Practical Renewable Energy for Church Buildings

Why Green the Church Buildings ?

Why on earth should we worry about greenhouse gasses emitted from our church buildings? They're only a minuscule part of the UK's total emissions, and the UK's emissions are tiny compared with those of the U.S.A and China. Anyway, this is the only country with a Climate Change Law; the Government is charged with ensuring that we cut our emissions by a huge 80% by 2050. Can't we leave it to them ? Surely, if we want to get involved in solving society's problems, there is enough to do running food banks, resourcing street pastors, standing up for asylum seekers and supporting the annual round of good causes from Christian Aid to the local hospice?

We live, however, in interesting times. As has been wisely observed, ours is the first generation to understand the devastating threats to the environment and the last generation with just enough time to take action. At heart, this is a spiritual issue. If relatively rich Christians cannot rise to the challenge of tackling global warming and environmental degradation (and the UK is the world's seventh richest nation), why should anyone else ?

In the first place (and it's the same whether you are a Creationist or an Evolutionist), God has charged us to protect, cherish, and live in harmony with God's wonderful Creation. That's what 'dominion' really means: the rule of a wise servant king – subduing pathogens and parasites, protecting polar bears and pollinators, and preventing climate chaos.

Alright (the over-worked priest and people may say), there is something in the Law and Prophets about caring for the land and respecting animals (and, implicitly, leaving the wild places wild), but we live under the New Dispensation, and by deed and word, Jesus put the care of needy people first. He taught that our hearts had to be right with God; that we would be judged on whether we clothed the naked, housed the homeless and tended the victims of muggers.

A good point. But then Jesus did't say much about shoring up old buildings, singing in choirs and stained-glass windows. Instead Our Lord lived a simple life, talking with His Father in the wilderness and the quiet fields before dawn. In the Nature parables, Creation exemplifies the Kingdom of Heaven in comforting and in challenging ways. These are not 'just so' stories: God really does care about the sparrow and delight in the flowers. You may, if you wish, question a literal interpretation of the miracles, but the message remains clear: Jesus had a deep empathy with the forces of Nature – and the Bible soars to a glimpse of the Cosmic Christ, coming to save not just humanity but the whole of Creation. So does Jesus weep today over our short-sightedness as He wept over Jerusalem ?

The imperative is to keep the bulk of known and accessible reserves of fossil fuels safely underground. As Professor James Hansen and other climate scientists have pointed out, were most of the accessible reserves burned then catastrophic climate change would result. Of course, we also need to protect and restore forests and wetlands and become less reliant on meat – but the greatest contributors to the global warming crisis are fossil fuels. Even if population numbers are stabilised, on present trends a disastrous 2 degree Celsius temperature rise will become inevitable within 30 years.

This leaflet has been produced by the Derby Diocesan Environmental Group, which is an ecumenical group seeking to encourage churches and congregations to continue acting on climate, environmental, and justice issues. Further details can be found on the Internet at http://www.derby.anglican.org/en/our-mission/environment.html

If you would like any more information please email the chair, the Revd Terry Thake at terry.thake@btinternet.com or the secretary, Mrs Rita Brierley Rita.Brierley@derby.anglican.org

There is an unavoidable ethical dimension for Christians. If we continue to use fossil fuels on a 'business as usual' basis, the earliest and most severe consequences for living things (after the Arctic) will be felt in tropical and delta regions (partly because tropical plants and animals have evolved in a stable and predictable climate). This will impact on many of the world's poorest communities (including, if it makes a difference, many fellow Christians). The 'Good Samaritan' would not see a 'carbon budget' that can be spent wisely. On the contrary, greenhouse gas emissions even now, will contribute to harming vulnerable people in the near future.

But will urgently cutting the carbon from church buildings (and, of course, our homes, cars and food), make much practical difference ? Well, lobbying MPs and others to take effective action carries more weight if there are fewer planks in our own eyes ! More positively, urgent and vital global agreements depend on Western governments like ours being able to demonstrate in international negotiations that they can deliver cuts. Our 'mite' will, under God's providence, have a huge multiplier effect.

Caring for the environment in which we live is becoming a higher priority in everyday life. Many Individuals are making changes to the way in which they live, and local groups, including church congregations, are looking for ways to make their life together more sustainable. Little things like changing light bulbs, turning down thermostats or creating insect friendly habitats are fairly easy to accomplish - but what about the bigger projects to make our church buildings greener, and offer low carbon or virtually zero carbon alternatives to fossil fuels ?

