Addendum Appendix

1. Barrhill Memorial Hall Energy Performance & Sustainability Report

2. Heat Loss - Barrhill Hall Existing

3. Heat Loss - Barrhill Hall Proposed

Barrhill Memorial Hall
Energy Performance & Sustainability Report

By Locate Architects
For the Barrhill Community Interest Company

To be read in conjunction with Collective Architecture's Feasibility Study (and may be incorporated therein)

Contents

Introduction

This report was commissioned by the Barrhill Community Interest Company (BCIC) as a Specialist Report to be prepared in conjunction with an ongoing Feasibility Study by Collective Architecture into the Proposed Renovation and Extension of the Barrhill Memorial Hall.

The purpose of this report is to ascertain the energy performance of the building as it stands, but primarily the energy performance of the building as proposed by Collective Architecture in their larger Study. This then allows for a reasonably accurate Services strategy to be developed based on clearly understood heat and other energy loads.

A further requirement of the report is to comment on the wider energy supply options that have been mooted as part of a much wider range of works initiated by BCIC, and to comment generally on the sustainability aspects of all of these various scenarios.

The Energy Performance of the Building as Existing

The building as existing is described in Collective Architecture's report, the intention here is simply to discuss the energy aspects.

Roof

There are several areas of variously pitched roof across the building. We only investigated one area which we have taken to be representative of the others. The slates rest on a felt / fabric (not bituminised we believe) and are fixed through this felt to timber sarking boards. These are supported by timber rafters which in most cases appear to form part of trusses over the main spaces. Parts of the roofs are combed and in these areas plaster is affixed to the underside of these rafters, while in central areas there is a loft area and ceiling joists to which the plaster is attached. There appears to be around 50mm of asbestos type insulation in parts of the roof. We have taken the 'U' value to be an average of 1.2 W/m^{2}k.

Walls

The external brick leaf beneath the rendered upper portions is stretcher bond without headers. We have assumed therefore that it is a cavity brick wall, although this would benefit from confirmation as it would have seemed more likely that this was a solid wall building judging by its age. We have assumed 100mm thick outer leaf, 100mm thick uninsulated cavity and 100mm thick inner leaf with battens and plaster finish internally. Externally there is a render finish to the upper portions of the wall but we have taken a 'U' value for all wall areas as 1.1 W/m^{2}k.

Joinery

All windows appear to be single glazed and in some cases are fairly draughty. We have allowed a standard 'U' value of 4.3 W/m^{2}k. We have taken doors to be the same as windows and included them in the same figure which is a little conservative.

Floor

The floor of the building appears to be of a suspended timber construction, although we have deduced this mainly from the ventilation bricks around the perimeter of the building externally. Internally the floors appear unusually solid and 'unbouncy' which probably indicates a greater number of supporting walls than is normally encountered. All those asked suspect that the floor remains uninsulated, so we assume that there is at least the timber floor boards on joists, and at most a second board layer over joists and we have proposed a 'U' value of 1.9 W/m^{2}k.

Ventilation

Apart from one or two extract fans, there is no mechanical ventilation to the building and apart from opening windows, the only ventilation feature appears to be three large grilles in the ceiling of the Main Hall which appear to allow all the warm air in the Hall into the uninsulated loft space. We can speculate as to the purpose of these grilles, one reason might be to ensure adequate ventilation to the roof spaces, which would underline the need for an adequate ventilation strategy to the roof members if the roof spaces are insulated. In the absence of any other ventilating apparatus we have taken for an air change rate of 0.6 which in practice we suspect to be largely achieved by air leakage.

Air Leakage and Thermal Bridging

With a ventilated solum which is almost certainly connected in parts to the void behind the wall plaster, and with large grilles in the ceiling leading to the loft spaces, we have assumed that there is a high level of air leakage in the building. Assuming further that thermal bridging takes place via wall ties in the relatively insulating walls, we have indicated a high additional heat load associated with air leakage and thermal bridging.

