Heating a small church

A report based on consultations with others using air-source heat pumps

Introduction

By the autumn of 2015, All Saints Church, Hethel had successfully installed a disabled toilet and a small kitchen unit. These facilities have made a significant difference to the life of the church, enabling the PCC to run more events for a wider range of people and to be more welcoming to visitors. As well as a clear rise in usage, many appreciative comments have been received.

Two other significant challenges remain: to improve parking; and to heat the church more effectively (than by portable gas heaters) so that it can be used all year round for a broader spectrum of activities. In 2016, the PCC decided to address heating.

Sustainability

For a number of years, Hethel Church has tried to both practice and promote sustainability. This thread of our existence has several strands to it, from a churchyard managed to promote biodiversity (for which we won a regional award in 2014), to ensuring that electrical energy is purchased from 100% renewable sources. In 2014, the church ran a full weekend on sustainability, showcasing everything from electric cars to rail travel, energy monitoring to carbon offsetting, and lightbulb choice to sustainable eating. It goes without saying, therefore, that any solution to heating the church should align with this policy of minimising carbon footprint and maximising sustainability.

This is entirely in line with the Church of England's national environmental campaign *Shrinking the Footprint*, which exists to enable the whole Church to address – in faith, practice and mission – the issue of climate change. To quote Archbishop Justin, "The present challenges of environment and economy, of human development and global poverty, can only be faced with extraordinary Christ-liberated courage. … Actions have to change for words to have effect." (www.churchcare.co.uk/shrinking-the-footprint accessed 5.7.17)

There is not space here and it should not be necessary to argue the case for Christians to be involved in mitigating climate change. The fifth 'mark of mission' of the Anglican Communion is "to strive to safeguard the integrity of creation, and sustain and renew the life of the earth" (www.anglicancommunion.org/identity/marks-of-mission.aspx). Those who remain to be convinced may be referred to Ruth Valerio's recent article in *The Magazine* (www.dioceseofnorwich.org/files/6014/8707/3424/The_Magazine_-_16_Mar-Apr_17.pdf), the Christian Aid (Board Chair Dr Rowan Williams) campaigns *The Big Shift* and *The Big Church Switch* (www.christianaid.org.uk/campaigns/climate-change/the-big-shift) or a book such as George Marshall's *Don't even think about it* (2015, Bloomsbury). Suffice it to say that 97% of the world's climate scientists are convinced that the climate is changing, that this is anthropogenic, and that major measures are essential to reduce carbon emissions if global warming is to be kept below 2^{o}C. Further resources include the IPCC 2014 report (summary here: www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf), the UN Framework Convention on Climate Change – think 'Paris Agreement' ('big picture' here: http://bigpicture.unfccc.int/) and the Cambridge Climate Lecture Series 2017 (http://www.climate-series.eng.cam.ac.uk/).

A significant conclusion from Marshall (op cit) is that rather than lone individuals, communities of practice are very much more likely to be successful in implementing change, with religious communities being singled out for mention for their historic effectiveness in encouraging people to make lifestyle changes. Churches are well-placed to lead individuals to amend their personal practice. However, arguments for change from those whose practice does not match their rhetoric are very unlikely to be listened to – the church which preaches one thing but practices another as an institution is unlikely to cut much ice. Pursuing sustainability as a church creates the best context within which to challenge the practice of individual members and so to build a community of practice. Such a community of practice stands a chance of influencing practice in the wider community to bring about real change in consumption patterns that will lead to a reduction in greenhouse gas emission.

How to heat a church – steady state or instant impact?

The church of All Saints, Hethel is currently used for a monthly (second Sunday) 8.30am service of Holy Communion and a 4pm family service once a month (fourth Sunday). There are a number of additional services and activities, but to date these have always been at weekends. The rural location of the church makes it unlikely that there will ever be activities on most days in the week. The church does have a regular stream of casual visitors who value the fact that it is always open.