This leaflet is a guide to some of the ways in which this can be done, describing the options for the use of renewable resources, offering practical advice, and signposting possible ways forward. We hope that it will be a valuable tool in enabling both groups and individuals to be better stewards of our God given creation.

What Is Sustainability ?

Above, we touched on the the notion of making our 'life together more sustainable'. What does this mean in practice ? If we take the theological perspective expressed in the Fifth Mark of Mission "To Strive to Safeguard the Integrity of Creation and Sustain and Renew the Life of the Earth", how does this relate to the definitions of sustainability that are used by environmentalists and politicians ? The Brundtland Commission of the United Nations defined sustainable development as follows,

> “sustainable development is development that meets the needs of the present
> without compromising the ability of future generations to meet their own needs”.

This suggests that sustainable communities must operate within the constraints of the natural resources that are available to them, both by consuming resources at a rate which does not degrade the sources of the raw material on which they depend, and by avoiding permanent damaging the environment by returning excessive amounts of spent materials.

The 2005 World Summit further considered what this meant for humanity by noting that this requires the reconciliation of environmental protection, social equity and economic demands, the "three pillars" of sustainability, or the "triple bottom line". This definition has been further refined however, by the suggestion that these concepts are instead nested inside each other. To quote Dr. Priya Shyamsundar from the South Asian Network for Development and Environmental Economics, Nepal, “...sustainable development should be seen as an economy serving society within Earth’s life support system, not as three pillars”.

Our society in its current form is clearly not sustainable. The expansion of the human society and the economy increase demand on resources from the environment, and the needs of the population, opportunism and greed, give rise to the consumption of resources and the production of waste products, at much greater rates than these materials can naturally be replenished from or accommodated within ecosystems, potentially giving rise to their failure, and creating a significant risk of both shortages of key natural resources, and environmental damage arising from pollution and waste.

As stewards of a sustainable environment then, we must seek materials and energy sources which we can obtain and dispose of, in a more or less steady state equilibrium with our environment. Further, in order to meet the social equity and economic requirements of sustainability, fair means must be found to achieve this equilibrium, in ways which are consistent with the wider objectives of Christian Mission. In short, living more sustainably is an integral part of our Christian Mission, and we should undertake all our activities in ways which respect and addresses the environmental constraints which we find imposed on us, just as we undertake other elements of Mission.

Sustainability then, is a broad concept, with the notion that we should use resources which are renewable and non polluting at its heart. The technologies listed here produce either provide heat or electricity, and avoid both the use

of fossil fuels, and the emission of carbon dioxide and other pollutants that would arise from their combustion.

As so much of our activity requires the use of energy, it is not surprising that our energy use is one of the key areas of non-sustainable activity. This is why finding and using renewable energy sources wherever we can, is key to us finding more sustainable ways to live, and is key to our Christian Mission.

What then, are the practical options we can consider ?

Electricity and Natural Gas

It may seem strange to start a paper on renewable energy by discussing electricity and natural gas, but renewables need to be considered against a baseline of whatever fuel and heaters are currently in use in the church.

Short of burning coal, electricity gives rise to the most CO_2 emissions per unit of space heating. If available for space heating, gas is significantly cheaper and less polluting than electricity. While very old gas boilers might only be 50 or 60% efficient, modern condensing boilers can be more than 90% efficient. If you are using electric heating at the moment, just switching to gas could halve your carbon emissions and fuel costs.

Shown left, is a modern compact 55kW gas condensing boiler. The flue gas temperatures are so low that plastic flue pipe can be used, which can run many metres to an outside wall. This allows a lot of flexibility when choosing where to mount the boiler. Substantially larger wall-hung gas boilers are also available.

Because natural gas is a relatively cheap fuel, and lower carbon than electricity, oil, or LPG, it is widely seen as the best compromise for space heating where it is available. In the long run however, gas prices are likely to rise, the carbon emissions are still a very significant impact, and the carbon dioxide released per kilowatt hour of heat delivered may increase over time as more gas is imported by ship, or gas is obtained from unconventional sources such as fracking.

Environmentally then, natural gas is far from ideal, and may get worse over time, but for the moment, may be the best option that many communities can afford, and the benchmark which in most urban area, other technologies have to beat.

In urban areas where gas is available, the use of renewables rather than gas is desirable, but may be hard to justify financially. In rural areas where gas isn't available, the use of renewables makes more financial sense as electricity, oil and Liquefied Petroleum Gas (LPG) are so much more expensive than mains gas.

