I: Thermal Model Reports

I.1 - Renewable Energy Heating Insulation - Technical Feasibility Study and Outline Design (April 2010)

Barrhill Memorial Hall & Barrhill Primary School

Renewable energy Heating Installation – Technical Feasibility Study and Outline Design

April 2010

The Engineering Support Partnership Ltd
13 Quay Level
St Peters Basin
Newcastle
NE6 1TZ
www.espprojects.com

Pri.1222

Carbon Trust Energy Consultant and Carbon Trust Biomass Consultant (Biomass Heat Accelerator)

Contents

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Acknowledgements

We are very grateful to Community Energy Scotland who have funded this report on behalf of the Barrhill Community Interest Company, and therefore made it possible for this study to take place. We would also like to thank the Scottish Government for their financial assistance through the Community and Renewable Energy Scheme (CARES).

1. Executive Summary

This report has been commissioned by the Barrhill Community Interest Company to outline the feasibility of installing a low carbon heating system to serve Barrhill Memorial Hall and Barrhill Primary School.

Consideration has been given to the installation of a biomass, air source heat pump or oil-fired heating system at the site, with either separate heating systems for each building or a single heating system capable of heating both the hall and the school. Under both arrangements, heat would be distributed via a new low temperature hot water (LTHW) system.

Following a site visit and analysis of the heating demand, five options have been outlined:

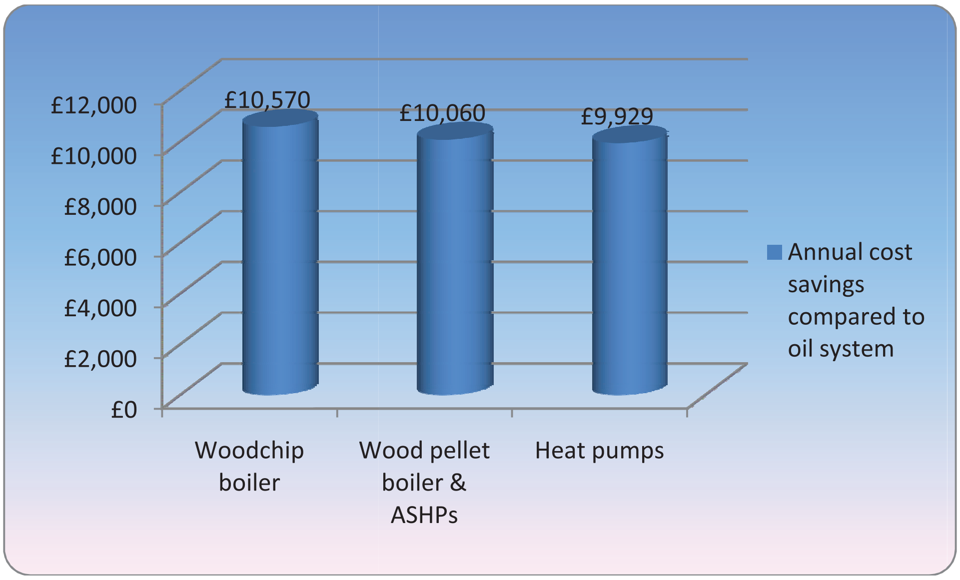
1) 70 kW woodchip/pellet boiler with a subterranean fuel store, supplying heat to both the school and the hall.
2) 25kW wood pellet boiler with above-ground fuel store supplying heat to the hall. 3 x 14kW air source heat pumps supplying heat to the school.
3) 3 x 14kW air source heat pumps supplying heat to the school, 2 x 14kW air source heat pumps supplying heat to the hall. Top-up from existing electric storage heaters in the school.
4) 90kW oil fired boiler providing heat to both the school and the hall.
5) 50kW oil fired boiler providing heat to the school and a 40kW oil fired boiler providing heat to the hall.

Preliminary designs for each option are outlined in this report, and budget costs have been compiled. Included in each option is the supply and installation of a new low temperature hot water distribution system, including district heating mains where appropriate. Annual cash flows and carbon savings have also been evaluated, and financial payback periods calculated.

The budget cost, annual cost savings and carbon reduction for each option are shown in the tables below.

Simple payback- combined

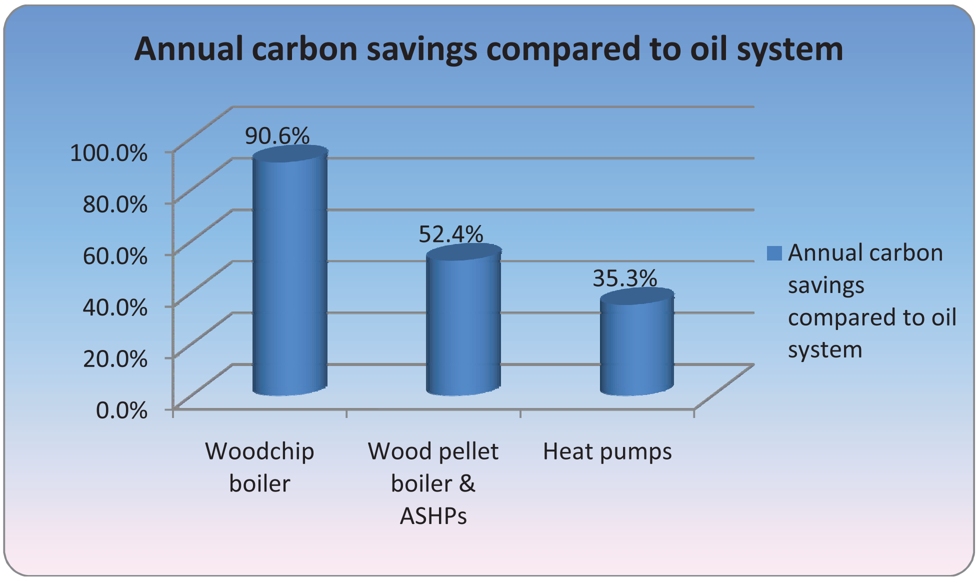
	Estimated Capital cost	Additional capital cost compared to oil system	Net annual running cost	Annual cost savings compared to oil system	Simple payback (years)
Oil boilers (option 5)	£58,819.00	NA	£6,843.60	NA	NA
Option 1- single woodchip boiler	£156,894.00	£98,075	-£3,725.96	£10,570	9.3
Option 2- wood pellet boiler & ASHPs	£110,742.00	£51,923	-£3,216.32	£10,060	5.2
Option 3- ASHPs	£79,068.00	£20,249	-£3,085.05	£9,929	2.0



Annual cost savings compared to oil system

Carbon emissions

	Annual carbon emissions, tonnes CO2	Annual reduction in carbon emissions, tonnes CO2	Annual reduction in carbon emission, %
Oil system	40.3	NA	NA
Option 1- single woodchip boiler	3.8	36.5	90.6%
Option 2- wood pellet boiler & ASHPs	19.2	21.1	52.4%
Option 3- ASHPs	26.1	14.2	35.3%



Annual carbon savings compared to oil system

The availability of grant aid should also be considered. The Low Carbon Buildings Programme Phase 2 offers grants of up to 50% of eligible project costs up to a maximum of £200,000, and the Community and Renewable Energy Scheme considers applications on a case by case basis.

In addition, the Renewable Heat Incentive could provide significant annual income should it be introduced in April 2011. However, it should be noted that there have been strong indications from government that some grants (including those issued under the Low Carbon Buildings Programme) will have be repaid in order for the installation to receive payments through the Renewable Heat Incentive.

The conclusion of this report must ultimately be deduced by Barrhill Community Interest Company, based on the criteria and issues identified within this document. However, it can be seen that simple payback analysis would favour the installation of air source heat pumps, whilst a desire to achieve maximum carbon savings would best be served by installing a woodchip boiler.

2. Introduction

2.1 Brief and Scope

This report has been prepared for the Barrhill Community Interest Company (BCIC) by The Engineering Support Partnership Ltd. It assesses the technical and financial feasibility of installing a new heating system to serve Barrhill Memorial Hall and Barrhill Primary School. Consideration has been given to separate heating systems for each building, and also to a single heating system capable of heating both the hall and the school. Under both arrangements, heat would be distributed via a new low temperature hot water (LTHW) system.

The following technologies have been considered:

- Biomass boiler (woodchip or wood pellet)
- Air source heat pump(s)
- Oil boiler(s)

In line with the above objectives, the suitability of each technology option has been evaluated in terms of economics, physical constraints and carbon emissions. The following methodology was used:

- A site survey was undertaken to assess vehicular access; determine physical layout; identify possible locations for new heating plant; identify possible locations for fuel storage; understand current space heating and hot water provision; review and understand all areas of energy use; identify capacities of existing building services.
- Building fabric was determined.
- Heat load calculations carried out by Locate Architects were used as the basis for assessing peak thermal load and annual thermal demand associated with the two buildings (For the hall, heat loads for both the existing and proposed building were considered). To verify these calculations, recent energy consumption data and CIBSE design guidelines were referred to.
- Annual energy expenditure was estimated based on energy consumption.
- Budget project costs have been compiled using quotes obtained from equipment manufacturers and suppliers (see Chapter 6) in conjunction with budget costs received from installers. Estimated costs for some items have been used where appropriate.
- The following documents were referred to:
  - Brief- Heating Community Buildings
  - Barrhill Memorial Hall rev
  - Heat Loss- Barrhill Hall Existing2

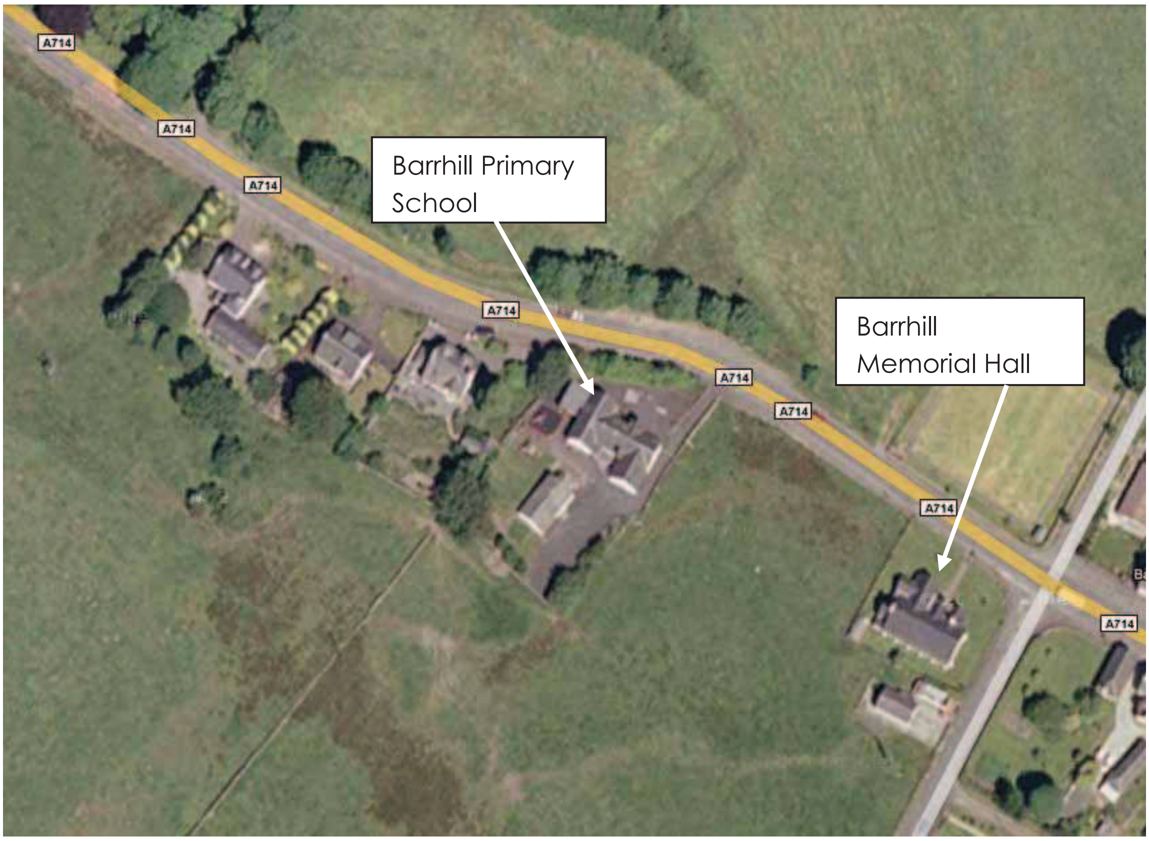
  - Heat Loss- Barrhill Hall Proposed2
  - Heat Loss- Barrhill School2
  - Barrhill Public bldgs
  - Barrhill (received from Andrew Marnie of South Ayrshire Council on 18/03/10)

- On-going consultation with Locate Architect, Collective Architecture, BCIC and South Ayrshire Council

The analysis offered here is intended to provide an indication of the feasibility of installing either a biomass, air source heat pump or oil-fired heating system at Barrhill Primary School and Barrhill Memorial Hall. It offers a preliminary design based on an initial site visit and consultation with BCIC, South Ayrshire Council, Locate Architects and Collective Architecture, and makes a number of assumptions in relation to ground conditions and suitable pipework routes; the report is not intended to offer a final design solution.

