownership below. Provided the MAT are open to hosting any renewable energy measures, there is sufficient space for ground-based systems.

Figure 18: Primary School land ownership

5.3.2. 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.

Heat provision is currently via a combination of underfloor heating (classrooms), radiators (admin and shared areas), and circulating air in the kitchens. Daily gas meter readings taken from 10 September to 24 September suggest a weekend daily demand of 10 gas units, increasing to 15-30 units/day during the week. This is representative only of a single week in Autumn and cannot be utilised to represent summer or winter gas usage.

The Client also provided a detailed price comparison and review of impact of COVID-19 on gas consumption. This included details of kWh consumed from December 2017 – November 2019. For analysis purposes, Locogen extrapolated this data to represent two, full, *business as usual* years, from January – December 2018 and 2019. This indicated a yearly gas consumption of 149,098kWh and 153,178kWh respectively. Averaging this provides an estimated usage of 151,130kWh per year. Assuming 10% of this is used for cooking, Locogen would expect a heat and hot water consumption of c. 136,017kWh per year. The Client advised the cost of gas to the school is 2.3157p/kWh with a standing day rate of £4.55 per day. Therefore, the heat and hot water gas consumption is calculated to cost in the region of £4,800 per year. Assuming a gas boiler efficiency of 90%, this gas consumption provides a high-level estimated heat and hot water demand of c. 122,500kWh/year.

To accurately estimate the peak heat demand of the Primary School, Locogen utilised the industry standard MCS *room-by-room* heat load calculator. The degree days for the site were assumed to be 2310, and average of 2019 and 2018 degree days, as stated in the Client's provided *COVID gas price comparison* spreadsheet. The model utilised building fabric details and floorplans provided by the Client and calculated an annual demand for heat and hot water of 127,290 kWh/year. This is within 5% of the high-level estimation of 122,500kWh/year, validating assumptions.

The conclusions from the demand analysis are outlined in Table 11 below and form the basis of the energy flow modelling.

		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

5.3.3. Energy opportunities

Solar PV generation

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.

Factor	RMPV2
Array size	3.9 kWp (G98)
# panels/canopies	13
Orientation	South 0º
Annual generation	3780 kWh
Capital cost	£3,315
% generation estimated to be used on site	100%
Annual savings from on-site consumption	£454
Simple payback without SEG	7.3 years
% of generated electricity exported to grid	0%
Annual income from SEG	£0
Annual combined income/savings	£454
Simple payback incl. SEG	7.3 years
Y1 CO2 offset (kg)	863
Y20 CO2 offset (kg)	6,981

Table 13: Impact of installing reduced scales of GMPV at Primary School

Renewable heat generation

Replacing the existing gas boilers is the clearest route to decarbonising the heating system in the Primary School. Although the school has the space available for the fuel storage facilities and plant room that would be required for a biomass boiler, as stated for other sites - the additional maintenance requirements in operating the pellet or woodchip boiler means it is not regarded as a favourable heating option for this project.

Direct electric radiators/boilers have also been ruled out as they are extremely expensive to run and would result in very large electricity bills in comparison to other solutions. They also fail to make use of the existing wet heating system.

Heat batteries have not been considered as appropriate technology for the site as the heat demand is so much larger than the capacity of solar PV that could be installed so the savings that could be made by combining the two would likely not be worth the capital investment.

Both ASHPs and GSHPs could be installed in the building grounds, however the heat demand means that very large area of ground would be required for a GSHP surface collector system and the only place that may be large enough to house the array would be the playing fields. The exact area required would need to be established after more detailed modelling during phase 2.

There is potential for drilling a borehole GSHP system on the playing fields as well or the grassy areas directly north of the school building. This would be much less intrusive than a surface array but would be much more expensive. Details of the exact ground area required would need to be investigated further during Phase 2 if the site is carried forwards.