Incidentals

Incidental gains are likely to be very low as the building tends to be unoccupied for large periods of time, and relative to a house, has few heat emitting lights, hot water pipes, pumps and fans etc. One could argue for a slightly higher level of gains due to the relatively large area of South-West facing windows, but in reality this is likely to be balanced by large areas of glazing elsewhere and large amounts of heat loss at nights for while there are curtains they are of negligible value in retaining heat and are presumably not always drawn at night.

Hot Water

Lastly, hot water use is taken to be minimal with a kitchen which is not used for food preparation and minimal hand washing need for hot water.

Energy Load

Based on the above, and the various areas noted in the spreadsheet, we have calculated a Specific Heat Loss of just over 1.6kW which is pretty high, and annual space and water heating demand (assuming a constant temperature of 19°C internally) of 84,000 kWh, based on an occupancy / heating percentage of 72.5%. Whilst we understand that the Hall itself is kept heated, this reduction reflects the fact that the rest of the building is maintained at a lower temperature for most of the time.

An initial assessment of the electricity bills for the Hall indicated an annual electricity demand (for both heating and power) of approximately 84,000 kWh. We have chosen the occupancy factor in order to match the actual bills, but there is clearly a degree of ambiguity about exactly what percentage of the overall area of the building is maintained at exactly what internal temperature. The heating component of this overall figure represents the largest portion, with daytime usage (presumably lighting and hot water) at around 4.5% of the total.

The Energy Performance of the Building as Proposed

The Proposed building as described in detail in the larger study by Collective Architecture extends the existing building. The Main Hall and ancillary areas to the North are retained and refurbished, while the Snooker Room is extended Northwards toward the road and the Kitchen and Toilets are demolished and replaced by a larger built form which extends the main pitched roof providing a first floor store and larger Kitchen and toilets beneath.

Roofs

The outline specification proposes a general overhaul of the slate roof along with the addition of 300mm of mineral wool fibre insulation. In new build areas and loft areas where there is a flat ceiling this will be easily achieved, but in the coombes, assuming that the rafters are not as much as 300mm deep, then this will not be straightforward. A partial fill of the existing coombe cavities could be undertaken with, for example 150mm batts inserted behind the plaster within the rafters (difficult to achieve), with the remaining 150mm placed internally within a secondary structure and a further plasterboard finish added. Alternatively the plaster could be removed to ensure a tight and complete fit of the insulation between the rafters, and the same operation undertaken with, say 150mm of insulation between rafters and another 150mm placed within a new structure. Both of these options appear expensive however. Alternatively again, the internal insulation could be a rigid or semi-rigid board to simplify things and reduce the need for additional structure.

An altogether simpler option might be to place all of the insulation internally. If this option was chosen, it would probably be simpler to install rigid or semi-rigid insulation in layers fixed back to the original structure to avoid the need for a secondary structure. This option will however reduce the ceiling heights and whilst this might not be an issue for the higher rooms and central areas, it may become an issue in the smaller rooms and where the coombe meets the windows. Acoustics have been an issue for the Community in the Main Hall so this will also need to be addressed with the finish.

In any event, we have allowed for a much improved 'U' value of 0.14 W/m^{2}k. In addition we are assuming a much better performance overall in terms of air leakage and thermal bridges in these areas.

Two additional comments might be useful in respect of the wider energy and sustainability agenda. Firstly, it is important that where insulation is fitted between rafters, that it is a 'soft' material with an ability to be readily squashed into a tight fit along all edges and between batts of the same material. This will ensure that a genuinely tight fit is achieved with no air gaps around the edges and along the interface of the rafters and the insulation material. In contrast, any rigid material such as polystyrene will – however carefully cut – not fit exactly and this will lead to minute gaps. Even if the initial fitting is very neat, such gaps will inevitable appear over the lifetime of the building. It has been established that these minute gaps can contribute disproportionately to heat loss, such that, for example, a 4% gap will lead to a 50% reduction in the thermal efficacy of the construction.