2.2 The Site

This report focuses on Barrhill Memorial Hall and Barrhill Primary School, located in Ayrshire. Both buildings are situated on the western side of the A714 and are approximately 60 metres apart, separated by a small field. Barrhill Primary School is owned by South Ayrshire Council and the hall is owned by Barrhill Community Association, and it is understood that both parties are interested in exploring the possibility of a joint heating system that will serve both the school and the hall. It is ESP's understanding that South Ayrshire Council has agreed in principle that the field between the buildings should be sold to BCIC for the primary purpose of providing a car park for the two buildings, and that this space has also been suggested as a possible location for a biomass boiler room and fuel store.



Aerial view of the Close House site Provided by Google Maps

Barrhill Primary School is a small school consisting of a main building, dining hall and an external storage/garage area. The school is made up of 3 classes with a total of around 37 pupils. The building dates back to the late 19th century and has a solid wall construction. Locate Architects have told ESP that the floor is thought to be of an un-insulated solid floor type, though it is possible that there is an un-insulated suspended timber floor. Locate also believe that there is around 100mm of loft insulation under the tiled roof.

Barrhill Primary School Provided by Google Maps

Barrhill Memorial Hall is used by the Barrhill community for a number of purposes including meetings, sports and community events, as well by pupils of Barrhill Primary school for PE lessons, assemblies and other activities. The hall currently suffers from poor thermal insulation and a high rate of air leakage, which stem from low levels of insulation in the walls, roof and floor, single-glazed windows and little or no draught-proofing.

However, a design study of the hall, which is in its latter stages, is being carried out by Collective Architecture. Collective are proposing a major refurbishment of the hall in order to improve the energy performance and thermal comfort of the building and to improve the extent to which the hall meets the needs of the community. The proposed refurbishment includes extensions to the hall, a new car park in the field to the west of the hall (referred to above) and major energy efficiency measures.

According to BCIC, the extensions to the hall and the construction of the new car park are expected to be long term projects. However, it is anticipated that the simpler energy efficiency measures such as cavity wall insulation, loft insulation and the installation of double glazing could be carried out prior to the installation of any renewable energy heating system.

As requested by BCIC, the recommendations in this report are based on the heat loads associated with the refurbished/ extended hall as proposed by Collective Architecture. That is, the heating plant has been sized to meet the heating demand once all refurbishment work has been completed. However, to ensure that adequate heating provision is in place prior to the second stage of the refurbishment, we have recommended that either some of the existing electric heaters are retained or that a back-up oil boiler is installed that has the capacity to meet the existing full heat load at the site.

Barrhill Memorial Hall Courtesy of Locate Architects

2.3 Existing arrangements

2.3.1 Heating and hot water plant

Both buildings are currently heated by electric heaters (28 in total- 16 in the hall, 12 in the school). Most of these heaters are of the storage convector type, but there are several non-storage heaters of different forms (see photos below). There are also a number of instantaneous electric water heaters, and the school contains two storage-based electric water heaters which are connected to a hot water storage tank located in the roof space above the library.

Examples of electric heaters in the hall and school

Electric heating is an expensive and high carbon form of heating, and storage heaters also offer very little user control. For areas with infrequent use, such as some rooms in the hall, storage heaters are particularly impractical as their output cannot be adjusted at short notice and therefore tend to be either left on permanently or not used at all. Installing renewable heating plant and a new wet distribution system will therefore offer financial savings, reduced carbon emissions, improved thermal comfort and better user control.

2.3.2 Electricity supply

Barrhill School has a three phase electricity supply with a single phase distribution. The hall has a three phase supply. The distribution boards in both buildings appear to be in good condition.

Barrhill School 3 phase distribution board

Barrhill Hall 3 phase distribution board

3. Energy Profiles

The heat loads for the school and hall have previously been calculated by Locate Architects as part of the on-going design study commissioned by BCIC. When calculating the heat loads and annual heating demand, Locate took into account building fabric, air tightness and internal design temperatures.

Although the figures for annual heating demand quoted by Locate reflect typical consumption patterns that should be expected from the building types in question, they are somewhat higher than the actual figures recorded in recent energy bills. This report has assumed that annual heating demand will be somewhere between that which has been recorded in the past, and the levels predicted by Locate Architects. This approach takes into account the fact that any replacement heating system is likely to offer a higher level of thermal comfort to users of the buildings and will be more affordable on a kWh basis, thus leading to slightly higher consumption. However, it seems unlikely these factors will result in an increase as large as that estimated by Locate.

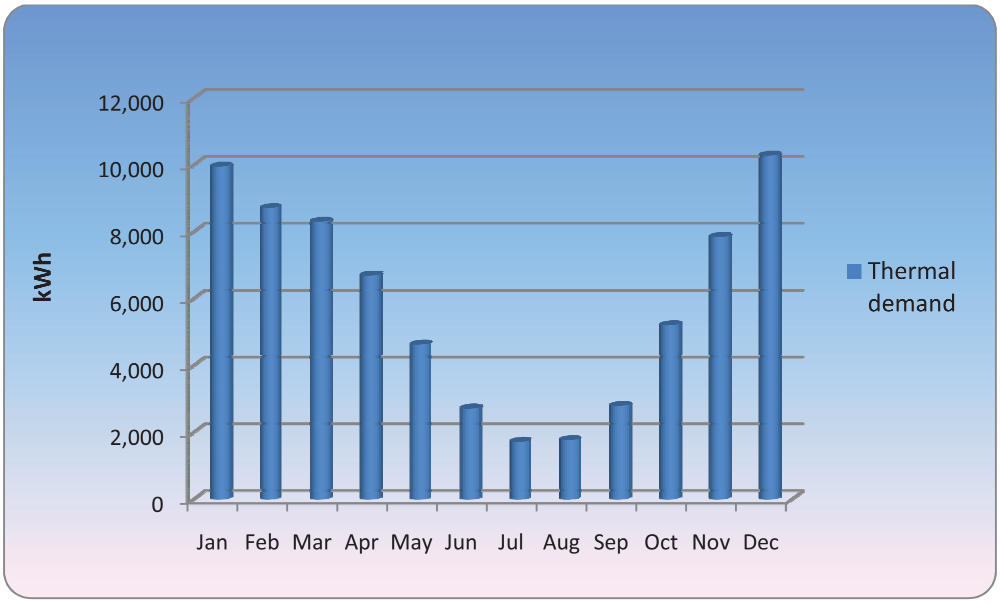
We are confident that the figures quoted below for annual heating demand offer a reasonably accurate representation of future heating profiles at Barrhill School and Hall, though it should be noted that the energy bills that were reviewed did not offer a breakdown of electrical consumption between heating and non-heating applications and an estimate of the split between different uses was therefore required.

With regard to peak heating loads, the figures quoted by Locate Architects appear to be in line with typical values for the building types being assessed and have been used here to size the heating plant.

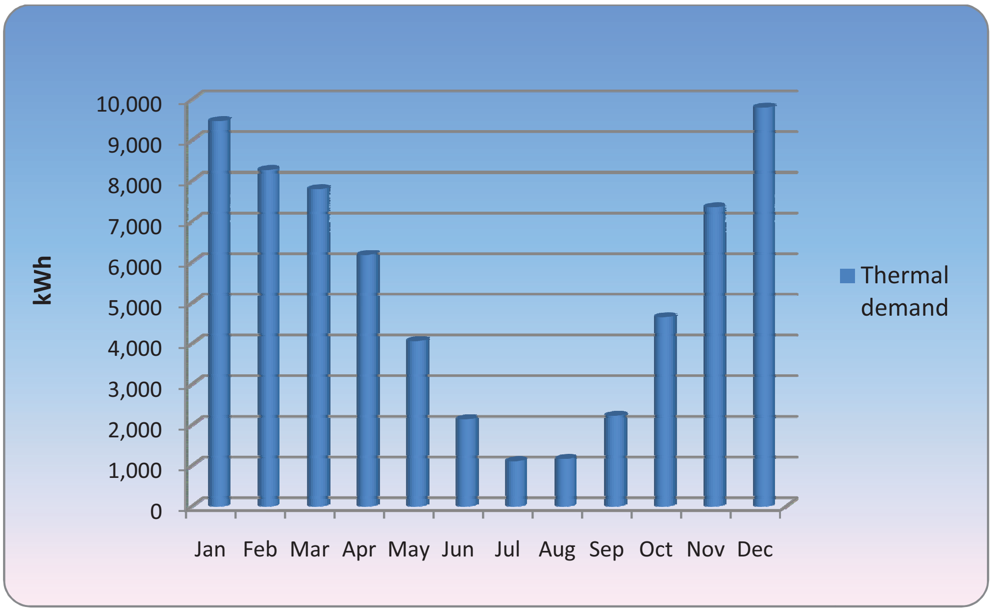
Peak thermal demand for the school is estimated at 44kW. Peak thermal demand for the hall is estimated at 18kW if the building is refurbished according to Collective Architecture's proposals, and 34kW if the existing set-up is retained.

Total peak thermal demand for the two buildings is therefore estimated at 62kW if the hall is refurbished, and 78kW if the hall is not refurbished.

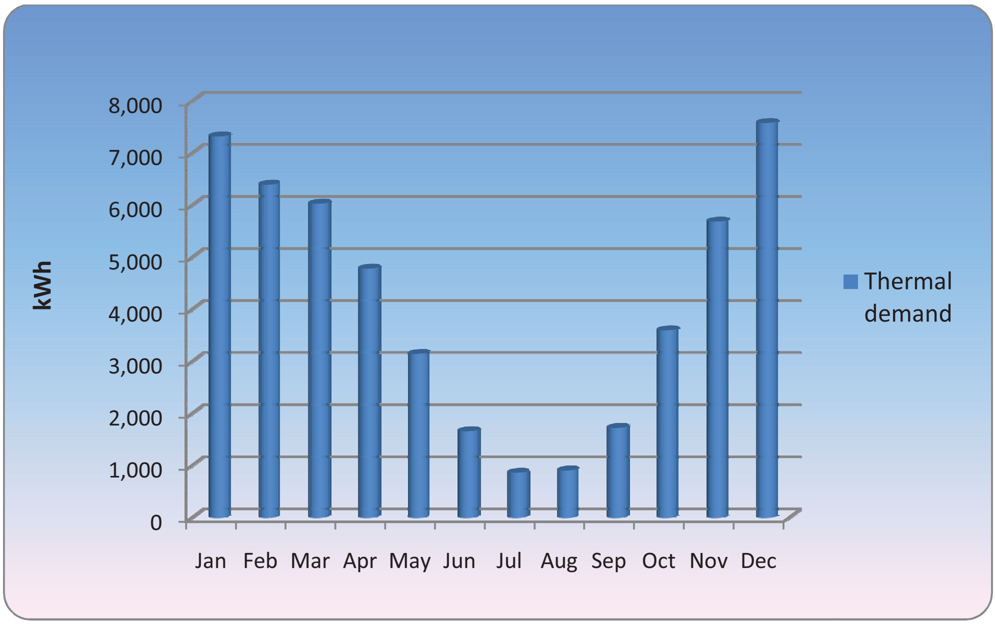
The following graphs show the estimated monthly heating demand for the school and hall**. As shown, total combined annual thermal demand for the site is estimated at 121,664kWh if the hall is refurbished, and 136,243kWh if the hall is not refurbished (both based on delivered heat demand).**



