# REPORT and RECOMMENDATIONS
## Sustainable Energy options for

# **Older Churches and Chapels in Wales**

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## 1. Introduction

1.1 Severn Wye Energy Agency is representing Wales in a project funded under the Intelligent Energy for Europe programme that seeks to show good progress in exemplar regions that are seeking to reduce carbon emissions and increase the use of renewable energy.

1.2 This guide is produced as part of that project but comes about as a result of case study reports completed over the last few months in respect of several church and chapel buildings, as well as research undertaken. A certain level of consistency has emerged and there are clear opportunities relating to many buildings of a particular era of construction or modification.

1.3 Very many Welsh church and chapel buildings that were built or substantially refurbished during periods of significant church growth in the 19th century and key features of the buildings point towards similar solutions to the modern problem of rendering them comfortable for intermittent use today – at reasonable cost. This is often true even though the external appearance of the buildings may vary dramatically.

## 2. Why Now?

2.1 There are several reasons why NOW represents a significant opportunity for change and investment:-

- Feed-in-Tariffs are available for renewable electricity generation and the rewards are likely to be lower in the future (post 31st March 2012)
- The Government has just announced a pot of money to support the Renewable Heat Incentive and this too might not be available indefinitely
- Many of the buildings are facing similar dilemmas on repairing suspended timber floors and the point at which they are replaced represent a particular opportunity – that might not be repeated for another century

## 3. Under-floor heating

3.1 In every case that where we were asked to advise we found that the main seating area for the congregation was constructed on a suspended timber floor. The seating was usually still pews and the floors were often nearing the end of their life, if not in dire need of replacement. It is strongly recommended that where the decision is taken to replace these areas of flooring the option of installing under-floor heating is very seriously considered for the following reasons:-

- It delivers heat to the right the place – people's feet. People are generally content to wear warm clothes in the historic building but their comfort (particularly whilst sedentary) will be greatly impacted by whether or not their feet are warm.
- The ceilings are usually high and so heating located above ground level or at the edges of the building will largely heat the air above, failing to deliver heat where it is actually needed.
- The replacement of the floor provides the opportunity to insulate below the heated medium.

- A low-temperature heating system that delivers heat evenly over long periods is much kinder to the fabric of the historic building than those that input heat quickly and intermittently.

NB It is important that the heated areas of flooring are not covered with wood, carpet or other materials that are insulating by nature.

## 4. The Source of Heat

4.1 The water temperature in the under-floor heating network will be relatively low and thus a range of renewable heat source options are available that could deliver the heat energy efficiently. The options currently under consideration (that are eligible under the Renewable Heat Incentive) are ground source heat pumps, wood pellet boilers and wood chip boilers. For the vast majority of Welsh chapel and church buildings it is only the first two that are appropriate.

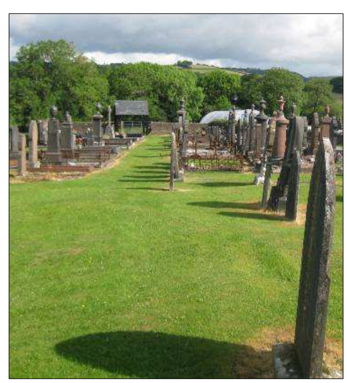
### 4.2 Ground-Source Heat Pump (GHSP)

A heat pump uses the same principles as a refrigerator – this takes heat from one place (the inside of the box) and transfers it to another (the cooling fins on the back of the box). In a heat pump, heat is taken from the ground (which maintains a surprisingly constant temperature all year round) and transferred into a warm water heating circuit. The refrigeration process (evaporating liquids and re-condensing them) multiplies the heat transfer effect to the extent that a well operated heat pump will extract 3.5 – 4 units of heat for every one unit of electrical energy input. This ratio is known as the coefficient of performance (CoP).

So long as there is a sufficient volume of ground from which heat is being extracted, a ground-source heat pump could efficiently and effectively produce low temperature heat (around 35℃) to an under-floor heating system to a church/chapel building. It would be able to do this at a high co-efficient of performance (CoP) and would thus be cost-effective (particularly if combined with a photovoltaic array – see later information). If, however, the heat-pump is asked to produce higher temperatures then the CoP is likely to drop and the costs of electricity used will rise quickly. It must be stressed that a heat pump is only a sensible option for a poorly insulated building if the intention is to only partially heat the meeting space. Almost all 19$^{th}$ century (or older) church and chapel buildings are very poorly insulated so any attempt to raise the internal temperature to domestic or office standards would see a very significant drop in the CoP with a resultant very high usage of electricity. (see later discussion about insulation and draught-proofing)

The extent of carbon savings arising from the use of the heat-pump will depend upon the average CoP and the carbon intensity of the electricity being used. The UK Government's policy intentions are to reduce the carbon-intensity of grid electricity, but it currently stands at one of the highest in Europe and thus leaves electricity as the one of the "dirtiest" heating fuels available.