Second, there remain among many Practitioners (including the Author) some very real concerns about the safety of mineral fibres. Unchecked, these fibres can enter the lungs and whilst they do not break down as finely as asbestos fibres, can nonetheless cause damage. Although this has been dismissed by the industry, the introduction of film-encased options might suggest a tacit recognition of the problem. An altogether 'greener' option might be to use the new generation of recycled plastic insulation. These insulations (there are several available) are of largely recycled material and consist of much larger fibres which do not pose the same risk to respiratory health.

Walls

The Outline Specification and QS costs indicate the use of external wall insulation (ewi), albeit to an unspecified depth, but which is likely to be around 50mm of ewi finished with a Sto render system or similar.

This may yet prove to be the way forward if we are incorrect about the walls, and certainly external wall insulation is preferable to internal wall insulation for a number of reasons. However, on the basis that the walls are cavity walls, we have indicated a simple filling of the cavity, which takes the 'U' value to a respectable 0.35 W/m^{2}k. Care needs to be taken to ensure that this installation does not block the air bricks to the solum, but otherwise, we can also assume that this will improve the air leakage as well as the steady state thermal resistance of the wall.

The process of cavity fill is likely to be considerably less expensive and disruptive than external wall insulation. Clearly this will have a significant effect on how the building looks, so cannot be a decision taken on the grounds of energy efficiency alone. Whilst external wall insulation in addition would of course improve the wall further, for the purposes of upgrading the building to a reasonable standard, this would not be necessary.

As much of the perimeter of the proposed building comprises new build wall (with an assumed 'U' value of approximately 0.17) we have indicated two types of wall build-up in the energy assessment.

Joinery

The outline specification suggests the use of Blair Windows for all replacement windows and doors. In discussion with Blair Windows we understand that the better of the two glazing options they offer is the use of "Planitherm" double glazed panel which, with argon fill, gives a glazing only 'U' value of 1.6 W/m^{2}k. (Meaning the whole window value will be somewhat worse / higher) Whilst this complies with Building Regulations, it is some way off the better performing windows on the market now and it may be worth considering windows / doors with a 'whole window' 'U' value of no worse than 1.2 W/m^{2}k if this is possible.

For passivhaus projects, it is not acceptable to use windows with a whole window 'U' value of greater than 0.8 W/m^{2}k – ie less than half the heat loss of the windows specified, however these high performance windows are very expensive. In the meantime, we have indicated a whole window 'U' value of 1.8 W/m^{2}k for the purposes of the energy assessment. Although this is the largest area of heat loss in the refurbished building, it is still theoretically less than half the heat loss of the existing single glazing. In addition, the new windows and doors will all be draughtstripped to modern levels of performance again increasing the overall performance of the building.

Floor

There doesn't appear to be a description of floor insulation in the specification or costs, only replacement and upgrading of the floor finishes. However, since underfloor heating is proposed, we assume that the floor is to be insulated. In order to minimise disruption to floor levels and skirtings etc. we have further presumed that when the floors are taken up, it will be possible to insert insulation between the joists before replacing the floor finish.

As with the roof, it would be advisable to use a 'soft' insulation. Ideally this would also be hygroscopic but in keeping with the roof, and to be cost effective, we suggest that one of the recycled plastic insulants would be suitable. To minimise thermal bypass, particularly air leakage and mixing with cold air beneath the floor structure, a vapour permeable but relatively airtight board (such as "bitvent" or "panelvent" should be laid at the base of the joists, all sides taped and then the joists infilled to a complete depth with insulation. The floor can then be laid over as normal. Assuming that the joists are 200mm deep, this would provide a 'U' value of approximately 0.16 W/m^{2}k. It is important that the boards are taped around their edges where they abut the joists, and it is also important that the perimeter of the floor structure is fully taped to ensure that air from within the solum cannot enter the building.