Table 14 below indicates the approximate cost and carbon impacts of replacing the existing gas boiler with low carbon heating systems. The capex values given do not include for any changes to the existing wet heating systems, which may be required to accommodate heat pumps. This is likely to include larger radiators to maintain temperature set-points within the building space and upsized pipework. The GSHP option has been costed based on the installation of boreholes rather than a surface collector. Although the surface collector is likely to be cheaper, the costs associated this are very variable depending on how much of the groundworks can be taken on by local contractors and several other factors including ground conductivity etc which must be looked at in more detail in phase 2 to establish an approximate price.

Factor	ASHP	GSHP
Capex	£41,250	£96,250
Running costs	£5,543	£4,850
Savings vs gas	-£546	£147
Simple payback	-	-
Y1 CO_2 offset (kg)	18,303	19,376
Y20 CO_2 offset (kg)	25,557	25,723

Table 14: Cost benefits of the heat options for the Primary School

5.3.4. 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. Locogen would recommend further investigating the option to import electricity from a potential PV installation at the Community Centre, as discussed in Section 6.1.

Following the cost benefit analysis above, the heating system selection for the site will come down to what the client wishes to prioritise – running costs or capital costs. The ASHP installation will be much cheaper than a GSHP but will not be competitive against the price of gas, whereas the GSHP will be much more expensive (with the potential of a slightly less expensive surface collector option) but could offer a competitive running cost. The GSHP option offers slightly higher carbon savings, but over 20 years the margin is relatively small so this is not the most important factor to consider. If the client is unsure then both could be investigated in more detail during phase 2.

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

5.4. Cricket Club

5.4.1. Overview

The MFHCA Cricket Club (HMFCC) is located to the south of Hillam, adjacent to the Football pitches. The site hosts a cricket ground with a car park and new pavilion containing bathrooms, kitchen, changing facilities and a social room. Figure 20 below shows an elevation of the property.

Figure 20: MFHCA Cricket Club

The Client advises that the building is used as a nursery during the winter, which results in higher heat and electricity loads in these months.

Figure 21 below outlines the assumed land ownership of the Cricket Club with the football field to the South. The pavilion has a small, south-facing roof, and there is also an area of open ground to the immediate south which may be suitable for a PV installation, in addition to the carpark. Both the ground space and the carpark space are likely to be suitable for GSHP installation. Furthermore, the situation of the pavilion away from residential makes a case for ASHP. The pavilion and the ground area to the south are relatively over-shaded, thus alternative ground for solar may be a better alternative.

Figure 21: Cricket Club land boundary

As in the case of the Community Centre, there is also the option to install carports over the existing carpark, which (while more expensive) will be less subject to shading losses and maximise space available for recreational activities. Again, this may link well in the future with EVCP installation.

5.4.2. Energy demand

The energy audit provided and annual electricity consumption figure of 4,500kWh. This is mirrored in the monthly annual utilities usage data supplied by the Client. The monthly data does not show and significant seasonal trends in electricity usage. And is reflective of full nursery operation. The demand profile for this site has assumed 75% of daily electricity usage is between 7am and 7pm.

The heating system currently consists of a combi boiler fuelled by LPG with the heat being distributed mainly by radiators and some hot water fan radiators in the changing rooms and social room.

The Client provided monthly LPG consumption data from October 2019 – September 2020. By assuming a conversion rate of 7.1kWh/L of LPG Locogen estimated the annual LPG consumption at 19,447kWh per year. The Client advised the cost of LPG to the club is 36.65p/Litre and the maintenance charge is £18/quarter which puts the heat and hot water gas consumption costs in the region of £1,076 per year which matches the value provided in the energy benchmarking summary. Assuming a boiler efficiency of 90%, this LPG consumption provides a high-level estimated heat and hot water demand of c. 17,502kWh/year.

To accurately estimate the peak heat demand of the community centre, Locogen utilised the industry standard MCS room-by-room heat load calculator. The degree days for the site were assumed to be 2307. The model utilised floorplans provided by the Client and Locogen used standard U-values for the building fabrics which information was not available for. The annual demand for heat and hot water was calculated 15,999 kWh/year which is within 10% of the consumption figures provided by the client. It is likely that the discrepancy is due to the limited information available on building fabrics and hot water usage.