It should be kept in mind that in most churches, the bulk of the energy used goes into heating the building rather than running lighting and appliances. Where renewable energy systems produce heat, it is nearly always used on the site where it is produced, but where electricity is produced, this may be exported back into the grid to earn an income.

Wind Power

Wind power is probably the most iconic form of renewable energy, and is generally used to generate electricity. The cost per amount of energy produced favours larger machines, and small wind turbines mounted on buildings are seldom cost effective.

Machines with a peak output of 5 or 6kW might be practical and have been considered for use in church yards. One was considered by a church in Derbyshire and the idea was not rejected by the DAC, though the project did not proceed for other reasons.

From an aesthetic point of view, the scale of the equipment has to be grasped to understand the impact that it will have. The turbine pictured is an Evance R9000 and has a hub height of 12 meters. It must also be understood that wind turbines will make some noise, and that people should not be encouraged to congregate under them for safety reasons.

Any wind turbine will only perform usefully if the average wind speed on the site is high enough to justify the initial investment, so the first thing to consider in any wind project is the siting of the turbine in an exposed location, ideally on a hill or ridge. The manufacturers data should be consulted to establish the likely energy yield for the wind speed available on the site. In a location with an average wind speed of 6.5 metres per second, the turbine above would generate approximately 13 MWh per year which would avoid the production of about 7 tonnes of CO_2 per year. If the machine lasts 20 years, it would save over 140 tonnes over its life, which is vastly more than the CO_2 emitted during the manufacturing process.

The machine would attract Feed In Tariff and Deemed Export payments (21p + 3.5p per kWh), so while it might cost £25,000 to install, it should earn more than £63,700 over its life, because the the FIT figure is revised annually to take account of inflation. FIT payments do not depend on the energy being used in the church, so it can earn an income even when nobody is in the building.

Because larger wind schemes are generally more cost effective, it might be worth considering installing a larger turbine at a better location, and involving the whole community in the ownership and funding of the project.

Hydro Electric Power

Most sites will have no access to hydro power on site. Again larger schemes tend to be more cost effective, so there may be a case for community ownership if this allows a larger system to be installed.

Most hydro systems are used to generate electricity, and export any which is not used on site into the grid, for which payments are made.

Hydro schemes require large flows of water to fall over a significant height to extract useful amounts of energy. There is no need to build new dams or other substantial infrastructure however, and it may

be possible to install turbines at old mill sites or weirs if these have convenient connections to the grid.

There is potential for hydro schemes to have significant environmental impacts by diverting water flows way from existing channels, and careless design might increase flood risk in some locations. The environment and other stakeholders should be contacted at an early stage if the development of a hydro scheme is being considered.

There are may types of turbine which can be used in hydroelectric systems, and many pose a direct hazard to fish. The Archimedean screw turbine (the type pictured at the bottom of the previous page) has been shown to have minimal adverse impact on fish which pass down through it, but fish passes might still be required to allow fish to pass up stream, which can add to the cost and complexity of projects.

For more information see:

http://www.friendsofthepeak.org.uk/download/files/HYDRO/PEAKPOWERMainreportAppA.pdf

Photovoltaic Power

Photovoltaic systems generate electricity from light. Whatever electricity is not used on site is exported into the grid, though Feed In Tariff payments are made for all electricity generated, not just that which is exported into the grid.

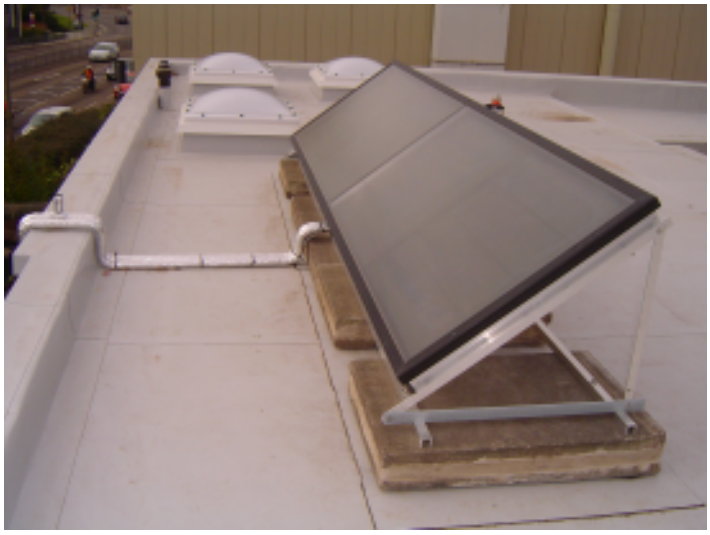
Most churches have a large south facing roof, and many have little shadowing. These would be suitable for the installation of PV systems.