Ventilation

The feasibility study proposes a broadly passive ventilation strategy that will presumably entail no or a very low- energy input. We have not investigated this in detail but would note that this is likely to result in a more controlled rate of ventilation averaged over time at something like 1.5 ach. Note that this may well require to be much higher depending on the interpretation of the building function, for example, under CIBSE Guide B, the recommendations for Assembly Halls suggest background levels of ventilation at 3-4 ach, with up to 10 ach for highly occupied periods. However, taking into account the whole building these figures may only be required when the building is occupied so we can assume a lower level of air flow when the building is unoccupied, giving the average indicated.

It remains the case however that heat loss from the ventilation accounts for over half of the overall heat loss associated with the refurbished building, and could be even higher if higher air flow rates are needed.

Under the Building regulations, we are required to provide high levels of ventilation. Some, including the Author believe these levels to be excessive, but in any event, they now represent in most cases the greatest heat loss component of any building completed according to the most recent regulations. We would suggest that it may be worth investigating heat recovery ventilation, which is distinct from air conditioning in that all incoming air is fresh (unconditioned), but has been indirectly warmed by being passed through a heat exchanger, picking up warmth from the outgoing air which is being simultaneously exhausted. Over 85% of the outgoing heat can be recovered leading to major savings in heat input required.

Adopting a passivhaus approach to the ventilation could lead to a significant reduction in the heat loss associated with the ventilation, bringing the overall heat demand by a least a third and possibly half of the noted amount.

Air Leakage and Thermal Bridging

Assuming an insulated floor, filled wall cavities, an insulted roof and replaced windows, we may assume that the thermal bridging and air leakage will be significantly improved. We have however remained cautious with our figure since all independent research undertaken appears to suggest that actual – as opposed to predicted – rates of air leakage and thermal bridging are often considerably higher, due to the issue being poorly understood (if at all) at the design stage, and poorly executed on site.

Incidentals

We have raised the incidental gains because whilst there may be a small increase in the use of the building, the improvement in fabric performance and airtightness will mean that those gains which do accrue will be much more readily assimilated into the overall comfort levels.

Hot Water

Hot water use is still taken to be minimal, with a kitchen which is not used for food preparation and minimal hand washing need for hot water, but we have increased the amount slightly to account for greater use generally of the building, and in particular the kitchen.

Energy Load

Based on the above, and the various areas noted in the spreadsheet, we have calculated a Specific Heat Loss of just over 0.9kW which is just over half of the existing building. The annual space and water heating demand (assuming a constant temperature of 19^{o}C internally) is reduced to 49,500 kWh, about half of the original heating load, but with much higher temperatures and comfort levels in all areas – not just the Hall - assumed, and with the additional area of building taken into account.

Potential Short Term Eco-Refurbishment Works

Even if the funding is found for the refurbishment works to the building, it is accepted that it will be several years before the Hall can be fully upgraded as proposed. In the meantime, responsibility for the day-to-day running of the building, including the fuel bills, is due to be passed to the Community. Soon, therefore, the Community will be faced with some fairly substantial energy bills on a regular basis.

For this reason, it makes sense to investigate the possibility of discreet works being undertaken in advance of the major overhaul envisaged by the Feasibility Study that would have the effect of reducing the energy load and thus fuel bills for the Community.

There are of course a number of non-architectural, management options that could affect savings, such as by clustering the activities so that heating need only be provided over the course of, say three or four days, and left off for four or three days while the Hall remained empty. Given the unresponsive nature of the largely storage heating based electric heating delivery, it might in this way make more sense to let the management of the Hall be the ‘responsive’ element. However, there are limits to the feasibility of this and it is also probably outwith the scope of this report. It remains the case however that in every project, it is the behaviour of the occupants which affects the energy use of a building far more than the building itself.