Heating up the fabric of the building, therefore – a process that would take many hours – is not the best alternative if it is possible to heat the air sufficiently quickly to give an acceptable level of comfort to churchgoers. The target is steady state, but steady state where the loss of heat from the air to the walls is equal to the heat added to the air by the heating system. This is different to the more normal form of heating design where steady state is achieved between the loss of heat to the outside through walls and windows etc, and the heat fed in by the heating system.

Further possibilities are localised heating of people, either by under-pew heaters or by radiant heaters that ‘send’ energy to the congregation without much being absorbed by the air in between.

How to heat a church – energy source

What is the **best energy source**: gas, LPG, electricity, oil or biomass? The sustainable options are electricity (from solar, wind, tidal or hydro sources) and biomass sourced from a supplier committed to replanting. Mains gas is not available at Hethel in any case. LPG would require a large and visually unattractive storage tank and is a non-renewable fossil fuel. Oil requires a smaller tank, but is likewise non-renewable.

A **biomass** boiler has been considered and an outline quotation obtained. Advice suggests that a fully automatic system should be installed because one cannot assume that volunteers are available who can handle (to load the boiler) 25kg bags of (eg) woodpellets. This would add very considerably to the expense. Storage space for fuel must be provided and there is a need for regular (manual) de-ashing. It may not be possible to site the boiler safely and silently inside the church building (we had wondered about the mausoleum area), so an outside shed may be required. A flue would be necessary in any case.

Turning to the need to get the heat into the building, a water central heating system would make it easy to transport and distribute heat. Messrs Biomass Anglia based at the Hethel Engineering Centre offered an outline design and quotation for Hethel Church using cast radiators for a total figure of around £35000. The impact on the building would, however, be huge, with all walls lined with radiators, all pews and aisles needing to be adjusted and a substantial loss to seating capacity. Using pipes in floor channels (eg as at St Stephen's, Norwich – but this is for an 'always on' situation) would obviate this, but the cost would be no less.

Installing a warm air system from a single biomass-fuelled heat source would require extensive, unattractive ducting if all corners of the building are to be warmed and such a system is likely to be no less expensive.

Finally, although biomass can be a largely sustainable fuel if properly derived, there is an inevitable carbon overhead to cutting, processing and shipping the product. For example, in 2015, around 75% of woodpellets burned in the UK came from North America (www.globaltimber.org.uk/pellets.htm).

Which leaves **electricity** as the best option for fuel, by more than a process of elimination:

- Electricity is the only energy source that can be truly renewable. Suppliers such as Good Energy and Ecotricity guarantee that all of their electricity comes from renewable sources.
- Overall UK energy consumption is less than 25% electricity. (The data is not easy to find in a digestible form, but the second graph in a 2013 BBC article puts it at about 20%: www.bbc.co.uk/news/business-24823641. Deliberately, this does not break down the fuel used for electrical generation.) The point was emphatically made in the Cambridge Climate Lectures (see above) that this fraction needs to rise dramatically as it is primarily electricity that can be sourced renewably. By using electricity, the church will contribute to this necessary national migration.
- Electricity is the most flexible, the most instant energy source, both in the sense that it requires only the flick of a switch and because most electrical heaters have a low thermal mass compared to other forms of heating – they do not take more than a moment before emitting heat to the environment. Given the logic above re 'instant impact' in a church used only occasionally, this is another advantage.
- Electricity is an essentially dry heat that is unlikely to affect the building in anything but positive ways. Unlike, for example, the portable gas heaters in Hethel Church, electricity produces no condensation and the intention is to heat the air for relatively short periods of time, the temperature of the building itself rising very little. According to St Peter and St Paul, West Wittering, "English Heritage indicated that the effect on the fabric of the building would be relatively slight."