The conclusions from the demand analysis are outlined in Table 16 below, and form the basis of the energy flow modelling.

		Cricket Club
Elec.	Annual kWh demand	4,500
Heat	Annual kWh demand	17,502
	Peak demand (kW)	7

Table 16: Demand analysis for the cricket club pavilion

5.4.3. Energy opportunities

Solar PV generation

There are three potential PV locations at the Cricket club, outlined in Figure 22 below.

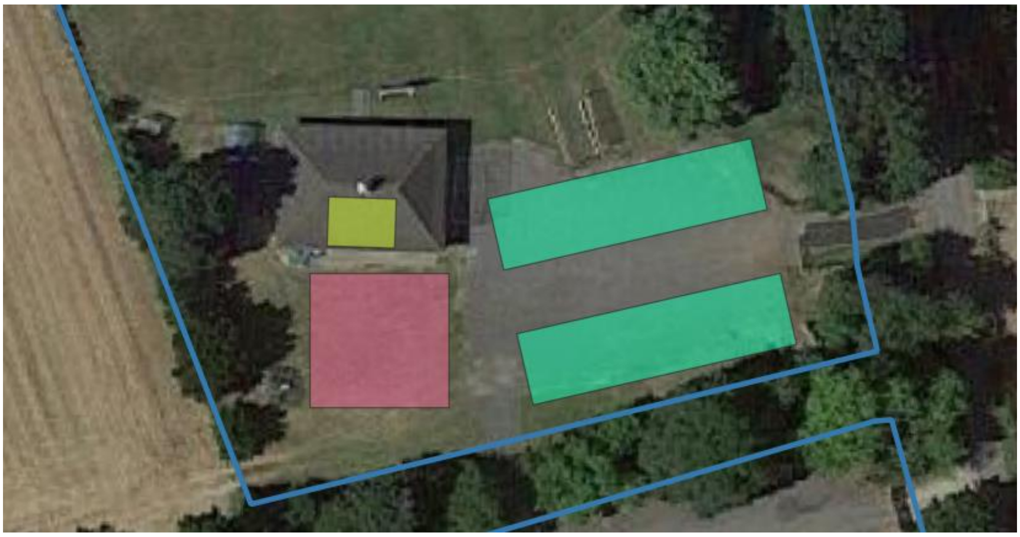

Figure 22: HMFCC PV options (RMPV: yellow; GMPB: pink; Solar canopies: green)

Factor	RMPV1	GMPV	Solar canopies
Array size	5 kW (max)	18 kW (max)	40 kW (max)
# panels/canopies	18 panels	60 panels	40 ports
Orientation	0° South		-12° from S
Annual generation	4850 kWh	17460 kWh	38720 kWh
Capital cost	£4,250	£18,000	£72,000
% generation estimated to be used on site	44%	15%	7%
Annual savings from on-site consumption	£254	£305	£319
Simple payback without SEG	16.8 years	59 years	225.6 years
% of generated electricity exported to grid	56%	85%	93%
Annual income from SEG	£137	£746	£1,803
Annual combined income/savings	£390	£1,051	£2,122
Simple payback incl. SEG	10.9 years	17.2 years	34 years
Y1 CO2 offset (kg)	1,107	3,987	8,842
Y20 CO2 offset (kg)	8,956	32,243	71,504

Table 17: Impact of maximum PV generation on Cricket Club

Table 18 below highlights the size of project required to achieve 75% of on-site consumption. A roof-mounted option has been selected, as the scale achievable is smaller than the roof space available, and has the lowest cost per kWp installed.