The key questions relating to the GSHP option revolve around the availability of suitable land into which trenches, grids or bore-holes can be situated. Professional advice needs to be sought on this subject because the heat pump must have sufficient ground-stored heat capacity if it is not to lose efficiency through over-cooling the ground.



Most church and chapel buildings have land around them but almost all of them are severely constrained by the fact that this land is or has been used as a graveyard. This is very clearly a significant constraint and will often rule out GSHP's as an option. Possibilities will exist where there is a long, continuous piece of ground that is clear of graves because it has been used for access.

If there is neighbouring agricultural or other undeveloped land then it may be possible to negotiate the right (with a contract of at least 20 years in duration) to bury the heat exchange network in the land concerned, with an excavated or "moled" connection to wherever the heat pump is housed. Horizontal heat exchange pipework is buried at a depth of around 1.5 m (5 feet) and so would be clear of any normal agricultural operations.

An alternative to horizontal heat exchange pipes would be several vertical bore-holes, but this option would be much more expensive and in some cases may still not be possible because of severely constrained graveyards or lack of suitable access for a drilling rig. There is an innovative example in Kent where angled bore-holes were drilled from a single point in a radial fashion, and this may offer a solution in some cases too.

The heat pump and associated thermal store would need to be housed somewhere in or close to the area to be heated. This could be within an existing side-room to the building, a new specifically constructed extension or separate building, or within an existing out-building. Some church and chapel buildings have existing or former boiler houses or rooms that can accommodate this equipment.

### 4.3 **Wood Pellet Boiler.**

A wood pellet boiler is probably the best option in terms of carbon emissions reduction and versatility for the following reasons:-

- The wood used in pellet manufacture is part of a (relatively) short cycle of carbon absorption as trees grow, and release as they rot or are burnt. Whilst (carbon emitting) energy is used in the manufacture and transportation of the pellets this is a small proportion of their calorific value.
- A pellet boiler is capable of producing high temperature water efficiently and according to pre-programmed cycles or in response to unplanned or one-off events.
- If used in combination with a large thermal store, it can very efficiently trickle heat into an under-floor heating system.
- The better boilers are capable of on-site up-rating, thus reducing the risk in terms of boiler sizing (which is notoriously difficult to get right). NB –It is strongly recommended that careful attention be given to the sizing of the boiler, and the temptation of using a larger boiler than is necessary avoided – over-sized boilers are inefficient.

The disadvantages of the pellet boiler are:-

- The cost of pellets is unlikely ever to be as volatile as oil but there is nevertheless some uncertainty about the future price of this fuel. Ironically, the Renewable Heat Incentive (see later section) may well lead to an increase in the unit price of pellets, as demand rises, but at current prices they certainly compete with oil or LPG. Oil and LPG are likely to rise in price much faster than wood pellets.
- There is a requirement to empty the ash container periodically but this is quite infrequent – for an intermittently-used building, it could be only once a month or less.
- There is annual servicing of the boiler required (somewhat more involved than for a fossil fuel boiler) and pellet stocks have to be monitored and replacement fuel ordered/delivered.
- The most serious disadvantage (and likely "show-stopper" in many cases) is the amount of space required for the boiler and fuel store. The boilers are larger than equivalent oil

or gas boilers, but it is the fuel stores that will take up most of the space. A pellet store will probably need around 27 cubic metres of space that is capable of being filled via flexible hose from a wood pellet delivery tanker that can park within 25 m (80 ft) of it.

The boiler and fuel store could be housed in an existing boiler house or a new building could be erected as an extension or separate structure. The only requirement for the fuel store is that the tank or hopper is kept dry so the structure can be reasonably inexpensive. It is likely to be the building conservation and appearance issues that have the greatest impact upon the cost of the structure rather than its function.

### 4.4 **Wood Chip Boiler**

A wood chip boiler is only likely to be appropriate under fairly rare circumstances and, as a stand-alone system, could perhaps best be described as a "cathedral" solution rather than church or chapel. Wood chips are a much bulkier fuel than pellets (which are compressed sawdust) and have a higher and more varied moisture content . They are much more difficult to handle and as a result require a much more robust fuel delivery system. The fuel store is likely to be bigger than a pellet system and must be capable of receiving deliveries by tipping trailers or lorries.

It is much more likely that a church and chapel might be part of a wider scheme involving a group of buildings that each purchase heat of a contractor that builds, operates and services a central wood-fuelled district heating system. One of the church buildings within the portfolio of case studies fell within this category of opportunity, but the church community concerned is entirely reliant upon a third party to instigate such a communal scheme.