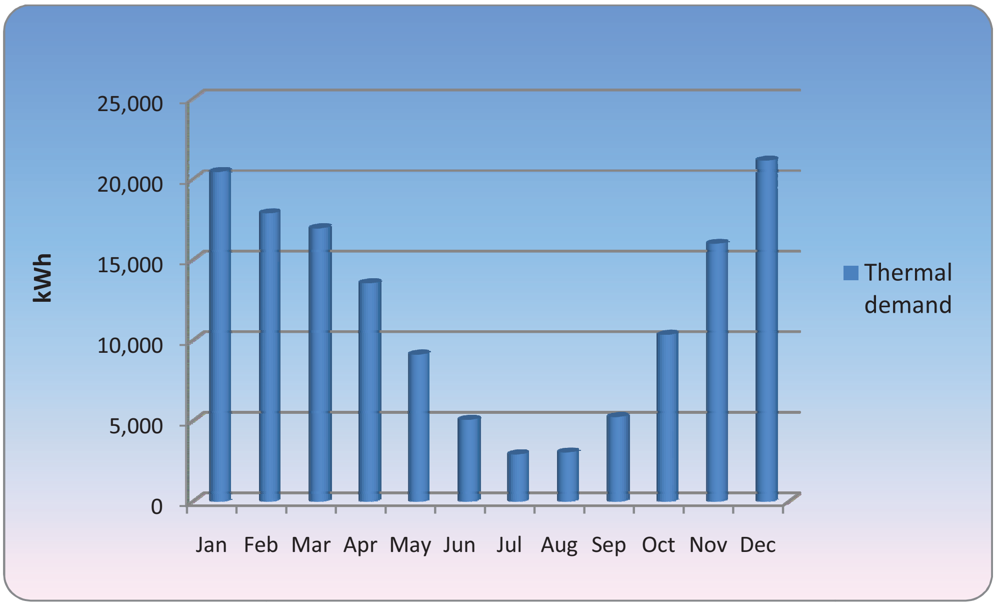
Estimated thermal demand for Barrhill School. Total annual demand- 71,993 kWh



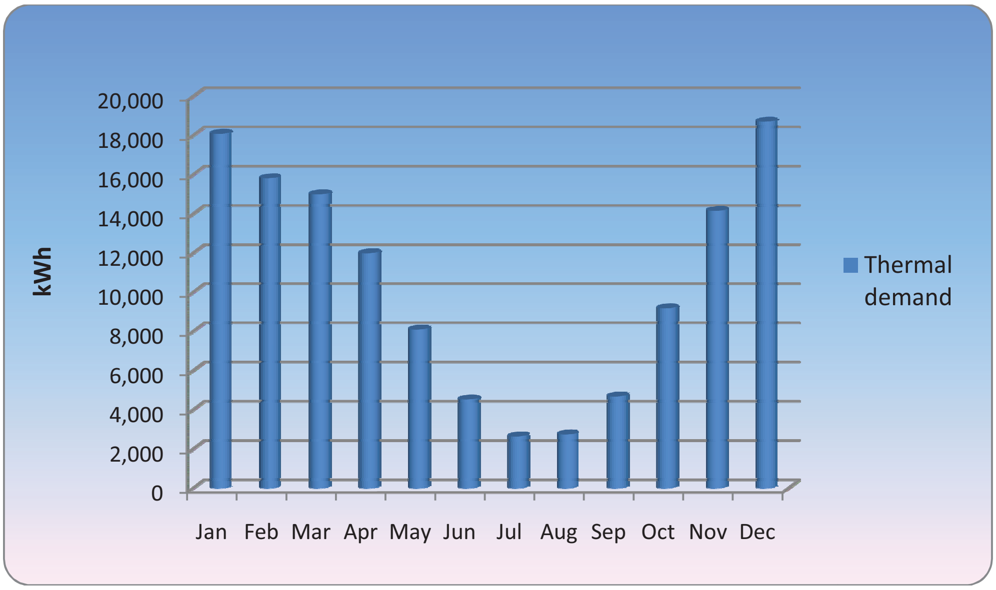
Estimated thermal demand for Barrhill Memorial Hall (**existing**). Total annual demand-64,250 kWh



Estimated thermal demand for Barrhill Memorial Hall (**as proposed by Collective Architecture and Locate Architects**). Total annual demand- 49,671 kWh



Estimated thermal demand for Barrhill School & Barrhill Memorial Hall (**hall as existing**). Total annual demand- 136,243 kWh



Estimated thermal demand for Barrhill School & Barrhill Memorial Hall (**hall as proposed by Collective Architecture and Locate Architects**). Total annual demand- 121,664kWh

For the purposes of this report, we have sized the heating plant based on the current peak demand at the site.

4. Technology options

4.1 Oil boiler

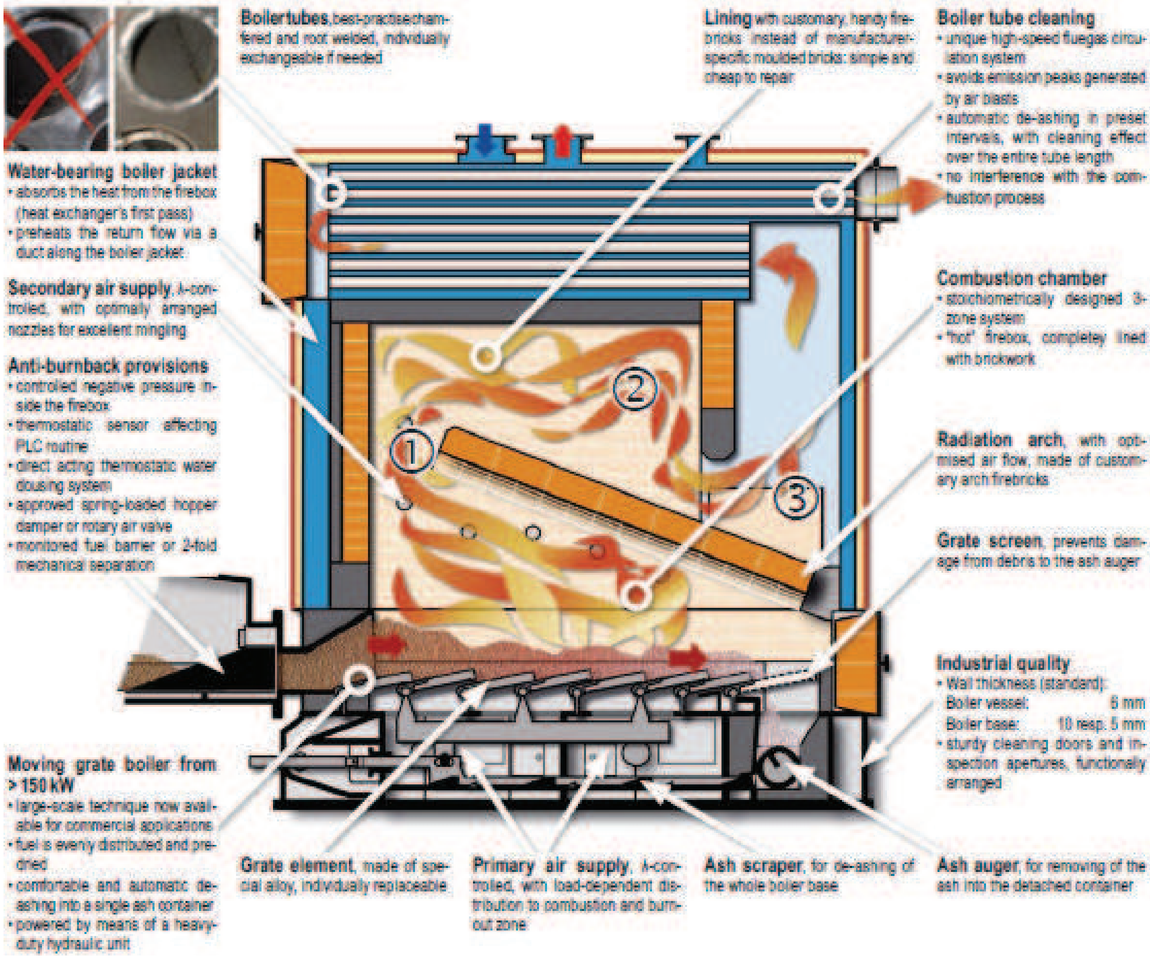
Oil boilers are used widely in areas that are not connected to the mains natural gas network. They offer a simple solution that is easy to install and operate, and relatively cheap to install. However, while traditionally regarded as the most viable alterative to gas boilers, oil boilers don't offer the environmental benefits associated with renewable energy systems.

Furthermore, if implemented, the proposed Renewable Heat Incentive could make renewable heating installations such as wood boilers and air source heat pumps more attractive than oil systems on cost grounds alone (see Section 5).

4.2 Biomass

Biomass heating systems are increasingly popular for use in buildings in the UK. Whilst relatively new in this country, the use of biomass boilers is widespread throughout Europe and especially Austria and Scandinavia. Biomass boilers are technologically mature and are a simple and effective alternative to fossil fuel systems, with modern boilers offering a high level of automation and user control.

Features such as burn-back protection, staged oxygen supply and automatic ash removal mean that biomass boilers are safe, efficient and user-friendly (see diagram below). Thermal efficiency is comparable to modern gas condensing boilers at above 90%, and with careful equipment selection user input can be minimal. Biomass boilers make use of a hot water accumulator tank to enable a turn down of output, as the boiler alone can only reduce output to around 30% of maximum output without this buffer vessel.



Detail of woodchip boiler with screw auger fuel extractor (courtesy of Wood Energy Ltd)

The use of biomass fuels can result in a significant reduction in carbon emissions compared to fossil fuel systems. Although there are some carbon emissions associated with the processing and transportation of biomass fuels, these are typically small; both wood chip and wood pellets are usually assumed to deliver a carbon saving of over 90% when compared to oil heating.

Biomass boilers can be designed to operate on a range of fuels, but for small commercial applications either woodchip or wood pellets are normally used. Woodchip is slightly cheaper on a kWh basis, but pellets offer greater bulk density and therefore require less storage space and less frequent fuel deliveries.

A number of options exist for fuel storage and handling. Woodchip requires a larger storage volume than pellet, and in commercial applications is typically stored in either a purpose-built blockwork fuel store or in a subterranean (underground) store. Additional options are available for pellets, including fabric silos, rigid metal silos and plastic storage hoppers. Pellets can be delivered to the boiler via a suction system or screw auger, while only the latter option is available for woodchip.

Typical arrangements of a woodchip boiler and wood pellet boiler with various fuel store options are outlined in Chapter 7.

4.3 Air source heat pumps

Air source heat pumps (ASHPs) are electrically powered appliances consisting of a compressor and two carefully matched heat exchangers designed to provide space and water heating to buildings. The technology inside an ASHP is similar to that in any domestic refrigerator, which uses a vapour compression cycle.

They work by extracting low grade heat from the external air and concentrating this into useful heat that can be distributed via a low temperature hot water distribution system. Like biomass systems, ASHPs have been used widely in European countries including France and Sweden for years, and are a well-proven technology.

Unlike conventional boilers, which are by the laws of thermodynamics always less than 100% efficient, the useful energy output of an ASHP is greater than the required input energy. That is, for every unit of electrical input needed to power the unit, more than one unit of useful output energy is recovered in the form of heat. The ratio of output to input energy is known as the 'coefficient of performance' (COP), and for well designed systems this COP can average in excess of 3 over the course of a year.

Where a high seasonal COP can be achieved (i.e. where the average COP over the course of a whole year is high), ASHPs can deliver relatively high annual financial and carbon savings. However, when considering the use of ASHPs careful thought should be given to the ambient air temperatures that are likely to be experienced as well as the design of the heating distribution system. The maximum achievable heat output from ASHPs usually drops slightly at very low (i.e. sub -10C) ambient temperatures, and the COP is drastically reduced if high flow temperatures are used. Both of these factors can have a major impact on the efficiency and performance of the unit and hence the financial and carbon savings offered by the system.

Heat pumps are compatible with both panel radiators and under-floor heating systems, but the lower flow temperatures associated with under-floor heating mean that higher efficiencies can be achieved with this set-up.

ASHPs offer a high level of user control that is comparable to that of any modern heating system, and require no more involvement than a typical gas or oil boiler. They must be located externally, and are quiet enough to be installed adjacent to domestic buildings. They also have a minimal visual impact, although when siting the units consideration should nonetheless be given to issues such as noise, vibration and drainage of condensate. An ASHP with an output of up to 14kW requires a space of approximately 1.5m x 2.0m x 1.5m high including access and air flow space. An example of a 14kW unit is shown below.