Factor	RMPV2	RMPV3
Array size	3.9 kW (G98)	2.1 kW (optimum)
# panels/canopies	13 panels	7 panels
Orientation	0° South	
Annual generation	3780 kWh	2030 kWh
Capital cost	£3,315	£1,785
% generation estimated to be used on site	52%	77%
Annual savings from on-site consumption	£237	£187
Simple payback without SEG	14 years	9.6 years
% of generated electricity exported to grid	48%	23%
Annual income from SEG	£90	£24
Annual combined income/savings	£327	£211
Simple payback incl. SEG	10.2 years	8.5 years
Y1 CO2 offset (kg)	863	464
Y20 CO2 offset (kg)	6,981	3,749

Table 18: Impact of installing reduced scales of GMPV at Cricket Club

Renewable heat generation

Replacing the existing gas boilers is the clearest route to decarbonising the heating system in the cricket club pavilion. Although the pavilion has the space available for the fuel storage facilities and plant room that would be required for a biomass boiler, the additional maintenance requirements in operating the pellet boiler means it is not regarded as a favourable heating option for this project.

Direct electric radiators/boilers have also been ruled out as they are extremely expensive to run and would result in very large electricity bills in comparison to other solutions. They also fails to make use of the existing wet heating system.

Both ASHPs and GSHPs could be installed in the building grounds, however the heat demand means that a reasonable area of ground would be required for a GSHP surface collector system and the most logical place to locate the array would be either on the cricket pitch or the football pitches so this option is dependent on the clubs willingness to close the area selected to players during construction. The exact area required would need to be established after more detailed modelling during phase 2.

There is potential for drilling a borehole GSHP system on the grassy ground behind the pavilion which would be the least disruptive location, or the cricket pitch could be used if required. This would be much less intrusive than a surface array but would be much more expensive. Details of the exact ground area required would need to be investigated further during Phase 2 if the site is carried forwards.

Table 19 below indicates the approximate cost and carbon impacts of replacing the existing gas boiler with low carbon heating systems. The capex values given do not include for any changes to the existing wet heating systems, which may be required to accommodate heat pumps. This is likely to include larger radiators to maintain temperature set-points within the building space and upsized pipework.

Factor	ASHP	GSHP
Capex	£9,500	£17,500
Running costs	£691	£605
Savings vs LPG	£385	£471
Simple payback	25	37
Y1 CO_2 offset (kg)	2,434	2,577
Y20 CO_2 offset (kg)	3,399	3,421

Table 19: Cost benefits of heat options for the pavilion

5.4.4. Summary

The Cricket Club has a relatively low electricity demand, with the optimum install being only 7 panels (2.1kW). While this presents the best payback options, installing larger arrays is still seen to be viable and will have more significant carbon impacts.

The ASHP and GSHP both offer running cost savings compared to the LPG currently used, however the ASHP option is much cheaper than the alternative. It offers the best value for money in terms of running costs and carbon savings and will be the easiest technology to install as well. If the client has a particular desire to pursue a GSHP for slightly lower running costs then this could be looked at in more detail, however it is recommended that an ASHP is considered as the most appropriate for this site.

Table 20 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	10.9	£390	£475	Low
GMPV	17.2	£1,051	£558	Low
Solar Canopies	25+	£2,122	£1,007	Low
RMPV2	10.2	£327	£475	Low
RMPV3	8.5	£211	£476	Low
ASHP	13	£385	£2,795	Low
GSHP	25+	£471	£5,115	Medium

Table 20: Economic and planning risk of options

5.5. Football Pitches

5.5.1. Overview

The Football Pitches lie immediately south of the Cricket Club. Figure 23 below indicates the land ownership of the Football Pitches.

Figure 23: Football pitches land boundary

There are no buildings associated with the Football Pitches, and therefore no requirement for renewable heat. There is near negligible demand for electricity (533kWh/year from Energy Audit). While the site itself has very little requirement for energy, it has excellent resource potential that could service other buildings in the MFHCA area.

The Client did raise the intention to install floodlighting to the football pitch. From discussions, it appeared that there were already proposals in place for a floodlighting system with integrated renewable generation. If this plan is not taken forward, or the proposals reflect differently, Locogen are happy to advise on means of installing renewable generation to service the floodlights.