Refurbishment Options

In terms of architectural works, what are needed are those works which would affect significant savings whilst not impinging on the proposed major works envisaged.

Insulating the floor, for example would not make sense as the floor is in good condition, it would be disruptive and expensive and it is intended to carry out this work in conjunction with underfloor heating installation and new heating delivery apparatus at the time of the proposed refurbishment. Replacing the windows would similarly be uneconomic and impractical in this light.

If the walls are of cavity construction, then filling the cavity would undoubtedly be the most cost effective and least disruptive work that could be undertaken. It would reduce the energy demand, improve comfort levels and would not lead to any reduction in the functionality of the spaces, even while the works were being carried out.

If the walls are solid, then it would not make as much sense to undertake the external wall insulation as this would more sensibly be carried out while the new construction was being erected, and as part of the wider overhaul of the external parts of the building.

This leaves the roof, and only the roof / ceiling of the Main Hall as all other areas would undergo alteration as part of the ultimate refurbishment. The details of any possible insulation are noted above under the Proposed Refurbishment, but amount to an increase in the insulation from nothing to 300mm.

Arguably, there is merit in only insulating the loft and between the rafters in the coombes, so that there is no, or little disruption to the Main Hall interior. This might mean reducing the depth of insulation installed (on the assumption that the rafter are not deeper than, say, 200mm). The flat ceilings could be insulated to the full 300mm but it would be very difficult to be confident that the combed areas of the ceiling were completely insulated (it is a long stretch and would be hard to physically install the stuff, let alone check). It is also true however, that increasing the insulation from none, to even as little as 150mm would be a significant improvement.

If a way could be found to ensure that the combed areas were adequately insulated (for example, removing the central area of plaster so that access can be gained above and below to the rafter void) then this might make sense. Any further internal insulation could be left until the major works, along with any alterations to the acoustic finish of the ceiling. This would significantly reduce the disruption and cost in the short term, but disproportionately improve the insulation levels and airtightness (assuming the grilles were sealed). Checking, upgrading and ventilation of the slates would have to take place at the same time. It would not be difficult to get a quote for these works.

Heat Supply Options

Given the high cost of electricity, it is possible that one option might be to replace the current storage / convection heaters with gas or oil supplied radiators (or even underfloor heating). Depending on what is known at the time on the likelihood of further works, this could be in itself a cost effective undertaking based largely on the lower cost of oil, which could ultimately be replaced with the woodchip boiler.

A better option, if it were possible, would be to install the woodchip heating boiler, whether or not it was linked to the School (see below) and use it to feed either radiators or underfloor heating, depending on the extent of the funding available at the time. It should be stressed however that distribution losses from underground pipes in district heating systems have been found to be far higher than initially predicted (often due to inadequate installation of insulation) and this should be factored into any prediction of the costs associated with a district heating system.

A simpler, but less ‘green’ option might be to replace the current heaters with fast response electric radiant heaters which provide large amounts of radiant only heating. These heat people, rather than air and need be switched on only when the building is occupied. This strategy has been employed on a number of buildings, but there are issues with the heaters themselves being in the way, for example, in Sports venues, and many people find them both unattractive and unpleasant in the type of heat they emit. A separate study could probably be provided by a Supplier for free to ascertain if substantial savings could be achieved. With no change in fuel supply and relatively little outlay, they could provide a sensible and cost effective temporary solution.

Of course, depending on how readily funding is available, there is nothing to stop all or any of the works being undertaken in the short term, walls could be externally insulated, floors lifted and insulated, windows replaced, woodchip boilers installed and so on, but we have focussed here on what is most likely to be cost effective. Financial pressures, changing priorities, more information about energy supply options and all manner of other variables may affect what ultimately makes sense in the short and medium term.