Typical 14kW air source heat pump installation

5. Government renewable energy tariffs

5.1 Renewable Heat Incentive

The Renewable Heat Incentive (RHI) is due to be introduced in April 2011, although it has yet to be passed by Parliament. Under this scheme, owners of renewable heating installations such as biomass or air source heat pump systems will be rewarded with a fixed payment for every unit (kWh) of heat produced by an eligible installation. The government's consultation document for the RHI was published in February 2010, and it proposed that biomass installations between 45 and 500kW should receive a payment of 6.5 pence per kWh and that air source heat pumps up to 45kW should receive 7.5 pence per kWh (see table below). Payments would be awarded on a deemed basis, meaning that annual energy demand at the site would be assessed at the time of installation with payments based on this estimate.At the tariff levels proposed in the government's consultation document the RHI would have a dramatic and very positive impact on the financial viability of both biomass and ASHP systems, with the annual payments associated with these tariffs set to be substantial. **For example, a 70kW biomass boiler with an assumed usage factor of 25% over the year would give an annual payment of £9,964 (70kW x 25% x 8760 hours x £0.065 per kWh). A 42kW ASHP installation with an annual usage factor of 38% would give an annual payment of £10,486 (42kW x 38% x 8760 hours x £0.075 per kWh).**

Tariff Levels for Renewable Heat Incentive			
Technology	Scale	Tariffs (pence/ kWh)	Tariff lifetime (years)
Small Installations			
Solid biomass	Up to 45kW	9	15
Biodiesel	Up to 45kW	6.5	15
Biogas on-site com-bustion	Up to 45kW	5.5	10
Ground source heat pumps	Up to 45kW	7	23
Air source heat pumps	Up to 45kW	7.5	18
Solar thermal	Up to 20kW	18	20
Medium Installations			
Solid biomass	45kW-500kW	6.5	15
Biogas on-soite com-bustion	45kW-200kW	5.5	10
Ground source heat pumps	45kW-350kW	5.5	20
Air source heat pumps	45kW-350kW	2	20
Solar thermal	20kW-100kW	17	20
Large installations			
Solid biomass	500kW and above	1.6 -2.5	15
Ground source heat pumps	350kW and above	1.5	20
Biomethane injection	All scales	4	15

5.2 Feed in Tariff

The Feed-in-tariff (FIT) was introduced on 1st April of this year. Under this scheme, electricity suppliers pay a fixed tariff for every kWh of electricity generated by renewable energy generating installations up to 5MW in size.

The level of the tariff is technology-specific, and for photovoltaic (PV) systems between 4 and 10kW the tariff is 36.1 pence/kWh. The FIT is payable for every unit of electricity generated by an eligible installation, whether this electricity is exported to the grid or used onsite. Well-positioned photovoltaic arrays can therefore generate significant revenue that will help to offset the cost of installation.

6. System Sizing

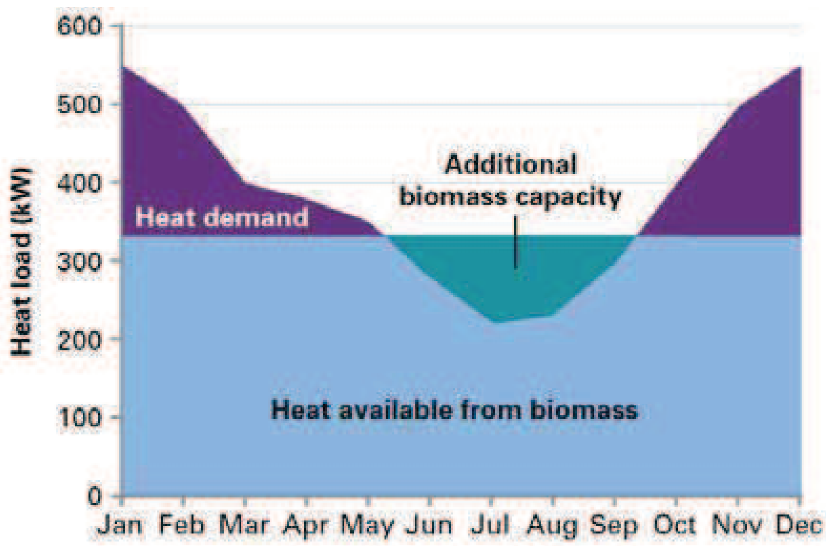
6.1. Biomass

From a technical point of view, biomass heating plant is best operated relatively continuously at between 30% and 100% of its rated output. Rapid system cycling or long periods at very low load conditions can significantly reduce the thermal efficiency of the system and result in accelerated wear and tear, and are therefore best avoided. However, sizing the biomass plant to ensure continuous operation will result in reduced overall output and will limit the ability of the plant to meet the peak load at the site.

To be able to size systems effectively, it is important to have an accurate view of the likely daily and seasonal heat demand profiles at the site. There are three main approaches for sizing a biomass system:

1) Base load: where the biomass system provides only the annual, continuous heat load at the site
2) Peak load: where the biomass system is sized to meet the entire heat load at the site
3) Optimum sizing: where a balance between the above two approaches is used

Base load sizing can improve thermal efficiency by ensuring continuous operation and will reduce capital costs due to the use of smaller plant. Peak load sizing will require greater capital expenditure and can lead to reduced thermal efficiency and increased wear and tear, but it will enable the biomass plant to meet a greater proportion of the overall heat demand at the site and therefore deliver larger financial and carbon savings. Optimum sizing achieves a balance between capital expenditure and operational costs, and aims to achieve the benefits of both base load sizing and peak load sizing.



Example of optimum plant sizing (Courtesy of The Carbon Trust)

Due to the seasonal nature of the heating profile at Barrhill, there is a very low thermal base load; base load sizing is therefore not a suitable option. For a combined system serving both buildings, optimum sizing of the system based on the proposed design for the hall would enable a smaller boiler to be used compared to peak sizing, but in the event of the hall not being refurbished there would be a considerable short-fall in capacity that would need to be met by an electric or oil system.

It is therefore recommended that for a combined system the biomass boiler is sized to meet the majority of the existing load (i.e. before the hall has been refurbished), with an accumulator tank installed alongside the boiler that will enable the biomass system to meet the full peak load at the site.

It is recommended that, for a single combined biomass system, a 70kW woodchip boiler is installed, with a 50kW electric immersion heater fitted within the accumulator tank to provide back-up to the school.

If a biomass system is to be installed to serve the hall only, it is recommended that a 25kW pellet boiler is used.

A 70kW woodchip boiler should be able to provide 100% of the annual heating load required by the school and hall, with the 25kW pellet boiler also able to supply 100% of the hall's heating and hot water requirements if this solution is chosen.

6.2. Air source heat pumps

Air source heat pumps are most efficient if they are operated with low flow temperatures, meaning that buildings heated using ASHPs have longer heat-up times than those heated by a boiler. Heat pumps are also least efficient when they are working at there maximum output at high flow temperatures. It is therefore good practice to operate the units at a relatively low output for prolonged periods, rather than at a high output for short periods.

Given the above factors, it is recommended that if it is decided to install a heat pump system, then two 14kW ASHPs should be fitted to supply heat to the hall and three 14kW ASHPs should be fitted at the school. If operated relatively continuously in colder months, this should enable the heat pumps to meet the peak thermal demand for both buildings the vast majority of the time. Should the hall be refurbished, the peak load for the hall will be met by a single heat pump for most of the year, with the second unit acting as top-up when required.

7.System Design

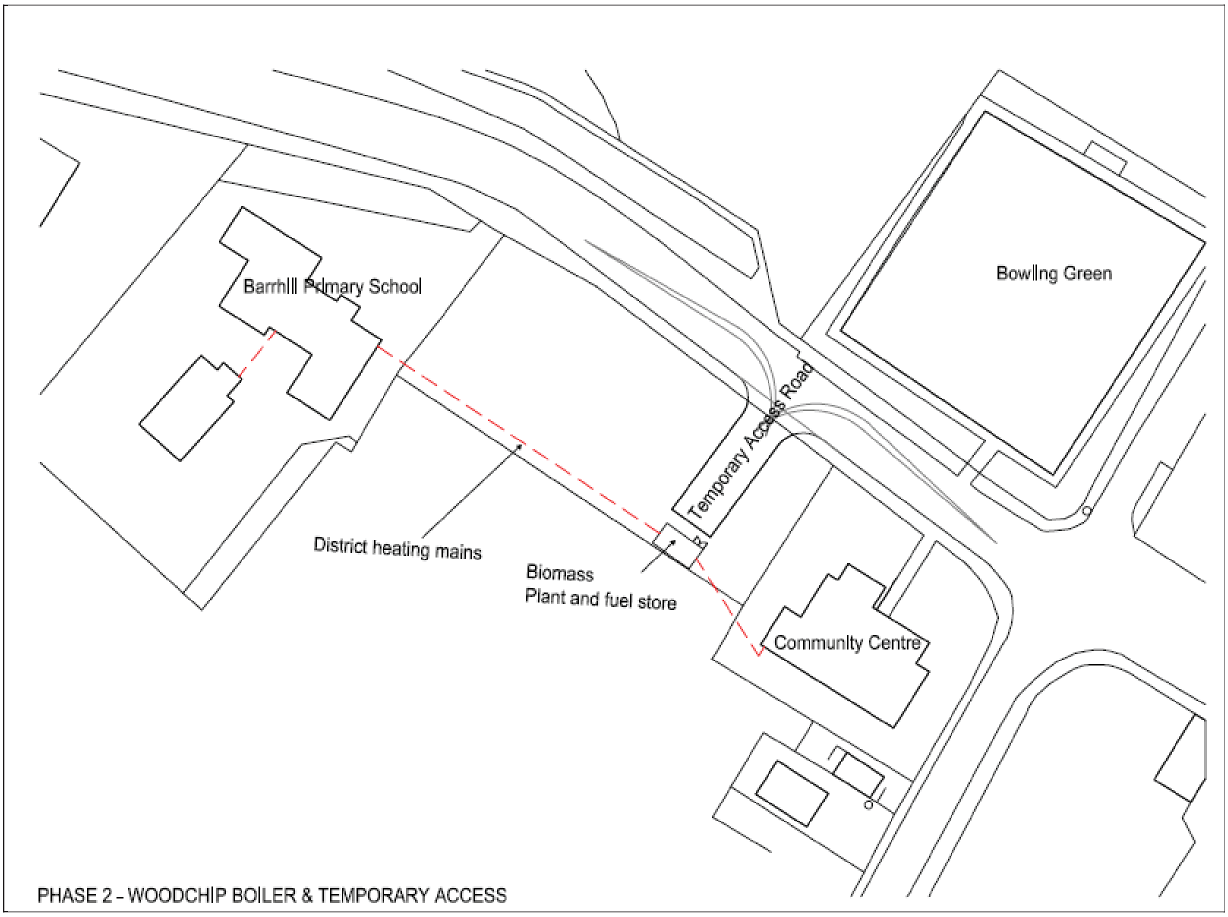
7.1 Heating plant

Five options have been outlined for the heating plant:

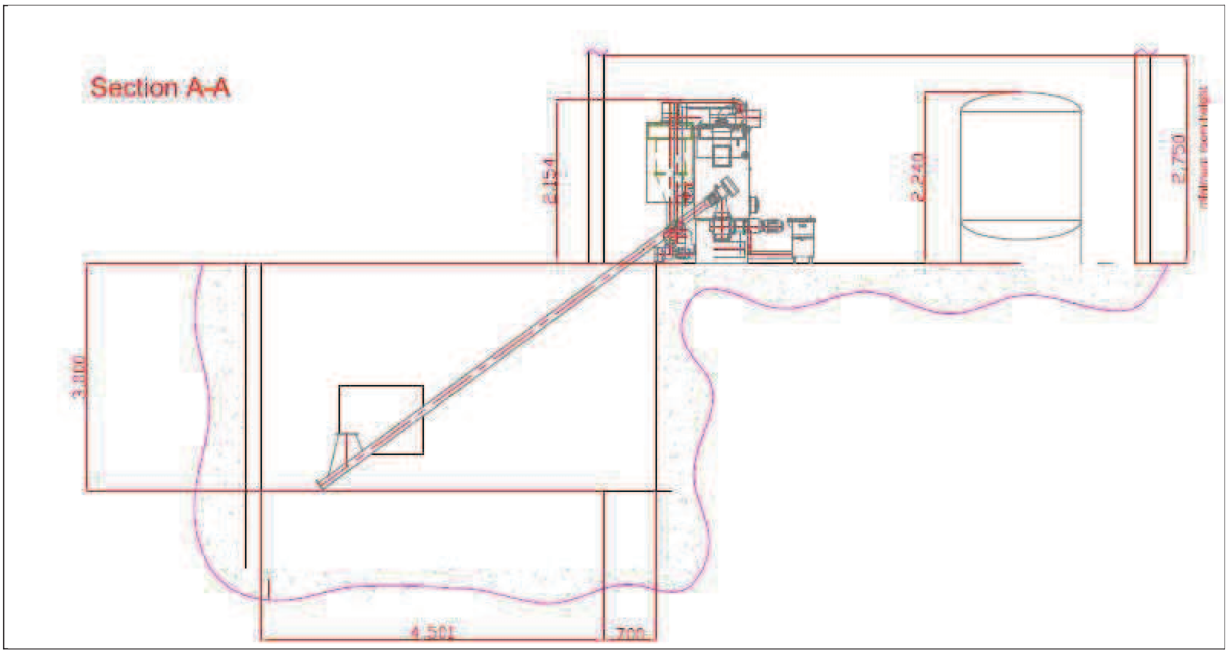
1) 70 kW woodchip/pellet boiler with a subterranean fuel store, supplying heat to both the school and the hall.
2) 25kW wood pellet boiler with above-ground fuel store supplying heat to the hall. 3 x 14kW air source heat pumps supplying heat to the school.
3) 3 x 14kW air source heat pumps supplying heat to the school, 2 x 14kW air source heat pumps supplying heat to the hall. Top-up from existing electric storage heaters in the school.
4) 90kW oil fired boiler providing heat to both the school and the hall.
5) 50kW oil fired boiler providing heat to the school and a 40kW oil fired boiler providing heat to the hall.