How to heat a church – heating technology

Having established that electricity is clearly the best fuel to use, how best to convert it to heat? A number of churches, including Flordon in the Mulbarton Benefice, have installed high-level radiant heaters. These, however, have significant 'downsides'. First, unless a church interior is very high, the heaters will always tend to heat people's heads more than their feet. This would certainly apply in Hethel with its relatively small size and interior ceiling. Secondly, Mrs Janice Hales, Churchwarden at St Michael's, Flordon, reports that the red glare from the heaters significantly affects her ability to see and to read. Thirdly, for, say, 30kW of heat, such heaters' electricity consumption is 30kW. A typical single-phase feed (such as to Hethel Church) is rated at 100A, which means that a 30kW heating system necessitates the installation of a three-phase supply at a typical cost of £5000.

Under-pew heaters, as recently installed at St Nicholas', Bracon Ash, can be effective, if somewhat limited in their power and unable to warm feet. But they could not be installed at Hethel without securing the pews to the floor, a retrograde step in terms of the versatility of the building and its present and future use. The same issue as for radiant heaters might well arise in regard to power output and the need for the installation of a three-phase supply.

Other forms of direct electrical heating such as a series of fan heaters would be possible. These could be attached to the walls at height or low down. The latter option would be problematic as pews abut the walls on all sides of the church. Again, to provide sufficient heat a three-phase electrical supply would need to be installed. This option would, however, provide instant heat at whatever output level was desired and opens the possibility of 'instant impact' heating of the air, sidestepping the need to heat the building itself.

Electrically driven air-source heat pumps (ASHPs) use refrigeration technology to pump heat from outside the building to blower units inside the church (so-called air-to-air systems). They have the big advantage of a 'coefficient of performance' (CoP) of up to 4.0 when the temperature outside is around 5C and the blower output temperature is around 35C. In other words, for every kilowatt-hour (kWh) of electricity used, approximately 4kWh of heat energy is pumped into the building. Clearly this has a very big ecological and cost advantage over other forms of electrical heating. Driven by renewable energy, ASHPs are low-resource, zero-carbon devices and are the clear front-runner from a 'green' point of view. They are widely praised and promoted in government literature. Although, at current prices, electricity can be about four times as expensive as gas per kWh, this cost disadvantage is eradicated by the CoP of ASHP systems. More than that, the 100A single-phase electrical feed to Hethel Church can potentially deliver 96kW of heating (100A x 240V x 4.0) – more than adequate for the church's requirements. There would be no need for the expensive installation of a three-phase supply. ASHP technology is the clear front-runner.

Reference has been made to the ChurchCare Guidance Note "Choosing the Right Heating System". This was, however, published more than four years ago, when there was little experience of ASHP use in churches. Their specific Guidance Note "Air source heat pumps" (updated August 2016) is a rather bland statement of the facts rather than a sharing of experience or design criteria. This among other reasons is why we have conducted extensive research ourselves and listened carefully to the actual experience of other churches.

In summary, the PCC believes that **electricity** purchased from a wholly **renewable** source is the right form of energy to drive Hethel Church's new heating system, and that **air-source heat pumps** are the best technology to convert electrical energy into heat. The aim will be **'instant impact'** – to heat the air in the building and not the building itself. This is, of course, 'other things being equal'– systems need to be affordable to install and run, reliable, visually and aurally suitable for use in a church environment and effective in regard to heat transfer and distribution. The next sections of this report will address these issues.

Air-source heat pumps

Having concluded that electrically-powered air-air ASHPs are the most promising way forward, detailed consideration of design issues is needed. A number of discussions have been held with Messrs Seckers of Norwich, refrigeration and air-conditioning engineers, with manufacturers of ASHP systems (Mitsubishi and Fujitsu) and with most of the churches on the Church of England Faculty Database (https://facultyonline.churchofengland.org/renewables) which have installed ASHP systems. This research has generated a large volume of information, the detail of which is contained in various supplementary documents to this summary report.