5.5.2. Energy demand

The demand for the football pitches is outlined in Table 1 below. Provided monthly demand data highlighted that the electricity supply is used minimally in October-December, with highest usage in the summer months.

		Football Pitches
Elec.	Annual kWh	533
Heat	Annual kWh	n/a
	Peak demand (kW)	n/a

Table 21: Summary of football pitches' demand

The Client has indicated there is an intention to install floodlights, and possibly a Sports Barn, at the football fields. This additional demand will be further assessed in Phase 2 works as the respective designs are developed.

5.5.3. Energy opportunities

Solar PV generation

While there is no significant demand at the pitches, the site provides an excellent opportunity for a GMPV installation. Figure 24 below highlights what may be considered a suitable area for ground-mounted PV, with sufficient space for up to a 94.5kW installation. While it is generally not worthwhile installing solely to offset the football pitches electricity demand (costing MFHCA c. £85 per year), the options presented in Table 22 highlights the potential impact of installing an export-only scenario with varying SEG rates.

Figure 24: GMPV option at football pitches

Factor	SEG at 5p/kWh	SEG at 8p/kWh	SEG at 10p/kWh
Array size	94.5 kWp		
# panels	315		
Orientation	-15° (SSE)		
Annual generation	91,280 kWh		
Capital cost	£94,500		
% of generated electricity exported	100%		
Annual income from SEG	£4,564	£7,303	£9,129
Annual combined income/savings	£4,564	£7,303	£9,129
Simple payback incl. SEG	20.8 years	13 years	10.4 years
Y1 CO2 offset (kg)	20,844		
Y20 CO2 offset (kg)	168,567		

Table 22: Value of exporting GMPV at variable SEG rates

While there is no means of directly offsetting building energy use, the revenue for this project could be fed into a Community Benefit Scheme, financially benefitting MFHCA.

Renewable heat generation

Similarly, the site provides an opportunity to install a large, ground array for renewable heat via GSHP. This could service the adjacent Cricket club, or a larger system may be sufficient for a shared-loop heating scheme. These options are discussed in the proceeding section.

5.5.4. Summary

The football fields present a suitable location for standalone solar PV, which can be exported to the grid, providing revenue to MFHCA. While this does not directly impact the energy use at any community building, the net carbon impact of MFHCA would be offset. Provided this opportunity is in line with community objectives, Locogen would recommend further investigating this option in Phase 2, possibly with the addition of Electricity Storage technologies.

The Client also detailed previous discussions with regard to building a 'sports barn' or sheltered sports area. A further possibility would be to install PV to the roof of this structure. This has not been explored in great detail in Phase 1, as there is no firm development plan for the barn, but it is expected that returns would be similar from the PV aspect as roof-mounting is comparatively cheaper. The generation capacity would be dependent on the scale of the structure to be built. The energy demand of the Sports Barn and/or Floodlights with be included in sensitivity analyses in Phase 2.

There is no requirement for renewable heat generation at the Football pitches, nor are there any significant nearby heat loads that would benefit from renewable heat source at the pitches.

6. Other opportunities

The Client suggested investigating collaborative schemes across multiple MFHCA sites. Options identified across multiple buildings are described in this section. Due to the complexity of these options, additional energy modelling would form part of Phase 2 works, with flexibility in technologies used.

6.1. Solar PV at Community Centre to supply Primary School

Given the high electricity demand at the Primary School, combined with few options for renewable installations, the option to import energy from the proposed GMPV at the community centre has also been investigated. The results of the simulation are presented in Table 23 below.

Factor	Import from Community Centre
Array size	30 kW
# panels/canopies	100
Orientation	14o from South
Annual generation	28800 kWh
Capital cost	£30,000
% generation estimated to be used on site	65%
Annual savings from on-site consumption	£2,255
Simple payback without SEG	13.4 years
% of generated electricity exported to grid	35%
Annual income from SEG	£501
Annual combined income/savings	£2,755
Simple payback incl. SEG	10.9 years
Y1 CO_2 offset (kg)	6,576
Y20 CO_2 offset (kg)	53,185

Table 23: Community Centre to Primary School export opportunity

More renewable electricity can be generated here, and therefore there is a larger carbon offset by the project. If this option is considered for Phase 2, it would be worthwhile modelling the combined demand of the Community Centre and the Primary School to assess the viability of installing a PV array to service both, perhaps with integrated storage to maximise utilisation.