PV can be attached to most kinds of roof but caution should be exercised on historic buildings where the effect of additional structural loadings should be carefully evaluated. Roof coverings should also be considered on a case by case basis, and expert bodies such as the Lead Sheet Association should be consulted.

Some communities have rejected PV on aesthetic grounds, but some such as Melbourne Parish Church (Grade 1 listed) have managed to locate their PV on parts of the roof which are not easily seen from the ground. Other churches such as Saint Barnabas in Derby have a very large and conspicuous PV array, which over is life will not only contribute to the finances of the parish, but reduce its net environmental impact, and set a clear example in the community.

Shadows can have a significant impact on PV performance, so the effect of trees and ornamental stonework should be taken into account. On a roof such as that pictured on the left, surprisingly little unshadowed roof may be left which could sensibly be used for the installation of PV panels.

In general, the more PV can be installed, the lower the cost per kW of the installation, but note that the Feed In Tariff goes down in steps as the size of installations increases. In most situations, this favours systems slightly under or significantly over 4kW and 10kW.



Solar Thermal Energy

Solar thermal systems heat water using light and heat radiated from the sun and sky. In the UK it is generally only practical to use this technology to heat domestic hot water.

Two types of solar thermal collector are in common use - flat plate (top left) and evacuated tube (lower left). Both may be mounted on frames on flat roofs, or mounted on pitched roofs, either over the tiles, or forming part of the roof covering.

As it's generally not possible to export hot water from site, there isn't usually any benefit to fitting systems which more than meet the typical demand within the building. This typically means that solar thermal systems will use a smaller area of panels on the roof than PV systems.

Solar thermal is useful in buildings where there is significant demand for hot water. Without a reasonable hot water demand there will be little environmental benefit or financial return. This technology then might be appropriate in a regularly used parish room or hostel, but little use in a building which is only used one or two days per week.

Shadows have less effect on the performance of solar thermal systems than on PV, but as far as possible they should still be located where direct sunlight can fall on them for most of the day.

Some financial incentives to use solar thermal are provided through the Renewable Heat Incentive which can make payments based on a Green Deal assessment for domestic properties, or the quantity of heat produced (measured by a heat meter) in non domestic properties.

Biomass Energy

For our current purposes, biomass energy refers to the burning of wood to provide heat for the buildings we use. Wood can be used as a fuel in three main forms, logs, wood chip and wood pellet. If you have a good supply of it, it is also possible to burn clean waste wood with a U4 exemption from the Environment Agency (which is free, and easy to apply for on line).

In practice, logs have the inconvenience that the boiler has to be manually stoked, and the fire must generally be started by hand. This has the potential to be quite inconvenient, and we have yet to find a church that has been interested in exploring the log / waste wood burning option.

Wood chip requires, for a given heat output, the most expensive boilers and plant. Fuel stores need to be constructed in such a way that trucks can tip loads of fuel into the store, so the necessary engineering works and infrastructure add substantially to the cost. On the other hand, the control of wood chip boilers can be automated, and they can be timed to start without manual intervention.

Wood pellet boilers are priced in between log and chip boilers. Fuel is more easily handled as it can be blown through pipes rather than having to be tipped from trucks. This means that fuel stores can be tucked into relatively inaccessible spaces in a building, as long as a delivery vehicle can get to within 20 metres of the fuel store. From the store it can be transferred to the boiler by auger, and again ignition and heat output can be controlled automatically.

Large pellet burners are large, heavy and expensive, and this should be taken into account when selecting

equipment. To give an idea of what a church might need, the pellet burner pictured can provide over 100kW of heat.

All biomass appliances require a flue which must comply with Part J of the building regulations. This should be thought through carefully, as a shiny modern stainless steel flue might look incongruous on a traditional church building, though the visual impact of flues may be reduced in a number of ways, including painting them to better blend with the building on which they are mounted.

While pellet burners are expensive to buy, the fuel is near zero carbon, and payments made under the Renewable Heat Incentive may cover the cost of the fuel. If the initial purchase can be funded then, the cost of the fuel for the next twenty years may be negligible, offering long term financial benefits over alternative sources of space heating, as well as significant benefits in terms of reduced emission of carbon dioxide from fossil fuels.