7.1.1 Option 1- 70kW woodchip boiler

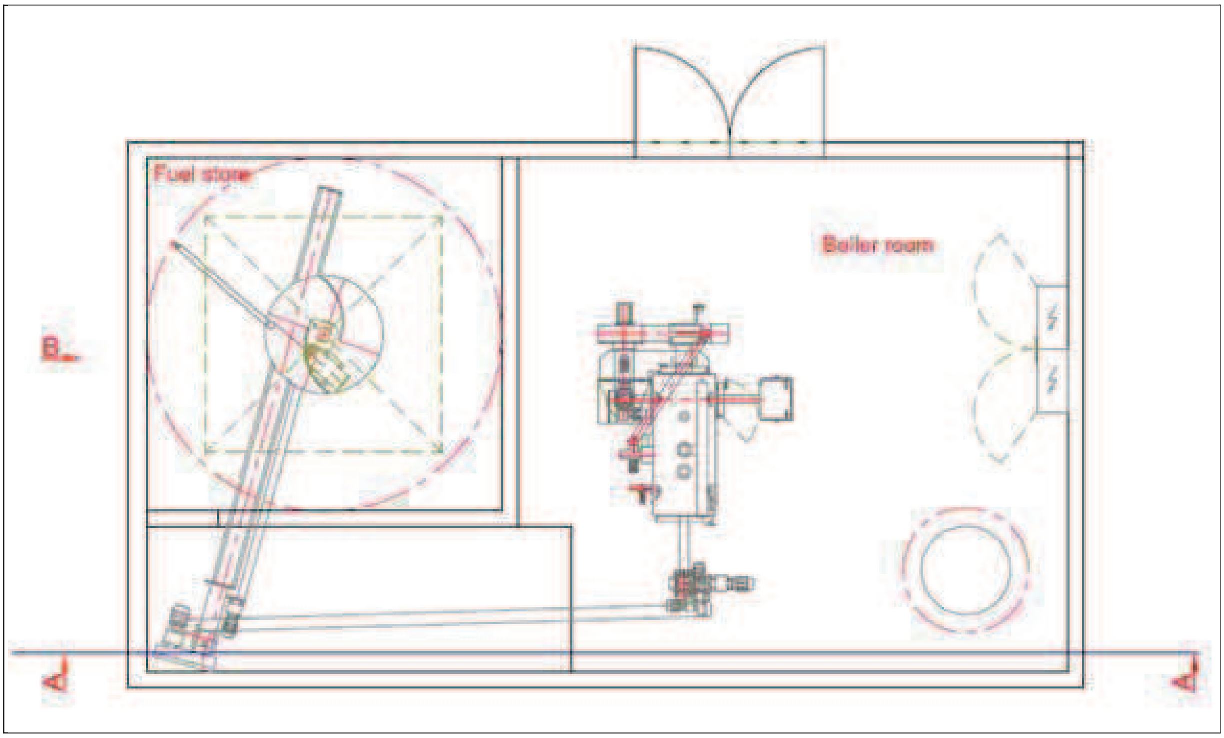
For this option it is proposed that a 70kW woodchip boiler is installed in a new purpose-built boiler room located in the south west corner of the proposed car park (as indicated in plan view drawing below- also see drawing *M003 Site Layout Option 1* submitted with this report). This will serve both the hall and the school, with heat distributed to the two buildings via buried district heating pipework as shown on the drawing below. An underground fuel store will be constructed adjacent to the boiler room. The fuel store will be sized to store approximately 10 tonnes of woodchips, which is equivalent to around 4 weeks of demand in winter months. The fuel will be transferred to the boiler via a rotary agitator and screw auger system (see indicative drawing below, and also drawing *M007 Boiler Room and Fuel Store Layout* submitted with this report).



Proposed location of woodchip boiler and fuel store, and routes of district heating mains (adapted from drawing produced by Collective Architecture)



Indicative design of fuel store, fuel handling system and boiler room- section A-A



Indicative design of fuel store, fuel handling system and boiler room- Plan view

Fuel will be delivered to the site by a standard tipper trailer delivery vehicle which will tip the fuel into the store via a hatch (see image below). This delivery method allows bulk deliveries without the requirement for manual handling or other involvement from onsite staff.

Indicative woodchip delivery arrangement for Option 1 (courtesy of Econergy)

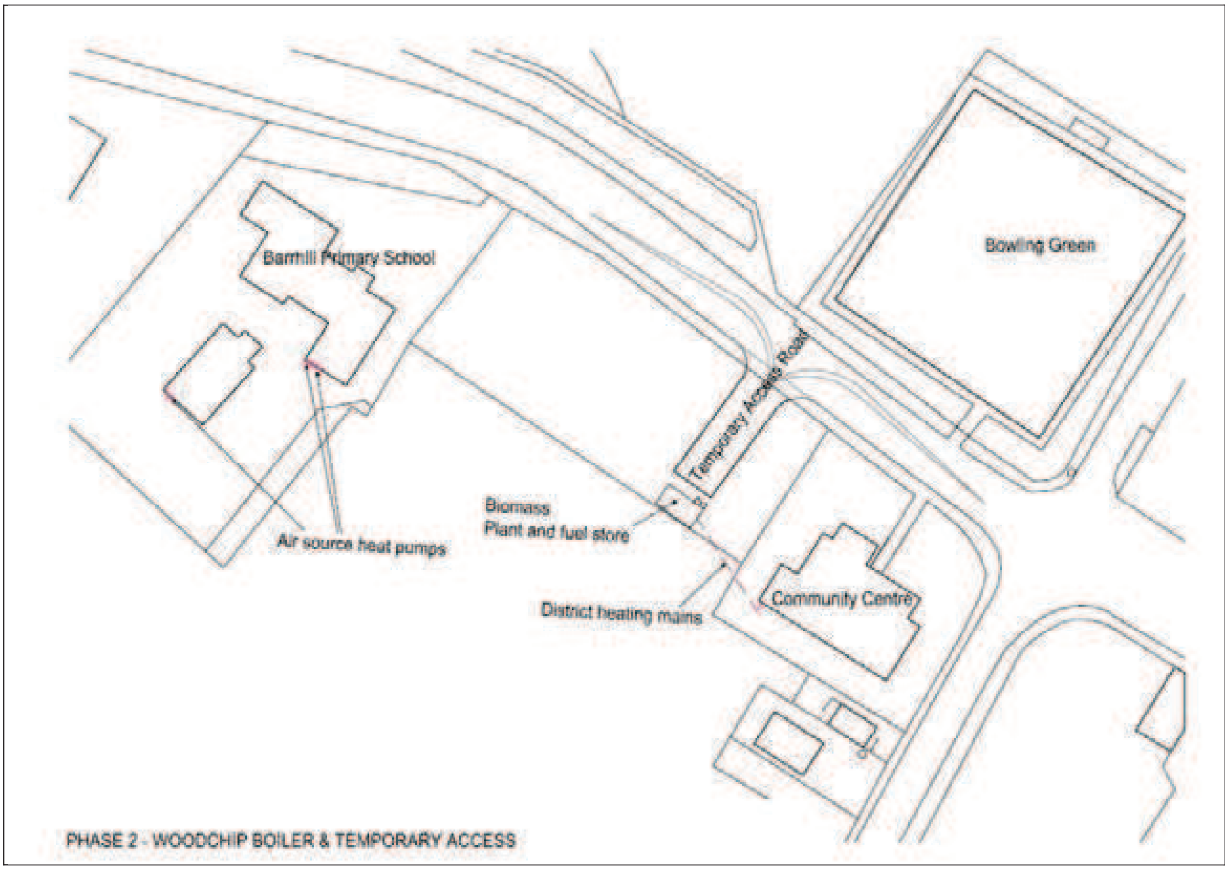
A 2000 litre hot water accumulator tank will be installed alongside the biomass boiler. This will act as a buffer, reducing cycling of the biomass boiler as instantaneous demand rises and falls. The use of an accumulator tank will also increase the effective peak output of the biomass system, with a fully charged tank able to meet the expected peak demand of 78kW (as existing) for approximately 6 hours without the need for the oil boiler to fire.

As requested by the client, allowance has been made within the costs for the provision of a 50kW electric immersion heater within the accumulator tank. This will provide heat to the school in the event of breakdown of the biomass boiler.

Within the boiler room there will be the 70kW wood pellet boiler, a 2000 litre accumulator tank, power and control equipment, a pressurisation unit and circulation pumps.

7.1.2 Option 2

For this option it is proposed that a 25kW wood pellet boiler is installed in a newly constructed boiler house. The boiler house will be located in the south west corner of the proposed car park, as per option 1 (as indicated in plan view drawing below- also see drawing M004 Site Layout Option 2, submitted with this report). This will serve the hall, with heat distributed to the building via buried district heating pipework.

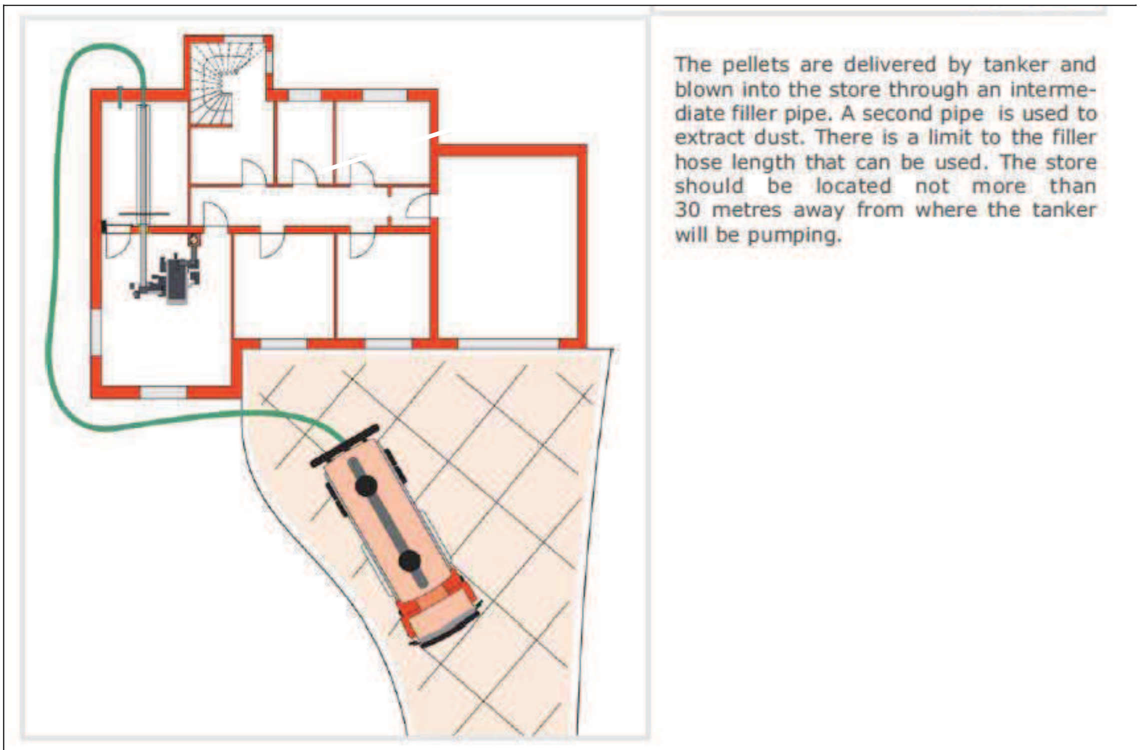


Proposed location of wood pellet boiler, fuel store and air source heat pumps (adapted from drawing produced by Collective Architecture)

An above-ground pre-fabricated metal pellet silo will be used for the storage of wood pellets, which will be clad with wood to improve the aesthetics of the silo and located adjacent to the new boiler room. It is recommended that a 5.7m3 silo is used, which would be capable of storing around 3 tonnes of pellets- equivalent to around 6 weeks of demand in winter months. The pellets would be delivered from the silo to the boiler via a screw auger.