6.2. Shared-loop heat network

Given the distribution of the buildings across Monk Fryston and Hillam, it is unlikely that all sites may be connected in a shared-loop heat network. This is essentially due to the number and density of residential properties between sites, and the distance from the three sites in Monk Fryston to the Cricket Club Pavilion and Football Pitches in Hillam.

The only realistic opportunity for a shared heat network would be to connect the Primary School and the Community Centre. As a GSHP system is underground, one option may be to place boreholes in the Primary School playground to supply both buildings from a single array. Furthermore, adding to this PV generation at the Community Centre and perhaps energy storage may provide significant carbon reduction.

On top of the risks usually associated with installing a GSHP, a key metric that indicates the suitability of a potential shared loop heating system is the distribution loss relative to the known heat demand – the pipe between the two sites will be subject to losses which will have to be paid for in capital, through oversized plant, and through electricity costs. Additionally, the centralisation of plant means that a fault could affect both sites simultaneously. Therefore, it would be advisable to have a backup heating strategy for each building, which would add further costs and complexity.

Given the relatively small heat demand at the community centre it is extremely unlikely that the additional costs required to install pipework across a public road would warrant the two buildings being connected.

6.3. Energy efficiency measures

Within any new buildings, a 'fabric first' approach is always recommended as the first step in carbon and energy reductions. Fabric first typically involves creating a very efficient building envelope with appropriately sized and oriented windows, suitable levels of insulation and passive building systems (such as openable windows where appropriate, rather than mechanical ventilation). It is an approach to building design that looks at maximising the energy performance of the structure itself before renewable mechanical and electrical solutions are considered.

Where buildings are already constructed and operational, consideration should still be given to the benefits of additional insulation (particularly in roof spaces) and double glazing and the positive impacts that these changes could have on space heating demands.

In addition to this consideration can be given to lighting design (including day lighting), in order to minimise lighting requirements and to reduce ongoing running costs via the selection of energy efficient lighting equipment and controls. In existing buildings, the replacement of traditional halogen bulbs (where still operational) with LED bulbs can also save money and reduce electricity demand. The energy audit highlighted that all MFHCA buildings use low-energy lighting.

A-rated energy efficient fixed and moveable equipment should be considered across the sites, but it is recommended only to purchase or upgrade equipment when required, once existing equipment has reached its end-of-life. Water saving fittings should also be considered, which can reduce the amount of water a building requires and reduce the associated cost and carbon requirement.

6.4. Electric vehicles

Electric vehicle (EV) chargepoints are noted not to be of particular interest to MFHCA at this time, but Locogen would recommend considering this, particularly as the UK government has recently consulted on making these mandatory for new buildings. The procurement and installation cost for a slow or fast chargepoint (able to charge a typical EV in 8 and 4 hours, respectively) is in the region of £1,000-£1,500. Currently, the Government is offering a £350 grant against this cost via OLEV.

As such, they are a relatively modest investment compared other low carbon technologies. The MFHCA would be able to decide how to charge for electricity consumed and whether to make the chargepoint(s) available to the public.

6.5. Electricity tariffs

While variable electricity tariffs are not new to the market, real-time electricity tariffs are now appearing which compete with standard tariffs to offer potentially better rates to building owners/occupiers who have battery storage. These variable tariffs rise and fall with wholesale energy prices on a half-hourly basis, so the cost per unit of electricity can vary significantly depending on nationwide electricity demands. Such a tariff typically relies on the use of a smart meter in order for the electricity supplier to calculate electricity usage throughout the day and apply the wholesale price.