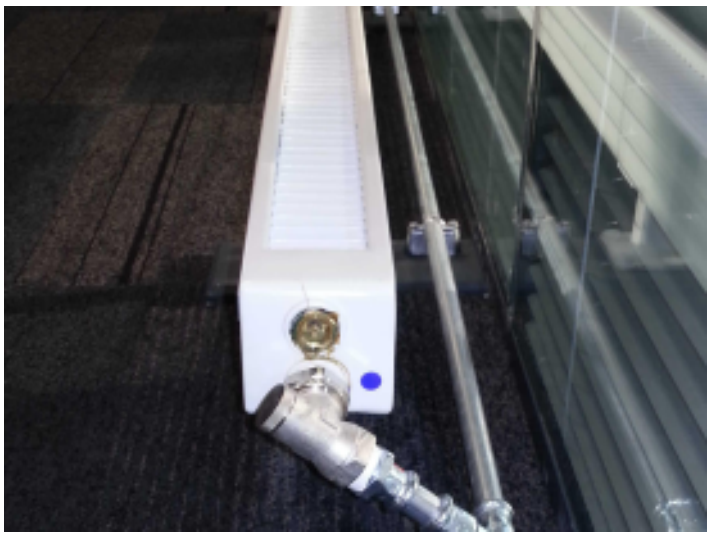
Heat Pumps

A heat pump is a machine which moves heat from one place to another. The commonest example is a fridge or air conditioning plant which moves heat out of an insulated box. This reduces the temperature on the inside, but increases it on the outside. If this technology is used in reverse, it is possible to cool the environment outside an insulated space such as a building, and warm the inside.

Although heat pumps are usually electrically operated, it only takes about 1 kilowatt of electricity to move 4 kilowatts of heat into a building, so they are much more cost effective and carbon efficient to operate than traditional electric heating, and like biomass systems, Renewable Heat Incentive payments may be claimed by eligible systems.

When heat pumps are used for heating, heat can be drawn from air blown through the machine by fans (for example see picture left, referred to as air source), or heat can be drawn from the ground by either coils of pipe buried in trenches one or two metres deep, or from pipes in boreholes which may be over a hundred metres deep (ground source). In a graveyard, boreholes would have the advantage that while very deep, the surface area of ground disturbed is very small.

It is also possible to take heat from large lakes, springs, streams and rivers, but as appropriate sites are relatively rare, this technique is less well established (water source).



Emitters

In addition to choosing a sustainable and affordable source of heat, it is necessary to find a way to distribute heat to where it's needed within the building which is efficient, effective and aesthetically acceptable. The choice of emitter must also take account of the source of heat, as the efficiencies of heat pumps and condensing gas boilers are adversely affected by operating at high temperatures.

Many churches use ancient corroded cast iron pipes which have very small surface areas. To dissipate much heat inside the building, these have to be extremely hot, and in general, these are not particularly efficient or effective.

Some churches have put modern radiators around the edge of the church, but this tends to create the problem that most heat is given out as a plume of hot air which rises quickly to the roof where much energy is lost because of poor insulation, The building fills with warm air from the top down, so in addition to much energy being lost, it takes a long time to bring the building up to temperature.

Another approach is to use fan assisted radiators, which are more effective than conventional radiators, particularly at low temperatures, but these produce noise from the fans, and having moving parts, are prone to squeak if not well maintained. Some congregations have remarked that they need to be switched off during services. While fan assisted radiators are good at transferring heat from air to water, the heated air is still prone to rise, and may not reach beyond the edge of the congregation.

A better approach may be the use of underfloor heating. This consists of pipes which are laid on thick insulation, then embedded in concrete. These heat over a very large surface area, so the water temperature can be quite low which helps to keep heat pumps and condensing boilers efficient. The gently heated air still rises, but more slowly than with radiators, and as the heating is under the congregation, the warmed air must pass the congregation as it rises. While these can be very effective, it takes some time to warm up the concrete in which the pipes are set, installation can be disruptive, and it may not be possible or appropriate to install this in all historic buildings.

Pews may also be heated directly by running heating pipes under them. If simple pipes are run, it may not be possible to dissipate enough heat unless the pipes are run at a high temperature. If more modest operating temperatures are required to enable heat pumps or condensing boilers to operate efficiently, or to avoid burns, finned pipe might be used, see example left.

Community Renewable Energy

Public unhappiness with the large energy companies and increasing prices seems to be on the rise, but there is an alternative, with many benefits for the local community, that is growing in popularity over the world.