Whilst the opportunities might seem to be few and far between they are deemed to be worthy of inclusion in this report as they do hold tremendous potential for fuel and economic efficiency for the users, the use of indigenous fuel supplies and the generation of local employment and economic activity. Wood chips are around half the price of pellets, per unit of energy delivered, so can make for an attractive long-term solution.

### 4.5 **Heat Pump and Boiler in Tandem.**

It is perfectly feasible to run a heat pump in tandem with a pellet or, probably more likely, a mains gas or LPG boiler. The heat pump would operate for the whole of the heating season maintaining the floor of the building at an even "warm" temperature whilst the combustion unit would be used to raise the temperature to full comfort levels (18-21℃) prior to periods of use of the building. This option may be worthy of consideration but is likely to prove very expensive and might prejudice the Renewable Heat Incentive payments (this issue should be researched if such an option were to be seriously considered).

### 4.6 **Air-Source Heat Pump**

Air-source heat pumps could be used in much the same way as a GSHP – though taking the heat from the air as opposed to the ground. At this time there is no recommendation to adopt this technology, although in some cases in might prove to be the most (only?) practical option. The uncertainty at this time is because:-

- Air-source heat pumps are currently excluded from the first phase of the RHI (but they may be included later)

- Air temperature fluctuates to a far greater extent than the ground and the CoP is highly dependent upon the difference in temperature between the source (in this case the outside air) and the heating medium (water in the pipes of the under-floor system).

## 5. The Renewable Heat Incentive (RHI)

5.1 The Government has made an announcement in respect of a revenue subsidy for renewable and low-carbon heat energy – known as the Renewable Heat Incentive. This is the first scheme of its type in the world. The final detail for the entire scheme is yet to be released but there is a reasonable level of clarity in respect of non-domestic buildings. The scheme is expected to start in the Autumn of 2011, and payments will be made for all green heat generated from accredited renewable heating installations, for a guaranteed period of 20 years from commissioning. The incentive provides, for instance, for tariff payments of 4.3p per kWh for GSHP of less than 100 kWth, with the heat having to be accurately metered (the heat meter can be provided by the installer) and reported quarterly to Ofgem.

5.2 In summary – this new government funded scheme will provide income for every kWh of productively-used heat energy produced by wood pellet or chip boilers, ground-source heat pumps and solar thermal systems (for heating water). The major proviso is that the equipment and the installer are accredited under the “Microgeneration Certification Scheme” when below 45kW in rated capacity.

## 6. Solar Thermal

6.1 If there is a significant demand for hot water on an almost daily basis (especially during the summer months) then it could be very worthwhile investing in a solar thermal system. This is, however, not a usual scenario for church and chapel buildings and, there is therefore no more detail given. Where it is applicable further information can be found in the references provided.

## 7. Solar Photovoltaics (PV)

7.1 Particularly if the heat pump option is chosen, it would be worthwhile considering the introduction of a photovoltaic array on the south-facing roof of the building (subject to a structural survey confirming that it is acceptable). PV systems generate zero-carbon electricity and, via an inverter, synchronise it to grid electricity. The accommodating roof should ideally be within 45° of due south, and largely un-shaded in o rder to be suitable for a PV array.

7.2 The government’s economic support for PV has moved away from capital grants to the Feed-in Tariffs (FiT) system. FiT payments come via the electricity supply company and come in two parts:-

- A guaranteed payment for each kWh of electricity generated by the system (whether or not it is used on-site). This payment varies by technology and the capacity of the installation but is most generous for smaller-scale PV systems (below 10kWp).
- A much smaller payment for surplus electricity exported from the building to the grid.

There is clearly additional and significant value in the electricity used on-site in that it displaces imported electricity, so there are ultimately three components to the financial benefit of a PV generation system – import savings, FIT payments and the export bonus.

The current system provides a contract for 25 years of index-linked payments, and is generally providing a straight pay-back in the region of 10 years or fewer. If a PV array can be financed then it would provide a healthy income to the church BUT:-

- The FiT payments and public sector capital support are considered to be mutually exclusive, and so a PV array would have to be funded from non-public sector (and the Lottery is considered to be public sector) or loan financing. Green tariff funds, from some of the large energy suppliers, are one compatible option, but applications are very competitive.
- The current FiT system and payments (for new schemes) are only secure until the 31st March 2012, with the future unclear beyond that point. The scheme is very likely to endure, but tariffs will be degressed, so the overall benefits may reduce somewhat.

7.3 One of the most obvious limitations to locating PVs on the roof would be the attitude of all those involved in the historic and building conservation decisions in respect of the building. There will usually be no hiding the fact that there are tens of square metres of reflective blue and silver coloured panels on the roof and that they are a very obvious modern addition. It is certainly possible to locate an array on other buildings or on a frame in the grounds but the church roof is the usual location of choice.

