

**Pre-feasibility study into the
possibility of heating
a Field Study Centre with wood fuel**

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1 Introduction

Wood Fuel Powys has contracted Horne Energy Consultancy to carry out a pre-feasibility study into the viability of wood heating at the field study centre in South Powys. The study is also to consider the possibility of other renewable energy technologies where appropriate, and to highlight any energy efficiency improvements that could be made.

There are a number of reasons why the Field Study Centre may consider installing renewable heating systems, and therefore a number of ways of assessing the viability or appropriateness of different technical options. The key reasons are:

- To reduce the environmental impact of the fossil fuels used by the current heating systems. Conventional heating systems rely on burning fossil fuels, which increases levels of carbon dioxide in the atmosphere, which contributes to climate change, generally accepted to be the greatest environmental threat we face this century.
- To reduce heating costs, and so improve economic viability of the centre. Recent increases in energy costs have increased the significance of heating costs in any organisation's economic analysis. Most renewable energy systems have either no fuel cost or a lower fuel cost than conventional systems, making them a valuable tool in combating the impact of increasing fossil fuel prices.
- To ensure that heating systems comply with current and future regulations. Building regulations and many planning policies now require new buildings to meet stringent carbon dioxide emissions limits and/or to install a certain level of renewable energy supply. Such regulations also apply to major refurbishment projects and, if they were to be applied to the properties in the current study, it would be virtually impossible to comply without changing the heating systems. It is likely that increasing pressure will be put on organisations' landlords to reduce the emissions of their buildings and, once basic energy efficiency measures have been carried out, renewable heating is the obvious next step.

All heat and other forms of energy are given in kilowatt hours (kWh), and all boiler sizings and other power ratings are given in kilowatts (kW).

2 The Property

The property consists of three buildings – the main house, the annex and the staff house.

The main house is a converted farmhouse, including accommodation for visitors, central dining and lounge areas for visitors, the main kitchens, and offices for staff. The building is an old stone walled building with slate roofs and solid floor. There is no insulation in the walls or floor, minimal levels of insulation in open loft areas, and an unknown level of insulation within the pitched ceiling above the office. Windows are mainly single glazed, but the roof lights in the office area are double glazed. Windows and doors fit moderately well, and there is an unheated lobby or conservatory sheltering the main entrance, but air change rates are still high due to the way the building is used.

The building is mostly heated by a combination of electric storage heaters and various plug-in electric heaters. There are two log stoves in the main communal areas which are sometimes used. The kitchen area is not actively heated. There is a fan heater in the drying room that is run all night when drying is required.

Water heating is by electric showers and point-of-use heaters in the accommodation, and a small hot water cylinder with immersion heater (permanently on) for the kitchen.

The annex is another converted farm building, similarly of stone and slate construction. This building is used entirely for visitor accommodation. Again there is minimal insulation in the limited areas of open loft space. Most of the ceiling area is pitched, and there appears to be very little insulation within the pitched ceilings.

Windows are double glazed but in an appalling condition, and several need to be replaced as a matter of urgency, irrespective of energy conservation issues. Rooms all open onto lobby areas, rather than directly to the outside. Air change rates are probably still high, though probably lower than for the main house due to the different usage pattern.

The staff house is a converted garage, now used to provide accommodation for staff. The pitched ceiling and some of the walls were insulated during refurbishment, although thicknesses are not known. The main French windows and the sky lights are good quality, well fitting and double-glazed, and there are three small older single glazed windows. Air change rates are probably low.

Heating and hot water is provided by a new combination gas boiler running on bottled propane. Despite its recent installation, the boiler appears not to be a condensing boiler.

3 Current energy usage

Data provided by staff suggests that current energy usage is as follows:

Daytime electricity		19,700 kWh per year
Off-peak electricity		47,000 kWh per year
Oil		3,330 litres per year
	=	32,100 kWh per year
LPG (propane)		Unknown

Heat loss calculations for the building suggest the following peak space heating demands:

Main house	32 kW
Annex	19.5 kW
Staff house	5.5 kW

These figures assume that internal temperatures will be maintained at 19°C as long as the external temperature does not drop below -3°C for an extended period.

To correlate these figures to the energy use figures provided above, we need to make certain assumptions about the way the buildings are heated, in terms of when heating is on and when it is off, and about the efficiency of the heating systems used. This is done by a combination of what we know about the systems and control strategies in place, and by a process of trial and error, until we have a consistent and credible set of parameters that match all the data. The eventual parameters for this group of buildings are:

Hours per day heated to design temperature

Main house	12
Annex	10
Staff house	12

Percentage of electric heating requirement provided by off-peak:

Space heating	90%
Hot water	65%
Drying	50%

Seasonal efficiency of boilers

Oil boiler	78%
LPG boiler	82%

Using these parameters we can estimate the individual heating requirements as follows:

	Annual space heating requirement kWh	Annual water heating requirement kWh	Total annual heating requirement kWh
Main house (excl kitchen)	42,500	2,500	45,000
Kitchen	-	8,000	8,000
Annex	21,600	5,000	26,600
Staff house	5,400	4,200	9,600
Drying	2,000	-	2,000

Once split rate tariffs have been averaged out, the Centre currently pays the following prices for electricity:

Off-peak	10.51 p/kWh
On-peak	12.76 p/kWh

We can estimate likely current costs for oil and LPG, based on historic prices at the centre and national trends.