Questions to be explored on the way to a final design specification are:

1. How effective in practice are ASHP systems in churches, especially in regard to heat distribution and noise, inside and outside the building?
2. Is the visual impact acceptable?
3. How reliable are ASHP systems, and what are the servicing needs?
4. Is one manufacturer to be preferred to another?
5. How much power would be needed to heat All Saints Church, Hethel?
6. What types of ASHP are available and which are to be preferred?
7. A word on costs.

1. How effective are ASHPs in churches?

The Church of England on-line faculty database lists 23 churches that have fitted ASHPs. Each of these churches has been contacted and, where relevant, their full response by email is appended to this report. A four-page tabular summary of these responses notes the most relevant or interesting points from each exchange. Three churches were visited; reports of those visits are available as well as the email exchanges with churches not visited. There are a number of photographs sprinkled through these documents.

The C of E list does not distinguish between ASHP use to drive an underfloor ('wet') heating system and an air-to-air heating system as proposed at Hethel. The experience of those 'underfloor' churches is not relevant to this project and is only noted in passing.

The overall impression gained was that the great majority of churches that have fitted air-air ASHP systems are satisfied with the **heating** outcomes. Churches in Alsager, Bickerstaffe, Edith Weston, Fletton, Halse, Moggerhanger, Rochford St Michael, West Wittering and Westhead all report satisfaction. It is, however, important to get the sizing right – where the system has not been fully satisfactory is where it has been too small to make the building warm enough.

A few churches are not happy with their installations. Burrough-on-the-Hill and Somerby churches installed systems in 2008/9 and are finding difficulties with obtaining spare parts. The ASHPs available at that time were first-generation; the technology is now more mature and there is every expectation that manufacturers will support their products for at least 10 years. The congregation at Helpston St Botolph (one of the churches visited) were not happy with the very expensive system installed there. But the message is, as ever, "let the buyer beware". The heating units blow hot air upwards, where it congregates in the cavernous roof space giving no benefit to the congregation below.

In regard to **noise**, few comments were made by respondents. Moggerhanger noted that their system met the St Albans Diocese 40dBA guideline. This was one of the visited churches, and certainly the sound level was not obtrusive. At Fletton (also visited, for a Sunday service), the noise *was*, in the author's view though not that of his companion, somewhat obtrusive. However, the churchwarden had kindly turned all the fan units to maximum in order to give us the best impression of the heating. In reality, fan units would more likely be set to 'medium' or 'low' during a service and, in a half-filled church, would barely be audible above what might be called people noise.

Data for Mitsubishi units gives typical figures of 48, 45, 40 and 37dB(A) for high, medium, low and ultra-low modes, measured 1m from the fan unit. Comparison charts suggest that 40dB(A) is the typical sound level in a library. Doubling the distance from the sound emitter to the listener reduces the level by about 6dB, so at 2m from the unit, the figures above will be 6dB less and at 4m from the unit, 12dB less. However, having several fan units will increase the overall noise level.

It was possible to conduct an empirical test in Mulbarton Church using the church's sound system, which has a white noise generator. A sound level meter was positioned 1m from a loudspeaker and the output level of the speaker adjusted to (say) 45dB(A), the noise level of a Mitsubishi pump set to medium. It is then possible to walk round the church assessing subjectively the intrusiveness or otherwise of the noise. Those present felt that, although just audible, the noise level was no more intrusive than many other sources of sound and a very small price to pay for being warm in church!

The external compressor unit of an ASHP also emits noise, typically 6dB more than the figures given above for the internal fan units. Only one church reported any complaints over external noise, but this was from a near neighbour who routinely complained about anything, however trivial. Given that the proposal at Hethel is to site the compressors high up behind the chancel/mausoleum parapet wall, external sound will be small, muffled and most unlikely to trouble neighbours who are, in any case, 50m or more away.