Indicative design of pellet fuel store for option 2 (Courtesy of Mafa)

Fuel will be delivered to the site by a specialist wood pellet delivery vehicle which will blow the pellet into the store via a flexible filler pipe (see image below). This delivery method allows bulk deliveries without the need for a subterranean fuel store, and requires no manual handling or other involvement from onsite staff.



Indicative wood pellet delivery arrangement for Option 2 (non site-specific). Courtesy of Econergy

A 1000 litre hot water accumulator tank will be installed alongside the biomass boiler. This will act as a buffer, reducing cycling of the biomass boiler as instantaneous demand rises and falls, and will allow the biomass boiler to operate continuously for several hours at times of sustained low demand. It will also increase the effective maximum output of the system, with a 1000 tank enabling the system to meet a peak demand of 32kW for over 3 hours.

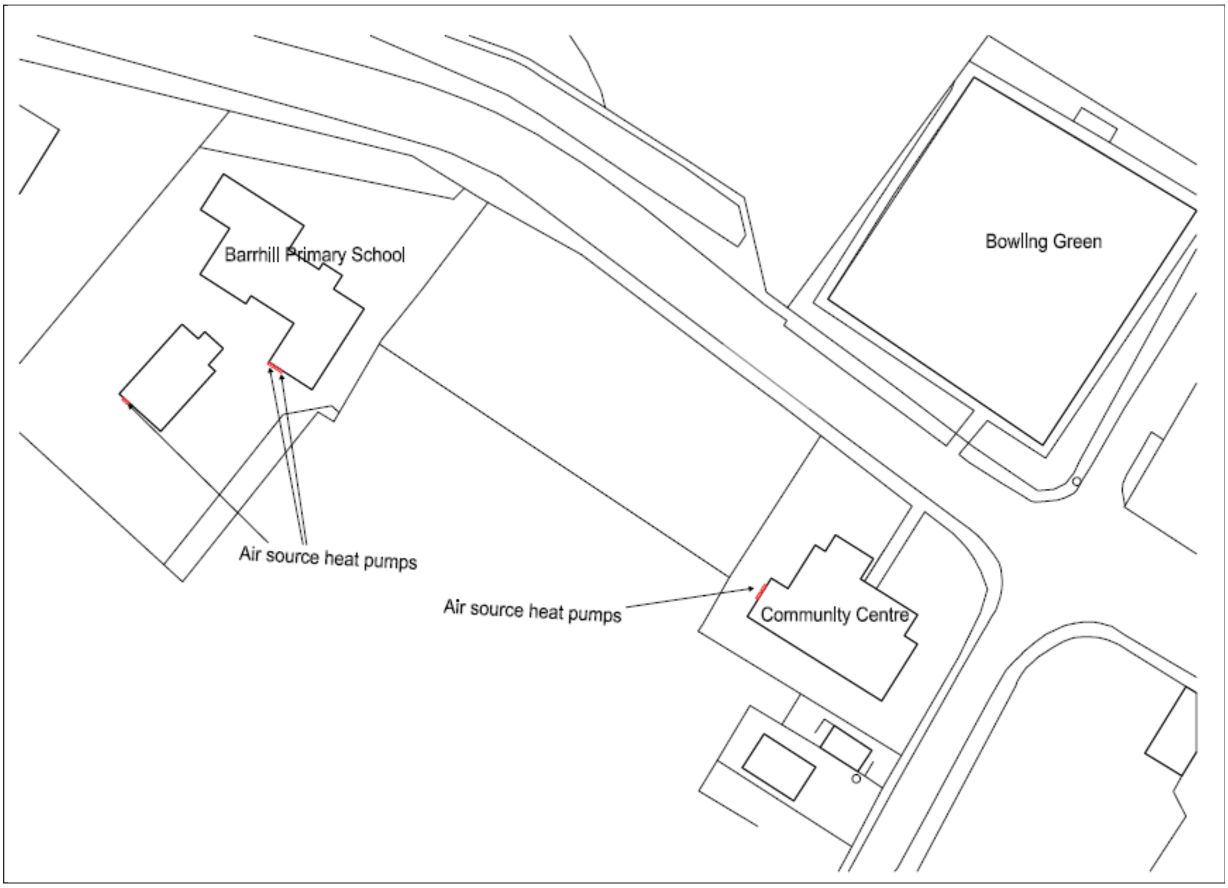
Within the boiler room there will be the 25kW wood pellet boiler, a 1000 litre accumulator tank, power and control equipment, a pressurisation unit and circulation pumps.

It is proposed that three 14kW air source heat pumps are installed to supply heat to the school. These will be located immediately adjacent to the school (see site plan on previous page), with heating supplied to the school via standard low temperature hot water distribution pipework.

The maximum combined heat output of the heat pumps in the school would be 42kW, dropping to around 36kW at very low ambient temperatures. Based on an estimated peak heating load of 44kW, it is apparent that top-up would be required in the event of very low ambient temperatures. To keep costs down, it is recommended that several of the existing storage heaters are retained for this purpose. However, if the client prefers then a number of new non-storage type electric heaters could be installed in place of the existing heaters.

7.1.3 Option 3

Under this option, ASHPs would be installed to provide heating and hot water to both the school and the hall. Three 14kW units would supply the school and two units would supply the hall, all of which would be fitted externally immediately adjacent to the relevant building (i.e. the units supplying the school would be located adjacent to the school and the units supplying the hall would be located adjacent to the hall) (see site plan below- also see drawing *M005 Site Layout Option 2*, submitted with this report).



Proposed location of wood pellet boiler, fuel store and air source heat pumps (adapted from drawing produced by Collective Architecture)

As under Option 2, the maximum combined heat output of the heat pumps in the school would be 42kW, dropping to around 36kW at very low ambient temperatures. Based on an estimated peak heating load of 44kW, it is apparent that top-up would be required in the event of very low ambient temperatures. To keep costs down, it is recommended that several of the existing storage heaters are retained for this purpose. However, if the client prefers then a number of new non-storage type electric heaters could be installed in place of the existing heaters.

Likewise, maximum combined heat output of the heat pumps in the hall would be 28kW, dropping to around 24kW at very low ambient temperatures. It has been assumed in this report that all of the existing electric storage heaters will be removed from the hall, however given that the hall currently has an estimated peak heating load of 34kW the client may wish to retain some of these heaters until the hall is refurbished.

7.1.4 Option 4

For comparative purposes, the option of installing a single oil boiler to serve both the school and the hall is outlined. A 90kW boiler would be installed in a purpose built plant room, which could be located either in the south east corner of the proposed car park as per option 1 or adjacent to the hall. The budget costs provided in this report are based on the former, with heat supplied to the two buildings via district heating pipework. An oil storage tank would be required, and based on the estimated heating demand for the site it is recommended that an 8000 litre steel tank is installed.

Heat output to each of the buildings would be metered, allowing individual billing, and the heating and hot water distribution systems would be identical to those outlined in Option 1.

7.1.5 Option 5

The installation of separate oil boilers has also been considered, with a 50kW boiler supplying heat to the school and a 40kW boiler supplying heat to the hall. The former could be located either within the storage area of the school's outbuilding or within a newly constructed plant room adjacent to this building, with a 3500 litre steel storage tank located externally. The budget cost outlined in this report assumes that no new plant room would be required.

The 40kW boiler supplying the hall would be located in a new purpose built plant room on the south side of the hall, with a 2500 litre steel storage tank installed externally adjacent to the plant room.

7.2 Controls and distribution system

7.2.1 Distribution system

For all five options outlined above, a new low temperature hot water (LTHW) distribution system will be installed in place of the existing electric system. For options 1, 2 and 4, highly insulated district heating pipework will be laid between the new boiler house and the building(s) to be heated. The routes of this pipework are indicated in the options outlined above.

For the biomass and oil options, standard panel radiators would be installed in the school and hall as indicated in the drawings below (also see drawing *M001 School Heating Plan View* and drawing *M002 Hall Heating Plan View*, submitted with this report). For the air source heat pump options, larger radiators would be required to compensate for the lower flow temperatures associated with ASHPs. The required output of each radiator (for biomass and oil options) has been indicated in the Radiator Schedule, submitted with this report.

For the ASHP option, whilst it is possible to achieve slightly higher efficiencies if under-floor heating is used (due to lower flow temperatures), it was felt that this would cause excessive disruption and that panel radiators would be a more practical solution. If under-floor heating is preferred in either the hall or school, then this could be installed in place of the panel radiators.

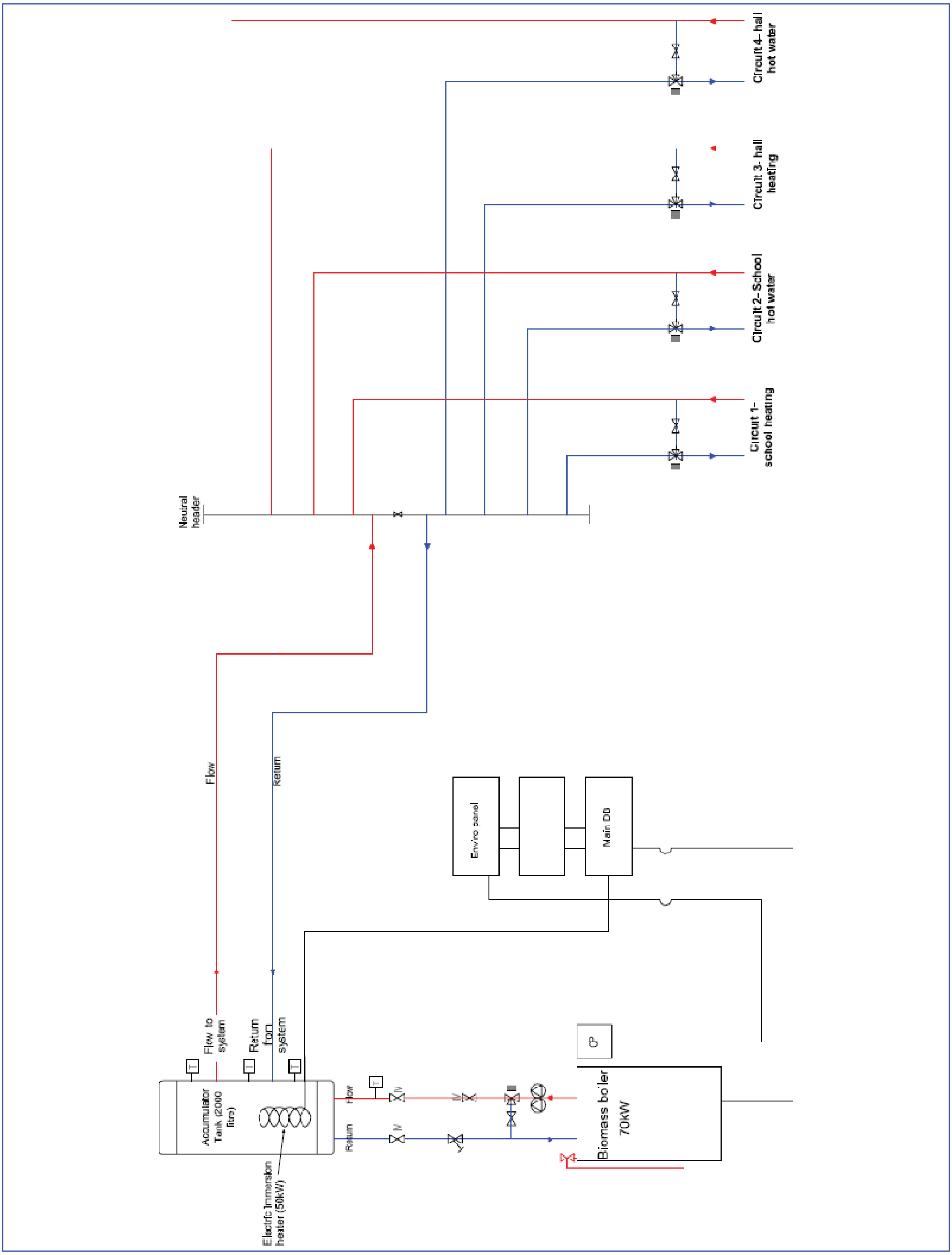
7.2.2 Controls

Where a single heating system has been recommended (Options 1 and 4), individual control is afforded by the inclusion of separate heating and hot water circuits for each of the buildings along with thermostatic radiator valves in all rooms. Separate billing is also made possible by the installation of a heat meter on each heating circuit.