Typically, the unit price of electricity peaks between 6pm-9pm; however, if a building had battery storage, rather than taking electricity from the grid, the occupiers can switch to using their stored electricity and avoid the higher peak prices. This works particularly well where large appliances, such as dishwashers and washing machines, can be delayed to run at lower tariff times, or where electric car charging can be done when the tariff is more favourable.

The Economy 7, or differential tariff plans also work well with battery storage, where any batteries can be topped up to full capacity with electricity during the cheaper rates period at night and this stored electricity used to offset grid imports throughout the day.

Since Feed-in Tariffs for solar PV were closed, the Government announced that owners of electricity generating equipment, including solar PV, could make agreements with licensed electricity suppliers for the payment of electricity exported back to the grid. These agreements, known as Smart Export Guarantees (SEGs) are made between the owner of the generating plant and the electricity supplier.

The SEG scheme came into effect on 1 January 2020.The details of guarantee (including the amount of money received and the length of the contract) will be determined by the supplier. For example, Octopus currently offers a SEG rate of 5.5p/kWh, and Social Energy offers a rate of 5.6p/kWh. The regulations, however, state that companies can offer any rate above zero, and the Solar Trade Association's (STA) *SEG & Export Tariff League Table* highlights that some companies pay as little as 1-2p/kWh. Conversely, it has recently been announced that Tesla are offering, as part of the Tesla Energy Plan, SEG rates as high as 11p/kWh.

In addition to this, some suppliers are now starting to offer variable 'agile' export tariffs, which don't give a guaranteed price per kWh for every unit exported back to the grid, but which vary this rate alongside half-hourly wholesale rates such that the rates received for exporting back to the grid are maximised. This works particularly well where batteries are installed, such that the energy generated can be reserved or 'held back' from the grid until the times where export payments are at their highest.

7. Summary and next steps

7.1. Phase 1 summary

This Phase 1 report comprises the results of an early stage, 'first pass' review of the following low and zero carbon electricity and heat generating technologies and associated storage options for installation with specific domestic and commercial buildings within MFHCA locality:

- Solar PV
- Electricity storage
- Wind
- Biomass
- Air source heat pumps
- Air-to-Air Heat Pumps
- Ground source heat pumps
- Shared loop systems
- Heat batteries

Due to technical, economic, and planning constraints, both biomass and wind developments were considered unsuitable for further analysis regarding installation within the local area.

Table 24 details the findings following the Phase 1 analysis and identifies which technologies have been deemed suitable for installation at this stage of feasibility, which technologies should be considered in more detail during Phase 2 of the works, and which technologies have been deemed unsuitable and will not be considered further.

Phase 1 findings	Suitable	To be considered further in Phase 2	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 24: Phase 1 summary

All of the sites presented have potential for solar PV installations. High-level analysis has indicated the merits of each option and identified where sites can either be interlinked or downscaled to maximise use of generation on site. Furthermore, opportunities for electrical and thermal storage have been identified.

The RHI scheme is due to end in March 2021 for commercial properties and as such has not been included in the financial analysis of renewable heat opportunities in this study. Extensions to the deadlines as a result of the nationwide Covid-19 lockdown are under consideration by the Government but are not guaranteed. Further financial support is also likely to become available, but the form that this support will take and the timescales for these supporting mechanisms to come to market are unknown.

Finally, it is deemed vital that MFHCA make contact with Selby District Council at the earliest opportunity to present the ideas set out within this report and determine what impact the position of the sites, specifically the Church, within the Greenbelt, Conservation Area and proposed location for the Monk Fryston bypass will have on the viability of low and zero carbon installations. It is necessary to understand which installations would trigger a planning application, the likely timescales and costs for determination of such planning applications and the potential obstructions to planning approval in order to better refine the solutions to be deployed and to mitigate any planning risks accordingly.