2. Visual impact

No churches reported concern over the appearance of ASHPs, either the fan units inside the building or the compressors outside. Internally, wall-mounted units were 'camouflaged' to match the surroundings, typically by being white on a white wall. In one or two cases, the units were painted to match the roof timber. Photographs are available (eg Edith Weston, Fletton, Moggerhanger, Rochford). Floor-mounted units are visually less obtrusive and normally white, blending in with typically white walls (eg Moggerhanger; Rochford).

External units were in every case hidden behind some sort of screen, either fencing, hedging or tucked into a corner or alcove out of view. Care has to be taken to ensure good air flow, however, and that each unit has 'clean' air, rather than drawing air that has already been cooled by another unit.

3. Reliability and servicing

Apart from the story of Burrough-on-the-Hill and Somerby (in the same benefice), who adopted early and probably before the technology was mature, there were no reports of unreliability. In Fletton, the units have been installed since 2012 with no issues to date. The same is true for Rochford, installed in 2013 and West Wittering, 2011/12. Helpston's Daikin units have given trouble, but the whole system has been poorly designed and Hethel proposes to use Mitsubishi units, leaders in the field.

ASHPs require a periodic service, ideally at least annually though this may be negotiable if the units are used infrequently. This is mostly to do with cleaning fans and filters on both inside and outside units. A typical price seems to be around £50 per unit per annum, but some churches seem to pay considerably more. With four systems proposed for Hethel, this is a significant but manageable cost.

4. Manufacturer

There are a number of manufacturers of ASHPs such as Toshiba, Fujitsu, Mitsubishi and Daikin. Daikin systems at Helpston have proved somewhat unreliable and the suppliers have had difficulty getting spare parts quickly. By contrast Alan George at Moggerhanger chose Mitsubishi because of his experience of them when he was working in Africa, where reliability and customer service were better than that of other firms.

When asked about the best make, the engineer at Adcock Norwich commented, "Mitsubishi – but you do pay more for a better model". This after he had been asked by Fujitsu to come up with a design. The design features of the Fujitsu blower units are also inferior to those of Mitsubishi.

This evidence all points towards Messrs Seckers' design using **Mitsubishi** systems.

5. Power output

After a long period of undocumented discussion and 'mulling' arising from the church's 'sustainability' weekend in 2014, this project was started by asking Messrs Seckers for a design and quotation for a heating system for Hethel Church. This was duly provided, a heat output figure of 24kW being specified, from three 8kW ASHP systems. This figure came from a computer program primarily used for air-conditioning systems (though also usable to calculate heating) and could not be corroborated by any basic physics principles.

An intrinsic difficulty in calculating the heat input needed to achieve a certain air temperature is that in the envisaged Hethel Church situation, steady state is not achieved. So calculating heat losses through walls, floor, windows, doors and ceiling and equating the total to heat needed to replace losses (as would be done in most other heating design situations) is of no benefit. Indeed, it proved impossible to find any formula or method at all to calculate what was needed to keep the air at a desired temperature, replacing the heat that it lost to cold walls, floor and ceiling. BRE (the Building Research Establishment) had no formulae or algorithms; they offered to build a miniature mock-up of the church and to explore air flows and heat losses – at a cost of £10k to £20k (more than the likely cost of the installation).

Apart from using software somewhat blindly, the best (perhaps only) method in use seems to be based on the volume of air in the building. This approach chimes with that recommended on the Centre for Sustainable Energy 'PlanLoCal' (planning for low carbon living) website. Their document "Estimating the heat demand of a hypothetical community building" (go to www.planlocal.org.uk and enter "estimating" in the search box; available 12/7/17) states:

> Stage 2) Estimating Peak Heating Demand
>
> Explain to the groups that the Peak Heating Demand of a building, in kW, can be estimated by multiplying the volume of heated space in the building (in m^3) by a given factor, which differs depending on how well insulated the building is. Peak Heating Demand is a sort of instantaneous figure – the maximum demand for kW of heat at any given moment. Then write up onto a flipchart

sheet: Poorly insulated building – 0.033 Good level of insulation in building – 0.022 Building constructed to 2010 Building Regs – 0.013

Using 0.033 and Hethel Church's 875m^3 volume of air gives a peak heating demand of about 29kW – in the same ballpark as Secker's quotation (see above).