The biomass boilers specified in Options 1 and 2 are supplied with a boiler control panel which enables full user control and programming of the boiler. However, for Option 1 an environmental panel (central control panel) would also be required to enable separate control of the two heating and hot water circuits in the school and hall. For the ASHP systems, a control panel would be fitted in the school (Option 2) and hall (Option 3) to control the output of the units. This would automatically balance the output between the different units to optimise efficiency, and would rotate use between units to ensure equal operating times and thereby reduce maintenance requirements.

Remote monitoring and control of the heating system could be made possible under all options depending on client requirements, but this has not been included for in this report.

7.3 System schematic- Option 1



Schematic arrangement- Option 1

8. Financial analysis and carbon savings

Budget costs have been compiled for the options outlined above. These costs are based primarily on budget quotations obtained from suppliers and installers, however estimates have been used for some items.

The annual operating costs associated with each option, including an oil system, have also been estimated, and simple paybacks calculated. In addition, the predicted carbon savings delivered by a biomass system relative to the existing electric system have been calculated.

8.1 Capital expenditure- cost breakdown estimates

8.1.1 Option 1

Item	Cost to school	Cost to hall	Total cost
Biomass boiler & accumulator tank	£ 18,050.00	£ 17,550.00	£ 35,600.00
Boiler room pipework & mechanical costs	£ 3,575.00	£ 3,575.00	£ 7,150.00
Boiler room electrical costs	£ 975.00	£ 675.00	£ 1,650.00
Flue	£ 900.00	£ 900.00	£ 1,800.00
System controls	£ 1,500.00	£ 1,500.00	£ 3,000.00
Boiler house construction	£ 11,300.00	£ 11,300.00	£ 22,600.00
Subterranean woodchip store	£ 20,000.00	£ 20,000.00	£ 40,000.00
District heating mains	£ 6,970.00	£ 1,475.00	£ 8,445.00
Internal radiators & pipework	£ 4,000.00	£ 4,000.00	£ 8,000.00
Commissioning	£ 500.00	£ 500.00	£ 1,000.00
Planning & structural engineering fees	£ 750.00	£ 750.00	£ 1,500.00
Sub-total	**£ 68,520.00**	**£ 62,225.00**	**£ 130,745.00**
Design & project management @ 10%	£ 6,852.00	£ 6,222.50	£ 13,074.50
Profit @ 10%	£ 6,852.00	£ 6,222.50	£ 13,074.50
Total cost	**£ 82,224.00**	**£ 74,670.00**	**£ 156,894.00**

Potential cost savings for Option 1:

- A 70kW Hargassner woodchip boiler has been specified. Cheaper boilers are available which could deliver a saving of up to £8000, however consideration should be given to warranty periods, the quality of after-sales service and reliability.
- A subterranean fuel store with capacity to store 10 tonnes of woodchip has been specified; this will give a fuel supply for approximately 4 weeks in the winter. As explained to Dave Holtom of BCIC, an alternative option would be to construct an above-ground blockwork fuel store. This could save up to £20,000, but it would require access to a front-loader such as a tractor or JCB to transfer woodchip to the store, and

thought would have to be given to where the woodchip would be dropped by the fuel delivery company. Alternatively, a smaller subterranean store could be used, but careful consideration needs to be given to the reliability of fuel supplies in winter months if storage space is reduced.

Additional considerations:

- No provision has been made for a back-up power supply for the boiler in case of grid failure. This can be added if required at a cost of around £4000.
- Provision has been made for back-up to the school (in case of breakdown of the biomass boiler) in the form of an electric immersion heater within the accumulator tank, as requested by the client. However, this has been sized for heating and hot water provision to the school only. In any event, grid failure will disable this immersion heater as well as the biomass boiler.
- No provision has been made for the construction of a new access road

8.1.2 Option 2

Item	Cost to school	Cost to hall	Total cost
Biomass boiler & accumulator tank	£ -	£ 24,250.00	£ 24,250.00
Boiler room pipework & mechanical costs	£ -	£ 3,850.00	£ 3,850.00
Boiler room electrical costs	£ -	£ 800.00	£ 800.00
Flue	£ -	£ 1,200.00	£ 1,200.00
Boiler house construction	£ -	£ 15,500.00	£ 15,500.00
Wood pellet store	£ -	£ 7,000.00	£ 7,000.00
District heating mains	£ -	£ 1,575.00	£ 1,575.00
Air source heat pump units	£ 15,460.00		£ 15,460.00
Heat pump pipework & pump	£ 4,000.00		£ 4,000.00
Heat pump miscellaneous equipment	£ 1,600.00		£ 1,600.00
Heat pump installation, commissioning & expenses	£ 4,200.00		£ 4,200.00
System controls	£ 1,500.00	£ 400.00	£ 1,900.00
Internal radiators & pipework	£ 5,500.00	£ 4,000.00	£ 9,500.00
Commissioning	£ 250.00	£ 250.00	£ 500.00
Planning & structural engineering fees	£ 200.00	£ 750.00	£ 950.00
Sub-total	**£ 32,710.00**	**£ 59,575.00**	**£ 92,285.00**
Design & project management @ 10%	£ 3,271.00	£ 5,957.50	£ 9,228.50
Profit @ 10%	£ 3,271.00	£ 5,957.50	£ 9,228.50
Total cost	**£ 39,252.00**	**£ 71,490.00**	**£ 110,742.00**

Potential cost savings for Option 2:

- A 25kW Hargassner woodchip boiler has been specified. Cheaper boilers are available which could deliver a saving of up to £8000, however consideration should be given to warranty periods, the quality of after-sales service and reliability.
- A pre-fabricated galvanised steel fuel silo with the capacity to store 3 tonnes of wood pellet has been specified; this will give a fuel supply for approximately 6 weeks in the winter. An alternative, cheaper option would be to include an integral pellet hopper adjacent to the boiler- these are typically available in sizes up to around 500 litres (up to 325kg of wood pellet). This could save up to £6000, but it would require manual loading of the hopper which would need to be carried out every 6 days or so in winter months.

Additional considerations:

- No provision has been made for a back-up power supply for the boiler or ASHPs in case of grid failure. A generator to back-up the ASHPs can be added if required at a cost of around £3000.
- No provision has been made for the installation of new non-storage electric heaters in the school (to top-up the heat pumps in the event of very low ambient temperatures). Instead, it has been assumed that several of the existing storage heaters will be retained.
- No provision has been made for the construction of a new access road

8.1.3 Option 3

Item	Cost to school	Cost to hall	Total cost
Air source heat pump units	£ 15,510.00	£ 10,340.00	£ 25,850.00
Heat pump pipework & pump	£ 4,380.00	£ 2,920.00	£ 7,300.00
Heat pump miscellaneous equipment	£ 1,824.00	£ 1,216.00	£ 3,040.00
Heat pump installation, commissioning & expenses	£ 4,150.00	£ 2,850.00	£ 7,000.00
Electrical supplies to ASHPs	£ 1,050.00	£ 700.00	£ 1,750.00
System controls	£ 1,500.00	£ 1,500.00	£ 3,000.00
Internal radiators & pipework	£ 5,500.00	£ 5,500.00	£ 11,000.00
Commissioning of distribution systems	£ 250.00	£ 250.00	£ 500.00
Planning & structural engineering fees	£ 125.00	£ 125.00	£ 250.00
Sub-total	**£ 34,289.00**	**£ 25,401.00**	**£ 59,690.00**
Design & project management @ 10%	£ 3,428.90	£ 2,540.10	£ 5,969.00
Profit @ 10%	£ 3,428.90	£ 2,540.10	£ 5,969.00
Total cost	**£ 41,146.80**	**£ 30,481.20**	**£ 71,628.00**

Considerations for Option 3:

- No provision has been made for a back-up power supply for the ASHPs in case of grid failure. A generator to back-up the ASHPs in the school can be added if required at a cost of around £3000
- No provision has been made for the installation of new non-storage electric heaters in the school (to top-up the heat pumps in the event of very low ambient temperatures). Instead, it has been assumed that several of the existing storage heaters will be retained.
- It has been assumed in this report that all of the existing electric storage heaters will be removed from the hall, however given that the hall currently has an estimated peak heating load of 34kW the client may wish to retain some of these heaters until the hall is refurbished.

8.2 Funding opportunities

The availability of grant aid should be considered. The Low Carbon Buildings Programme Phase 2 offers grants of up to 50% of eligible project costs up to a maximum of £200,000, and the Community and Renewable Energy Scheme considers applications on a case by case basis.

In addition, the Renewable Heat Incentive (RHI) could provide significant annual income should it be introduced in April 20110, **and the financial analysis in this report assumes that the RHI will be introduced at the tariff levels set out in the government's consultation document. However, it should be noted that there have been strong indications from government that some grants (including those issued under the Low Carbon Buildings Programme) will have be repaid in order for the installation to receive payments through the Renewable Heat Incentive.**

8.3 Financial analysis

A preliminary financial analysis has been carried out in order to estimate the annual savings associated with each of the biomass and heat pump options outlined in this report. The annual running costs have been compared to those of an oil system, with indicative pay back periods based on the capital cost of installing separate oil systems as per Option 5.

The variables used in this analysis are given in the table below. Annual heating demand for both buildings is based on the assumptions stated in Section 3 of this report, while costs for woodchip and wood pellets are based on budget prices obtained from local suppliers. It has been assumed for the heat pump options that the majority of heating demand (approximately 75%) will be during the daytime, and therefore electricity tariffs will reflect this. However, if a decision is made to install ASHPs the client should be aware that more cost effective tariffs than those used here may be available, and that tariffs specific to ASHP users have recently been introduced by some electricity suppliers.

It should be noted that operation and maintenance costs have not been taken into account in the following analysis. For a 25kW wood pellet boiler it is estimated that an annual maintenance contract would cost in the region of £500, and for a 70kW woodchip boiler the cost is estimated at around £1000. For ASHPs, maintenance costs should be minimal (on a par with oil boilers).

Variables for financial analysis

Annual heating demand for school	71,993
Annual heating demand for refurbished hall	49671
Total annual heating demand for school & refurbished hall	121,664
Annual fuel demand for school at 80% efficiency	89991.25
Annual fuel demand for refurbished hall at 80% efficiency	62088.75
Total annual fuel demand at 80% system efficiency	152,080
Percentage of heat demand met by biomass (biomass options)	100.00%
Percentage of heat demand met by electric (biomass options)	0.00%
Percentage of heat demand met by ASHPs (ASHP options)	90.00%
Percentage of heat demand met by electric heaters (ASHP options)	10.0%
Estimated seasonal COP of ASHPs	2.80
Cost of wood pellets (£/kWh)	£0.0370
Cost of woodchip (£/kWh)	£0.0275
Cost of heating oil (£/kWh)	£0.0450
Cost of electricity for heating (average)	£0.1000
Value of Renewable Heat Incentive (£/kWh) (biomass <45kW)	£0.0900
Value of Renewable Heat Incentive (£/kWh) (biomass 45 to 500 kW)	£0.0650
Value of Renewable Heat Incentive (£/kWh) (ASHPs <45kW)	£0.0750
Carbon emissions factor for oil (kg CO_2/ kWh)	0.265
Carbon emissions factor for wood pellets (kg CO_2/ kWh)	0.025
Carbon emissions factor for woodchip (kg CO_2/ kWh)	0.025
Carbon emissions factor for grid electricity (kg CO_2/ kWh)	0.592

Option 5- Oil system (separate systems for each building)

Budget capital costs

	School	Hall	Total
Capital cost of oil system	£23,305	£35,514	**£58,819**

Estimated annual operating costs

	School	Hall	Total
Annual oil cost	£4,049.61	£2,793.99	£6,843.60
Estimated annual income from Renewable Heat Incentive at 6.5 pence/kWh	£0.00	0	£0.00
Net annual operating expenditure	**£4,049.61**	**£2,793.99**	**£6,843.60**

Option 1- single biomass system

Budget capital costs

	School	Hall	Total
Capital cost of biomass system	£82,224	£74,670	£156,894
Capital cost of oil system	£23,305	£35,514	£58,819
Additional capital cost of biomass system	**£58,919**	**£39,156**	**£98,075**

Estimated annual operating costs

	School	Hall	Total
Annual woodchip cost	£2,474.76	£1,707.44	£4,182.20
Estimated annual income from Renewable Heat Incentive at 6.5 pence/kWh	£4,679.55	£3,228.62	£7,908.16
Net annual operating expenditure	**-£2,204.79**	**-£1,521.17**	**-£3,725.96**