On the basis of what we understand now, and in conclusion; if the walls are of cavity construction, they are definitely worth filling and it probably makes more sense also to insulate the roof and ceiling of the Main Hall as described. No other insulating works are likely to be cost effective in the short term, given the impending refurbishment works, and the focus should be on management of the facility to reduce fuel bills. Regardless of the insulation measures, it would be ‘green’ and almost certainly cost effective to install the Woodchip boiler with whatever heating delivery mechanism made most sense in the short term, probably radiators.

Wider Energy Supply Options

Unfortunately for those who crave some clarity and brevity, the issue of possible alternative ‘external’ energy supply technologies and strategies only serves to complicate what is already an unwieldy set of variables. We are aware that a separate study will be commissioned by BCIC to investigate a range of renewable energy supply options, not necessarily limited to those that could supply Barrhill Memorial Hall.

In conversation with Dave Holtom, and in respect of potential renewable supply to Barrhill Hall, it was mentioned that two possible options have been mooted. The first, a stand-alone wind turbine is, we understand, not a likely candidate, but we were asked to put down some thoughts on this nonetheless. The second, a possible Woodchip Boiler supplying the hall and adjacent School is apparently much more likely.

A Wind Turbine

We understand that a number of relatively controversial wind farm projects have recently been given the go-ahead locally, and whilst these are likely to be financially beneficial to the community, it is unlikely that further turbines would be welcome.

A stand alone wind turbine, sized to manage all or most of the energy (heat and power) needs of both the Hall and the School would have the following advantages:

1. Whilst it is relatively easy to insulate buildings and reduce space heating loads, and to reduce hot water heating loads with solar thermal systems, it is relatively difficult to address the growing power needs of buildings. A wind turbine would enable both buildings to effortlessly de-carbonise their (almost certainly increasing) electrical power requirements. This is in addition to a de-carbonised heating and hot water demand of course.
2. Mains supplied electricity is by far the most carbon intensive (polluting) fuel available and so it is in many ways the one we should be doing most to avoid.
3. The National Grid is under increasing pressure, particularly when there is most demand, and UK plc now imports an ever increasing amount of electricity to cover our shortfall. Anything which reduces this pressure is to be welcomed, and any building independently supplied is of course insulated from probable future power-cuts or rationing.
4. Locally and renewably supplied electricity allows us to take proper advantage of heat pump technology and realise the environmental benefits of this technology, particularly if carried out in combination with insulation works.
5. With locally and renewably supplied electricity, a number of other technologies or strategies which are otherwise not necessarily environmentally benign, such as rainwater harvesting and to an extent heat recovery ventilation, become unambiguously benign and more cost effective.
6. Any communally owned turbine would almost certainly provide cheaper electricity, depending on the purchase and maintenance arrangements, which would have significant benefits to the long term security of these valuable community facilities.

Arguably, the only disadvantage of a turbine is that whilst it makes a strong visual statement, it does nothing to draw people in the community together and will create little in the way of local work, apart, possibly, from a small amount of maintenance.

A Woodchip Heating System Shared with the School

We understand that a Woodchip Boiler has been mooted located centrally between the Hall and School as an integral part of the proposed landscaping works. Such an installation would have the following advantages.

1. It would create and reinforce social and economic links in the local area, between the School and Hall, and between both and Forestry Sector, creating a small amount of employment and retaining wealth in the local economy.

2. It would almost entirely de-carbonise the heating of space and water to both buildings, dispensing with carbon-dense mains electricity and replacing it with a locally available, renewable and almost zero-carbon source.
3. It would reduce the costs of the heat delivered to both Hall and School. Unlike other biomass fuels, it is unlikely that prices will track worldwide fossil fuel prices, so that those low prices are more secure in the long term.
4. Being a district heating system it would also increase efficiencies against individual boilers and could, if designed carefully allow for upgrading to enable supply of heat to other buildings in the area (for example, properties in the main street)
5. It would ensure that buildings remain warm even if power cuts or rationing are threatened. This may seem unlikely now, but many believe this will become a more common feature of daily life in the near future.