7.4 It also has to be checked that the array would not suffer significant shading from, for instance, trees and/or a tower. It needs to be borne in mind that the partial shading of some PV panels will have a much greater impact than might be imagined. Shading a portion of the array is likely to cut electricity production by the entire array, due to voltage drops in series-connected modules.

7.5 If a PV array is acceptable but the cost is deemed to be prohibitive then a third party might well be interested in paying for and installing the array and benefitting from the FiT payments, which can be assigned in this way. Thechurch would still benefit from the free electricity generated, at least when demand matches the solar resource. The third party might be an investor such as one of the Electricity Supply Companies but could also be an individual or cooperating group of individuals or businesses from the community. This is the so-called “rent a roof” model, already used in the domestic sector.

## 8. Insulation and Draught-proofing

8.1 Using less energy is always the priority over switching to low carbon sources, but experience suggests that there is usually very limited opportunity for insulation measures in churches and chapels. There may, however, be all or some of the following possibilities:-

- Where there are accessible loft spaces, ensure that they are filled with around 250mm (10 inches) depth of insulation material.
- Where bulk insulation material may be pumpable into other voids between ceilings and roof. Seek the guidance of a specialist contractor (care needs to be taken to avoid creating conditions whereby condensation takes place on cold surfaces).
- Plain plastered walls or ceilings may be suitable for “dry-lining” – thus insulating the building from the inside. This again needs to be done carefully to avoid condensation problems leading to fabric damage.
- If the exterior of the building is rendered that the application of external insulation may be possible and specialist assistance should be sought.
- Secondary double glazing may be possible under some circumstances.
- It is always worth checking the external drainage arrangements of the building – wet/damp walls are cold walls (since they conduct heat better) - so drains and rainwater goods need to be maintained properly.
- Gaps around, and holes within, windows and doors can often be reduced in size or removed. Any uncontrolled entry of outside air should be avoided where possible.

## 9. Next Steps

9.1 The first step is to work through this guidance to see if the description fits with your situation. The point is stressed about this being the time to act. If the decision is being made to replace the suspended timber floor in the main seating area/s then this might be a once in a hundred year opportunity to change to under-floor heating.

9.2 The next step in the process of pursuing a renewable heating scheme would be to approach several Microgeneration Certification Scheme (MCS) accredited installers and ask them to visit, size your system and provide quotations. The list of installers can be found on the website:- http://www.microgenerationcertification.org/

9.3 It is vitally important that you brief the potential installers well, giving them your requirements in respect of the area of the building in which you intend to install the under-floor heating and the standards of comfort that you are expecting to be achieved, over what periods. It is also important to discuss the issues relating to the fabric of the building and the extent of temperature fluctuations and the rate at which those fluctuations are allowed to occur – there is clearly a need for input from your conservation architect.

9.4 It is important that you examine the whole package of any tenders and not simply the price. The track-record of the installer and the equipment should be examined and it might be a very good idea to ask for and take-up references. MCS accreditation will not be fool-proof and you should do your own investigations.

## 10. Further Guidance

The material available from the Energy Saving Trust is rather basic but it might be worth visiting the web site www.est.org.uk .

The following sources go deeper and might be of assistance:-

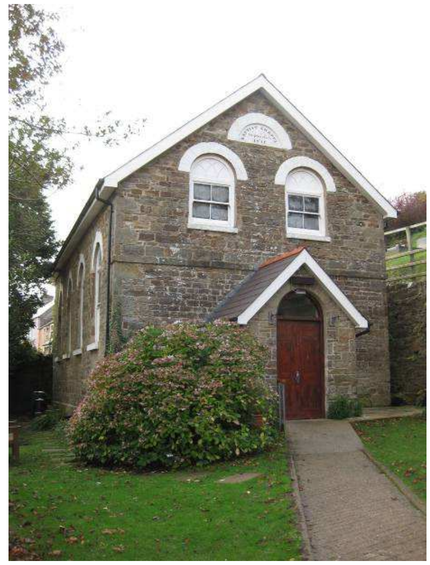
The Centre for Alternative Technology - http://info.cat.org.uk/biomass & http://info.cat.org.uk/heatpumps

The Biomass Energy Centre - http://www.biomassenergycentre.org.uk/portal/page?_pageid=73,1&_dad=portal&_schema=PORTAL

Logpile - www.logpile.co.uk

Heat Pump Association - : http://www.feta.co.uk/hpa/

IEA Heat Pump centre: http://www.heatpumpcentre.org/en/Sidor/default.aspx



### References in Respect of Historic Buildings

Renewable Energy and Your Historic Building – Welsh Assembly Government and Cadw

Heritage and Culture, Energy Saving in Historic Sites and Modern Buildings – Carbon Trust

The Green Guide for Historic Buildings – The Prince's Regeneration Trust

Severn Wye Energy Agency has produced tailored reports for several church and chapel buildings in Wales and these form the basis of the generic advice contained within this report.