Accordingly, all churches contacted were asked for their building's internal dimensions and the heat output of their ASHP systems. These data are in the fifth and sixth columns of the summary table; the seventh column gives Watts per cubic metre of air volume in the building. The results are interesting: all figures are in the range 24 – 48 W/m^3 and it is noticeable that those churches who report "OK, but not hot" for their heating (Bickerstaffe, Helpston, Thornton) pump less than 30W/m^3 into the church, while the church that is totally happy (West Wittering) outputs 48 W/m^3. Edith Weston was specified at 45 but manages with 37; Westhead would have liked 45 but manages with 37; the original spec for Thornton was 45 or 51 W/m^3.

These empirical results suggest that a design specification **somewhere in excess of 40 W/m^3** is needed for comfort in cold weather. Given that Hethel Church wants to broaden the range of activities in the building, to include, for example, Saturday or Sunday morning newspapers and coffee, it is very desirable to achieve a level of comfort that, even if not 'toasty', allows outside coats to be removed. Further, it is a thermodynamic fact that the colder the air outside, the lower will be the CoP, leading to a somewhat reduced heat output. If anything, it is better to over-rate the system at +5C outside so that it will perform well when the outside temperature drops to -5C.

The volume of air in Hethel Church is about 875m^3; a 40kW system (4 x 10kW ASHPs) would thus give 45.7W/m^3 in optimum conditions and can be expected to give good levels of comfort.

6. What types of ASHP are available and which are to be preferred?

Three types of warm-air blowers have been considered, and two types of outside heat pumps.

The so-called 'cassette' unit can be recessed into the ceiling and blows warm air out of all four side vents and the main downward vent. Brief consideration was given to setting two or three such units into the nave and chancel ceilings of the church, but this is not thought to be the way forward. It is very likely that structural work would be necessary to strengthen the ceilings to take the weight of the units and to allow installation of the necessary pipework in the void. Secondly, although regular maintenance could be done from below, it would require a scaffold tower. Although there could be some merit in collecting warm air from ceiling level, heating it and blowing it down to ground, this is outweighed by the constructional and maintenance disadvantages.

Wall-mounted units are easy to fix, will blend in with the off-white walls, and require no pipework or cabling from inside the building – connections to the external pump unit are taken through the wall behind the heater. Sited 3 – 4m from the ground, the air intake of a Mitsubishi unit is from above, pulling cooler air down from ceiling height, warming it and blowing it down to the floor, to some extent counteracting convection currents. Experience from other churches suggests that this is an effective option.

Some churches have used floor-standing units, well (Moggerhanger) and badly (Helpston). In the latter case, units were used that are designed primarily for air-conditioning, where blowing *cold* air upwards so that it convects down again is a good mechanism. However, *warm* air blown upwards in a cold building will simply sit in a pool at ceiling height, to no benefit of the congregation. The Mitsubishi units at Moggerhanger are

better in that they vent some warm air out at ground level and the top vent can be set at an angle to the vertical. Their air inlet is, however, low down, where it might be better to be collecting air that has naturally convected out of useful range and blow it back down again.

Usage at Moggerhanger demonstrates a further point: floor-mounted heater units can only be used where pews do not abut the walls. This church has floor-mounted units in the south aisle, from which pews have been removed, and wall-mounted units in the north aisle, where pews remain. The pews at All Saints, Hethel abut the walls on both north and south sides of the church. The pews are not fixed to the floor, but to fit floor-mounted heaters would require repositioning (turning the pews in the north aisle through 90^{o}, for example) and the loss of a significant amount of seating capacity. An associated point is that 10kW floor-mounted units are not available, so more heaters than four would be required to achieve the desired 40kW, adding to clutter, external pipework and servicing costs.