A woodchip heating system would not address the power requirements of the buildings unlike a turbine, but perhaps it is unfair to compare apples and pears in this way. There are storage, supply, access and safety issues to be addressed as well, but these would undoubtedly be addressed along with the overall design and implementation of the shared car park area. It is important also to emphasise the heat losses associated with inadequately insulated external pipe runs; this area should be carefully assessed in any feasibility work undertaken for BCIC.

We have carried out an initial energy assessment of the School. Given the high ceilings and high comfort levels required, our assessment anticipates 84,000kWh annually assuming a 60% reduction factor associated with school holidays and the reduction in heat input during the unoccupied periods (The school is generally only occupied for one third (8 hours) of the 24 hour period). This is at odds however with the recorded kWh used in conversation with the Janitor which is closer to 50,000kWh annually and also presumably includes lighting and equipment costs (though this is not confirmed). Apart from the possibility that the building is not consistently kept at the required temperature, which would explain some of the discrepancy, it is hard to fully explain this.

For the purposes of estimating the scale of boiler required, it would make sense to obey convention however and base the loads on the peak loads in the Hall and School of 34kW (as existing) (or 18kW when refurbished) and somewhere around 45kW for the School. It is not good practice to oversize Woodchip boilers because it is better to have them working at full capacity for long periods of time and reduce idling, so at this very initial stage, assuming that the Hall remain uninsulated, a boiler of around 80kW would seem in order. Perhaps a 50kW and 30kW boilers (rough sizes only) could be paired with the larger unit taking the load most of the time while the smaller unit kicks in on the rare occasions (often no more than 10 days in the year) when the peak loads are required.

Conclusions

The Proposed refurbishment of the building will have the overall effect of reducing the heat requirement by somewhere around a half, depending exactly on what is undertaken. Further investigation may be worthwhile in respect of the wall construction and ventilation strategy.

If more immediate insulation works are undertaken, it would make most sense to carry out cavity fill insulation – if the walls are of cavity construction - and it is also probably worth insulating the roof of the Main Hall.

Assuming that a Wind Turbine is not likely to be installed, the installation of a central Woodchip Boiler makes good sense on social, financial and environmental sustainability grounds and is to be strongly endorsed.

Appendices

Appendix A: Energy Performance Spreadsheets

Heat Loss Calculator	Barrhill Memorial Hall - As Existing			
Treated Floor Area	261			
Element	Area - m^2	U' value - W/m^2	Heat Loss - W	notes
Roof 1	310	1.2	372	
Roof 2			0	
Roof 3			0	
Wall 1	210	1.1	231	
Wall 1 Windows + Doors	60	4.3	258	
Wall 2			0	
Wall 2 Windows + Doors			0	
Wall 3			0	
Wall3 Windows + Doors			0	
Floor 1	261	1.9	495.9	
Floor 2			0	
Floor 3			0	
Add for Thermal Bridging and Air leakage			150	50W normal house (200sq.m), 25W passivhaus
				1507
Add Ventilation	Volume	W/m^3		
	937	0.33	Specific Heat of Air	
Heat required for 1 ac/hr		309.21		
Air Changes	0.6		185.53	0.6 a/c normal, 0.3 for PH
Specific Heat Loss			1692.43	Watts for 1°C temp difference
Heat Load for 20°C Uplift	SHL x 20/1000		33.85	kW (not Watts)
			28.4	volume/33 = typical peak load
Incidental Heat Gains in W			1000	average 1kW for house
Incidentals / SHL			0.59	°C
Base heating temperature			19	°C
Required Uplift after Incidentals			18.41	°C
Degree Days (look up next page)			2830	
Annual Space Heating Demand		dd x 24 x SHL	**114950**	in kWh/yr
kWh/sq.m/yr			440	
Add Hot Water	(say 1500kWh per person per annum in a house)			
			1000	in kWh/yr (kitchen use only)
	minus solar water		0	
Combined Total for Space and Water Heating			**115950**	in kWh/yr
kWh/sq.m/yr			444	
Occupied / Heated - %		72.5	**84063**	in kWh/yr
Gas				
Boiler Efficiency - %	85	Actual consump	98898	in kWh/yr
Unit cost of gas in kW/h (£)	0.031			
Annual Cost (excl standing orders)			£3,065.84	£/yr
Carbon emissions @	0.19	kg/kWh	18.79	in tonnes/yr
Conventional Electricity	(100% efficient at point of use)			
Unit cost in kW/h (£)	0.073	(Averaged from actual bills, excludes standing charges, VAT)		
Annual Cost (excl standing orders)			£6,136.63	£/yr
Carbon emissions @	0.59	kg/kWh	68.41	in tonnes/yr
Heat Pump				
Boiler Efficiency - %	150	Actual consump	56042	in kWh/yr
Unit cost of in kW/h (£)	0.12			
Annual Cost (excl standing orders)			£6,725.08	£/yr
Carbon emissions @	0.59	kg/kWh	33.06	in tonnes/yr