7.2. Next steps

Following issue of this report, a meeting will be held with the Client to discuss the findings herein. During this meeting, Locogen will support the client to make a decision on how to progress the project to Phase 2. The anticipated sequence of events are as follows:

- Interim meeting to discuss draft report, and shortlist options;
- Formal Phase 1 report submitted;
- Up to three options to proceed to Phase 2: Focussed Assessment;
- Contact Selby District Council planning department for initial steer on acceptability;
- Contact Northern Powergrid and assess grid constraints;
- Conduct site visits (in line with Covid-19 guidance) to collect further data, refining the underlying technical assumptions, and determine the best locations for plant, as well as any practical barriers for installations in each location;
- Validate data, and carry out detailed energy and financial modelling; and
- Develop business case for the preferred energy systems.

As per the timeline we would anticipate the review meeting being undertaken w/c 3 November, and Phase 2 to start w/c 9 November, with a target of submitting the Phase 2 report on or before 18 December.

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. Estimated carbon degression profile

Year	Carbon content of grid (kg/kWh)	Year	Carbon content of grid (kg/kWh)
2019	0.2560	2035	0.0411
2020	0.2283	2036	0.0399
2021	0.2037	2037	0.0387
2022	0.1817	2038	0.0376
2023	0.1621	2039	0.0364
2024	0.1446	2040	0.0354
2025	0.1289	2041	0.0343
2026	0.1150	2042	0.0333
2027	0.1026	2043	0.0323
2028	0.0915	2044	0.0313
2029	0.0816	2045	0.0304
2030	0.0728	2046	0.0295
2031	0.0649	2047	0.0286
2032	0.0579	2048	0.0278
2033	0.0517	2049	0.0270
2034	0.0461	2050	0.0262

Table 25: Carbon degression estimate, years indicated in blue are targets/estimations

- 2019 grid carbon content from BEIS: *Greenhouse Gas Reporting Conversion Factors 2019*
- 2035 estimated grid carbon content from BEIS: *Energy and Emissions Projections*
- 2050 UK Government grid target of 90% reduction by 2050.

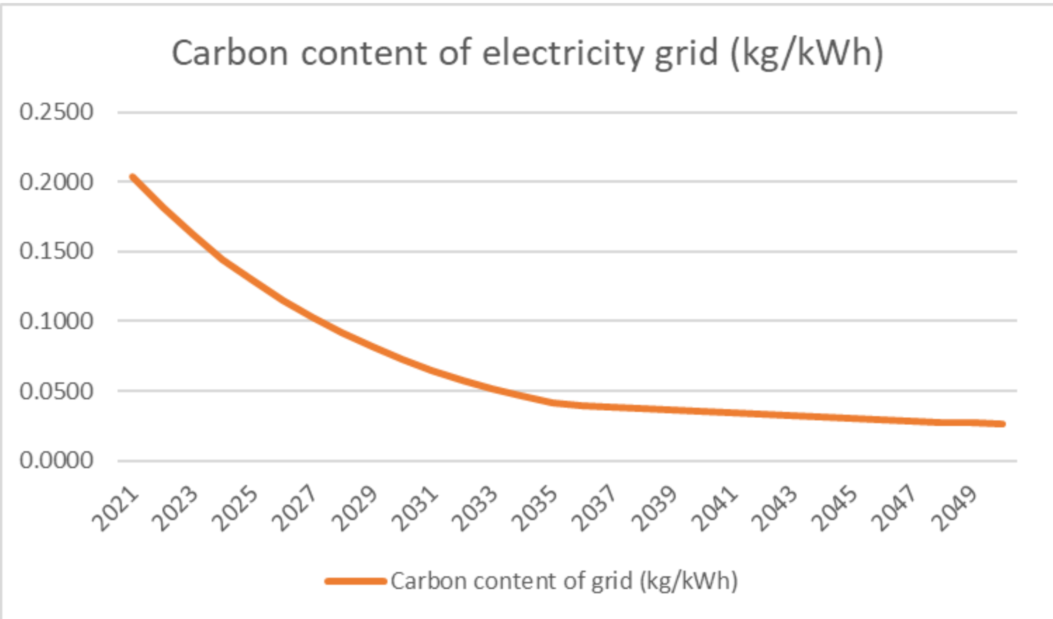

Figure 25: Carbon degression profile