Option 2- wood pellet boiler for hall, ASHPs for school

Budget capital costs

	School	Hall	Total
Capital cost of pellet/ ASHP system	£39,252.00	£71,490	£110,742
Capital cost of oil system	£23,305.00	£35,514	£58,819
Additional capital cost of biomass system	**£15,947.00**	**£35,976**	**£51,923**

Estimated annual operating costs

	School	Hall	Total
Annual wood pellet cost		£1,838	£1,837.83
Annual electricity cost (heating)	£3,033.99		£3,033.99
Estimated annual income from Renewable Heat Incentive at 9 pence/kWh (hall biomass)		£3,228.62	£3,228.62
Estimated annual income from Renewable Heat Incentive at 7.5 pence/kWh (school ASHPs)	£4,859.53		£4,859.53
Net annual operating expenditure	**-£1,825.54**	**-£1,390.79**	**-£3,216.32**

Option 3- ASHPs for both buildings

Budget capital costs

	School	Hall	Total
Capital cost of ASHP system	£47,897	£31,171	£79,068
Capital cost of oil system	£23,305	£35,514	£58,819
Additional capital cost of biomass system	**£24,592**	**-£4,343**	**£20,249**

Estimated annual operating costs

	School	Hall	Total
Annual electricity cost	£3,033.99	£2,093.28	£5,127.27
Estimated annual income from Renewable Heat Incentive at 7.5 pence/kWh	£4,859.53	£3,352.79	£8,212.32
Net annual operating expenditure	**-£1,825.54**	**-£1,259.51**	**-£3,085.05**

Simple payback- school

	Capital cost	Additional capital cost compared to oil system	Net annual running cost	Annual cost savings compared to oil system	Simple payback (years)
Oil boilers (option 5)	£23,305.00	NA	£4,049.61	NA	NA
Option 1- single woodchip boiler	£82,224.00	£58,919	-£2,204.79	£6,254	9.4
Option 2- wood pellet boiler & ASHPs	£39,252.00	£15,947	-£1,825.54	£5,875	2.7
Option 3- ASHPs	£47,897.00	£24,592	-£1,825.54	£5,875	4.2

Simple payback- hall

	Capital cost	Additional capital cost compared to oil system	Net annual running cost	Annual cost savings compared to oil system	Simple payback (years)
Oil boilers (option 5)	£35,514.00	NA	£2,793.99	NA	NA
Option 1- single woodchip boiler	£74,670.00	£39,156	-£1,521.17	£4,315	9.1
Option 2- wood pellet boiler & ASHPs	£71,490.00	£35,976	-£1,390.79	£4,185	8.6
Option 3- ASHPs	£31,171.00	-£4,343	-£1,259.51	£4,054	-1.1

Simple payback- combined

	Capital cost	Additional capital cost compared to oil system	Net annual running cost	Annual cost savings compared to oil system	Simple payback (years)
Oil boilers (option 5)	£58,819.00	NA	£6,843.60	NA	NA
Option 1- single woodchip boiler	£156,894.00	£98,075	-£3,725.96	£10,570	9.3
Option 2- wood pellet boiler & ASHPs	£110,742.00	£51,923	-£3,216.32	£10,060	5.2
Option 3- ASHPs	£79,068.00	£20,249	-£3,085.05	£9,929	2.0

8.4 Carbon savings

As would be expected, a reduction in annual carbon emissions would be achieved following the installation of either a biomass or ASHP system. As can be seen from the below table, the carbon savings associated with a biomass system are significantly greater than those delivered by ASHPs. This is due to the reliance of ASHPs on grid electricity for their input energy (although this reliance could be reduced to some extent if, for example, a photovoltaic array was to be installed in conjunction with the ASHPs- see Section 9).

Carbon emissions

	Annual carbon emissions, tonnes CO2	Annual reduction in carbon emissions, tonnes CO2	Annual reduction in carbon emission, %
Oil system	40.3	NA	NA
Option 1- single woodchip boiler	3.8	36.5	90.6%
Option 2- wood pellet boiler & ASHPs	19.2	21.1	52.4%
Option 3- ASHPs	26.1	14.2	35.3%

9. Photovoltaic installation

The Barrhill community has expressed interest in the idea of installing a photovoltaic array to supply electricity to the hall and school. Based on a 9.45kWp system (i.e. a system with a rated peak output of 9.45kW) producing 7530kWh of electricity per year (as indicated by a PV installation company consulted by the client), carbon savings of around 4.5 tonnes/year would be achieved and FIT payments of £2718 received (7530kWh x £0.361).

Power from the PV installation could either be entirely exported to the national grid, or as is more common could be used onsite when the demand exists and exported to the grid when there is insufficient onsite demand. The latter is easily achieved by installing a control panel and export panel which automatically control the input and output of electricity to/from the grid.

To monitor electricity imports and exports, it is necessary to have a generator meter (measures the output of the PV panels), a supply meter (measures imports from the national grid) and an export meter (measures exports to the national grid). Generator and export meters are also required in order to claim the Feed in Tariff and export tariffs.

10. Planning considerations

If the decision is made to progress with any of the options outlined in this report, the local planning authority should be contacted at the earliest opportunity to discuss the proposed scheme. Whilst it would be inappropriate to pre-empt any decision by the planning authority, planning officers are increasingly being encouraged to consider renewable energy schemes in a positive light and to assist with their development wherever possible.

The main issues to consider in terms of planning are:

- Construction of new boiler house and fuel store (biomass)
- Fuel delivery arrangements (biomass)
- Boiler emissions (biomass)
- Flue requirements (biomass)
- Location of air source heat pumps
- Noise (air source heat pumps)

10.1. Option 1- woodchip boiler

For the woodchip boiler, the subterranean fuel store should not be an issue in terms of its visual impact given that it is underground. The boiler house will have to designed in such a way as to ensure that it is in keeping with the surrounding area. Fuel deliveries under this option would be infrequent, with a standard 10 tonne-capacity tipper trailer lorry delivering woodchip to the site approximately once every 4 weeks in winter months and as little as once every 10 weeks in summer months.

The flue will be of a stainless steel circular construction with a diameter of 200mm, and will terminate approximately 1000mm above the roofline of the boiler house. This can be painted if necessary. In terms of emissions, the specified boiler is Clean Air Act exempt.

10.2. Option 2- wood pellet boiler and air source heat pumps

The fuel store and boiler house will have to be designed appropriately, and the local planning authority should be consulted at the earliest opportunity. Deliveries of wood pellet would be approximately once every 6 weeks in winter months and only every 12 to 15 weeks in the summer. Delivery would most likely be via a fixed 6 or 8 wheel lorry, and the pellets would be blown from the delivery vehicle to the fuel silo through a flexible hose. The noise associated with this process can be significant (the fuel supplier should be consulted for accurate noise levels), so fuel deliveries should be timed appropriately.

The boiler flue in this case will be of a stainless steel circular construction with a diameter of 170mm, and will terminate approximately 1500 to 2000mm above the roofline of the boiler house. The increased height compared to Option 1 is due to the fact that the smaller boiler does not have an induced draught fan to generate the necessary draught. The flue can be painted if necessary. In terms of emissions, the specified boiler is Clean Air Act exempt.

The main issue to consider with ASHPs is the noise level. For the units specified here, the noise level measured at 1 metre from the unit is 53dBA. Given that there the nearest dwelling is approximately 15 metres from the school, this shouldn't be an issue.

10.3. Option 3- air source heat pumps

As with Option 2, the main factor to consider here is the noise level. However, the noise associated with the ASHPs specified in this report should not be an issue as there are no dwellings in the immediate vicinity of the hall and the nearest dwelling to the school is around 15 metres away.

10.4. Photovoltaic array

The local planning authority should be consulted regarding the installation of photovoltaic panels, but planning guidelines for photovoltaic systems have become increasingly favourable and it is unlikely that there will be any major issues in this area.

11. Conclusions and recommendations

This report has considered the viability of installing a renewable energy or 'low carbon' heating system for provision of heating and hot water to Barrhill Primary School and Barrhill Memorial Hall. Biomass and air source heat pump systems have been evaluated, and for comparative purposes an oil boiler system has also been looked at.

Based on heating demand profiles and other site-specific factors, the following options are considered to be the most suitable:

1) 70 kW woodchip/pellet boiler with a subterranean fuel store, supplying heat to both the school and the hall.
2) 25kW wood pellet boiler with above-ground fuel store supplying heat to the hall. 3 x 14kW air source heat pumps supplying heat to the hall.
3) 3 x 14kW air source heat pumps supplying heat to the school, 2 x 14kW air source heat pumps supplying heat to the hall. Top-up from existing electric storage heaters in the school.

In addition, the following oil boiler options have been considered for comparative purposes:

1) 90kW oil fired boiler providing heat to both the school and the hall.
2) 50kW oil fired boiler providing heat to the school and a 40kW oil fired boiler providing heat to the hall.

The capital expenditure, annual running costs and carbon emissions associated with each of the above options have been evaluated, and are summarised in the tables below. It is important to note that net annual running costs assume that the Renewable Heat Incentive will be introduced in April 2011 at the tariffs proposed in the government's consultation document, and that this is a major component of the estimated annual savings outlined in this report.

Simple payback- combined

	Capital cost	Additional capital cost compared to oil system	Net annual running cost	Annual cost savings compared to oil system	Simple payback (years)
Oil boilers (option 5)	£58,819.00	NA	£6,843.60	NA	NA
Option 1- single woodchip boiler	£156,894.00	£98,075	-£3,725.96	£10,570	9.3
Option 2- wood pellet boiler & ASHPs	£110,742.00	£51,923	-£3,216.32	£10,060	5.2
Option 3- ASHPs	£79,068.00	£20,249	-£3,085.05	£9,929	2.0

Carbon emissions

	Annual carbon emissions, tonnes CO2	Annual reduction in carbon emissions, tonnes CO2	Annual reduction in carbon emission, %
Oil system	40.3	NA	NA
Option 1- single woodchip boiler	3.8	36.5	90.6%
Option 2- wood pellet boiler & ASHPs	19.2	21.1	52.4%
Option 3- ASHPs	26.1	14.2	35.3%

The installation of a woodchip boiler serving both buildings would deliver the greatest annual carbon reduction (about 90% compared to an oil-fired system), but requires significantly more capital expenditure than other options. Installing air source heat pumps in the school and hall is by far the lowest cost solution, but the carbon reduction associated with heat pumps is only 35% and many people would not consider this option to be a renewable energy installation.

Option 2, which considers the installation of a wood pellet boiler for the hall and ASHPs for the school, may be a more attractive solution depending on the preferences of the BCIC and South Ayrshire Council. This offers relatively high carbon savings, and reduced capital expenditure compared to Option 1.

All three options deliver similar annual cost savings when compared to an oil-fired system

Issues to consider

It is apparent that the capital costs outlined in this report are of major concern to the client. In light of this, the following factors should be considered:

- For Option 1, a 70kW Hargassner woodchip boiler has been specified. Cheaper boilers are available which could deliver a saving of up to £8000, however consideration should be given to warranty periods, the quality of after-sales service and reliability.
- For Option 1, a subterranean fuel store with capacity to store 10 tonnes of woodchip has been specified; this will give a fuel supply for approximately 4 weeks in the winter. As explained to Dave Holtom of BCIC, an alternative option would be to construct an above-ground blockwork fuel store. This could save up to £20,000, but it would require access to a front-loader such as a tractor or JCB to transfer woodchip to the store, and thought would have to be given to where the woodchip would be dropped by the fuel delivery company. Alternatively, a smaller subterranean store could be used, but careful consideration needs to be given to the reliability of fuel supplies in winter months if storage space is reduced.
- For Option 2 a 25kW Hargassner woodchip boiler has been specified. Again, cheaper boilers are available which could deliver a saving of up to £8000, however as with

Option 1 consideration should be given to warranty periods, the quality of after-sales service and reliability.

- For Option 2 a pre-fabricated galvanised steel fuel silo with the capacity to store 3 tonnes of wood pellet has been specified; this will give a fuel supply for approximately 6 weeks in the winter. An alternative, cheaper option would be to include an integral pellet hopper adjacent to the boiler- these are typically available in sizes up to around 500 litres (up to 325kg of wood pellet). This could save up to £6000, but it would require manual loading of the hopper which would need to be carried out every 6 days or so in winter months.

Ultimately, the most suitable solution depends on the priorities of the client and the relative importance of factors such as carbon emissions, capital expenditure and the level of automation required in fuel deliveries and fuel handling. In addition, it should be remembered that the annual cost savings outlined within this report are dependent on the introduction of the Renewable Heat Incentive at the tariffs proposed in the government's consultation document.