Heat Loss Calculator	Barrhill Memorial Hall - As Proposed			
Treated Floor Area	317			
Element	Area - m^2	U' value - W/m^2	Heat Loss - W	notes
Roof 1	380	0.14	53.2	
Roof 2			0	
Roof 3			0	
Wall 1	160	0.35	56	
Wall 1 Windows + Doors	80	1.8	144	
Wall 2	100	0.17	17	
Wall 2 Windows + Doors			0	
Wall 3			0	
Wall3 Windows + Doors			0	
Floor 1	317	0.16	50.72	
Floor 2			0	
Floor 3			0	
Add for Thermal Bridging and Air Leakage			75	50W normal house (200sq.m), 25W passivhaus
				396
Add Ventilation	Volume	W/m^3		
	1065	0.33	Specific Heat of Air	
Heat required for 1 ac/hr		351.45		
Air Changes	1.5		527.175	0.6 a/c normal, 0.3 for PH for houses
Specific Heat Loss			923.095	Watts for 1°C temp difference
Heat Load for 20°C Uplift	SHL x 20/1000		18.4619	kW (not Watts)
			32.3	volume/33 = typical peak load
Incidental Heat Gains in W			1500	average 1kW for house
Incidentals / SHL			1.62	°C
Base heating temperature			19	°C
Required Uplift after Incidentals			17.38	°C
Degree Days (look up next page)			2570	
Annual Space Heating Demand		dd x 24 x SHL	**56936**	in kWh/yr
kWh/sq.m/yr			180	
Add Hot Water	(say 1500kWh per person per annum in a house)			
			1500	in kWh/yr (kitchen use only)
	minus solar water		0	
Combined Total for Space and Water Heating			**58436**	in kWh/yr
kWh/sq.m/yr			184	
Occupied / Heated - %		85.0	49671	in kWh/yr
Gas				
Boiler Efficiency - %	85	Actual consump	58436	in kWh/yr
Unit cost of gas in kW/h (£)	0.031			
Annual Cost (excl standing orders)			£1,811.53	£/yr
Carbon emissions @	0.19	kg/kWh	11.10	in tonnes/yr
Conventional Electricity	(100% efficient at point of use)			
Unit cost in kW/h (£)	0.12			
Annual Cost (excl standing orders)			£5,960.52	£/yr
Carbon emissions @	0.59	kg/kWh	34.48	in tonnes/yr
Central / District Woodchip Heating Plant				
Boiler Efficiency - %	75	Actual consump	66228	in kWh/yr
Unit cost of in kW/h (£)	0.02			
Annual Cost (excl standing orders)			£1,324.56	£/yr
Carbon emissions @	0.03	kg/kWh	1.99	in tonnes/yr