There are good reasons for choosing **wall-mounted heaters** and no reason not to. Other than to gain a moderate stream of warm air at ankle height from the Mitsubishi units, there are no convincing reasons for choosing floor-mounted units and several reasons not to.

In regard to the **external heat-pump units**, several options are possible. Frequently these are paired 1:1 with heaters, sometimes 1:2 and sometimes much bulkier external systems drive several internal heaters. The configuration seems to be as much a practical matter as a technical one. If the internal design specifies, say, 8 x 7kW heaters, it may be hard to conceal 8 heat pumps outside the church. Two cabinet-sized 30kW pumps may be easier to site. On the other hand, a smaller installation may be better with 3 or 4 1:1 systems, with a dedicated heat-pump connected to each warm air heater.

A factor not yet discussed is the need for a short (perhaps two minute) infrequent (perhaps every 45 minutes) **defrost cycle** to keep the external heat-pump units clear of frost as they cool the air by drawing heat from it. This effectively switches off the heating system for a brief period. If all or several internal heaters are connected to a single large pump, all heaters stop working at the same time during the defrost cycle. Helpston St Botolph had such a configuration and noted this downside. If each heater has its own pump, there will be a randomness about the various defrost cycles and no more than 25% (say) of heating capacity should be lost for any given two-minute period.

7. A word on costs

Criteria for choice have not centred on costs, and cannot do so unless all costs are considered, including the ultimate cost of carbon pollution. Nevertheless, solutions chosen for other reasons need to be affordable and give reasonable value for money.

A typical four-unit ASHP installation of the kind envisaged at Hethel is likely to cost of the order of £10000, plus the cost of installing an electricity supply to the four external pumps – perhaps £1250: £11250 in total. If the pumps last only 10 years (which at the rate of usage would be surprisingly low, especially given the normal longevity of refrigeration equipment), the capital cost per year is £1125.

The running costs of 4 x 10kW pumps with a CoP of about 3.5 and electricity at £0.16 / kWhr would be £1.83 / hour. If the church is heated for 7 months / year, for 2 services and 1 event / month, each requiring heat for 2.5 hours, the total cost of energy is £96.07.

Unfortunately the Government's Renewable Heat Incentive (RHI) does not cover ASHPs installed in public buildings. Biomass boilers are included in the RHI scheme, but this does not materially affect the argument for ASHPs in our circumstances.

Annual servicing costs at £50 / unit amount to £200 / year.

These figures compare very well with a biomass-fuelled system, the other low-carbon installation under consideration, for which running costs would be comparable, installation costs two to three times higher and servicing costs probably of the same order.

Assuming that the installation costs can be covered by fund-raising, gift and grant, the day-to-day costs of an ASHP system are low: to be able to run a winter event for under £5 for heat allows a church to be open more often and to run more events without fear of overheads.

In parenthesis we can note that the present heating system of five portable gas fires using butane costing £0.163 per kWh costs approximately £6.11 per 2.5 hour event for a heat output of 15kW – 40% of what a 40kW ASHP system will deliver for £4.57.

The £200 annual service cost is an additional expense, but will be part-covered by savings in bottled gas and the occasional service costs of the fires.

In summary, the preferred heating system for a church uses electrical energy from a renewable source to drive a configuration of ASHPs which will give approximately 45W for every cubic metre of air in the building. Mitsubishi systems are recommended, whether wall-mounted or floor-mounted may vary from site to site. Wall-mounted heaters are better where pews abut the wall, and may be preferable anyway because the airflow they engender helps to counteract convection currents that tend to take hot air to ceiling level and leave it there. The reliability of Mitsubishi ASHP systems is good; servicing costs are modest – but it is advisable to shop around or make comparisons. Running costs are likely to be less than a church is currently paying for much less effective heating.

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