In contrast to the traditional model of large, utility owned generators; community energy projects are typically smaller and have a focus on providing engagement, control, and benefits to the local community that hosts them.

Such schemes are typically started by members of the local community who select land or a building that is suitable for the scheme, and develop an energy project (normally with professional support regarding planning, engineering design etc).

Funding for community schemes is typically via a share issue, so the ownership and benefits from the scheme remain in the local community (members of the community e.g. church congregation can be prioritised for shares if required).

Once built, income from the scheme is typically paid to shareholders as a dividend. A proportion is often used for community benefit, for example awareness raising, or the development of additional projects or energy efficiency measures in the community such as insulation or additional renewable energy projects.

In addition to the increasing the amount of renewable energy available, additional benefits include community engagement, and raised awareness of energy issues.

Ideally the community should be involved in the specification and choosing the location of the project from the outset, which in turn tends to leads to higher community acceptance.

If desired, local contractors and suppliers can be prioritised to retain the benefits from the project in the area.

Community schemes can help communities reduce their fuel bills by providing some control and ownership of the energy supply.

Community energy schemes also have the advantage that they are exempt from energy efficiency requirements to obtain Feed In Tariff income (a significant issue when dealing with churches and other listed buildings), and income from dividends can be tax free via an Industrial and Provident Society.

Community Renewable Energy Schemes in the UK include wind turbines, hydroelectric generators, and PV, including a solar farm worth many millions of pounds. Community energy has been very popular in other European countries such as Denmark and Germany, where around half of all renewable energy is produced from community owned schemes.

If you are interested in starting a Community Renewable Energy Scheme, please contact the Derbyshire Alternative Technology Association via Data@DerbyshireAta.org.uk

Financial Notes - Feed In Tariff (FIT) And Renewable Heat Incentive (RHI) Figures

The Feed In Tariff and Renewable Heat Incentive rates that will be payable will depend on the date of application, whether the installation is domestic or commercial, the scale of the system, the EPC rating of the building, and for domestic systems, the energy consumption deemed by a Green Deal Assessment. The FIT is payable for the generation of renewable electricity, and the RHI for the production of renewable heat. For domestic projects the RHI is payable for 7 years and the FIT for 20. The commercial RHI and FIT are currently payable for 20 years.

Note also that at the moment, receipt of certain capital grants to pay for the cost of equipment may preclude payment of the Feed In Tariff and the Renewable Heat Incentive.

Putting Things In Context

It would be rash to embark on a substantial renewable energy project without first considering if more cost effective improvements might not be made by insulation and other improvements to the building envelope. Unfortunately these can be just as contentious as renewable energy projects, with many stakeholders seeking to

preserve the appearance of buildings and conserve historical construction techniques, with the Diocesan Advisory Committee (DAC) acting as gatekeeper.

It is understood that some insurers are now requiring churches to protect their windows from vandalism. From an energy conservation point of view I would rather see sheet plastic used in this application as it will provide some shelter from the elements, reducing both heat loss and noise to some degree. By contrast, the DAC have expressed a preference for galvanized steel mesh. While accepting that plastic sheet will in the end become opaque, embrittle, and crack, steel mesh will also rust, possibly staining the stonework.

The DAC accept that the ultimate outcome and life expectancy will be influenced by the quality of materials used, and may be willing to consider proposals based on the use of high quality plastic sheet, see picture above.

Thanks

Thanks to the following for the photographs used in this leaflet - The Friends Meeting House Derby, Rushcliffe Country Park, Mann Power Hydro, Saint John The Evangelist Derby, Eckington School, Rural Energy, Hilton Guides and Scouts, Saint John The Evangelist Charlesworth, Nottingham University, and Buxton United Reform Church.

Resources

By all means contact the technical author, John Beardmore, on 0115 9448910 / 07785 563116 or John@Beardmore.org.uk

There are a number of feasibility studies on the use of heat pumps, biomass and hydro systems in church and community buildings on http://www.t4sustainability.co.uk/?downloads

The Centre for Alternative Technology has an excellent range of leaflets and books covering a range of renewable technologies. They also offer advice, though not all these services will be free. See http://www.cat.org.uk or call 01654 705950.

Even with renewable energy generation on site, it is usually necessary to buy in some energy from external sources. A number of companies sell 100% renewable electricity, and now renewable gas. If you are considering renewing your electricity supply contract, please consider sourcing your energy from renewable sources, and as with any energy supply contract, please read the terms and conditions with care to ensure that you get the tariff you want.