Oil 44 pence per litre = 4.56 p/kWh
 LPG 99 pence per kilogramme = 7.67 p/kWh

We can estimate CO₂ emissions from existing heating, using UK standard conversion factors:

Electricity 0.42 kg/kWh
 Oil 0.27 kg/kWh
 LPG 0.23 kg/kWh

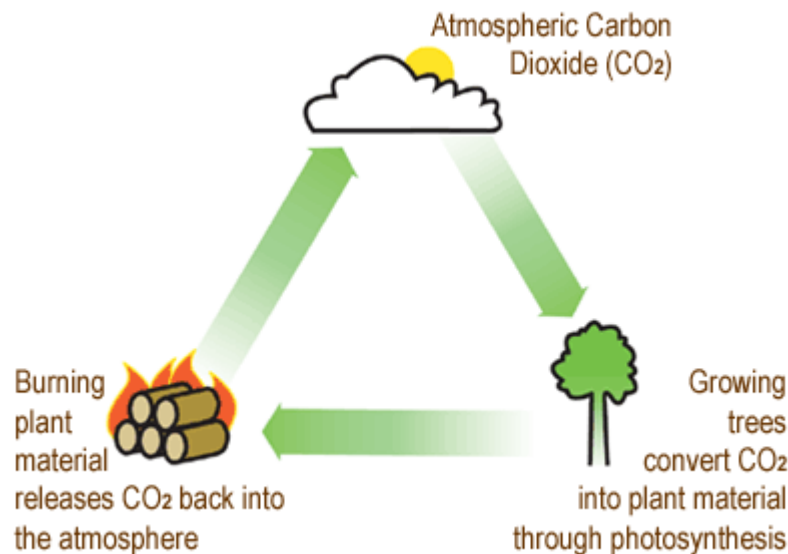
On the basis of these figures, current costs and emissions from heating at the property are as follows:

	Annual cost (£)	Annual emissions (t CO ₂)
Electric space heating	£4,793	18.68
Electric hot water	£1,194	4.44
Oil heating	£1,264	7.48
Oil hot water	£295	1.40
LPG heating	£504	1.51
LPG hot water	£397	1.19
Total heating	£8,447	34.69

4 Wood Fuel Technologies

Wood is a renewable resource, in that it uses only sunlight, water and carbon dioxide to grow. In the UK, virtually all harvested wood comes from sustainably managed forestry in that all trees harvested are replaced by new growth.

When wood is burnt, carbon dioxide is released to the atmosphere. However, this is the same carbon dioxide that was absorbed during growth and which is now being re-absorbed by the next tree. The carbon therefore forms part of a closed carbon cycle, and atmospheric carbon dioxide levels are not affected.



This is different from burning fossil fuels, where carbon that has been locked in the earth's crust for millions of years is released to the atmosphere with no chance of re-absorption, so increasing atmospheric carbon dioxide levels and contributing to climate change. Burning wood does not do this – it is carbon neutral, and does not contribute to climate change.

In normal circumstances, all wood contains water. The moisture content of wood varies dramatically from over 60% of the total weight for some sawmill and harvesting residues to under 10% for some delivered fuels. This has a huge effect on the density and calorific value of the wood, and also on whether the fuel will burn effectively in a given boiler. Wood fuel is often sold by volume (generally bulk volume) or by wet weight (measured in green tonnes). However, for consistency in this report, wood fuel is measured in oven dry tonnes (odt), that is the weight of wood that would remain if all the water were driven off.

Wood fuel is available in the UK in three main forms – chips, pellets and logs. All three have different technical characteristics, costs and availability, and they therefore need to be considered separately.

3.1 Wood Chip

Wood chip is made by feeding any low value timber into a chipper. The resulting material is relatively homogenous, low density, usually cheap, and can be moved mechanically in augers. If the raw material and the chipper are of an appropriate quality, then the chip produced will be suitable for burning in wood chip boilers.

Wood chip is generally available with a moisture content of between 30% and 50%, without any need for active drying of the chip. Many boilers require a moisture content of no more than 35% although it is possible to specify and install a boiler that will burn wood at 50% or even higher. However, this is generally only practical for larger boilers.

Chip boilers are available from 25 kW upwards, but the very smallest are prone to operational problems, particularly with the fuel feed system. It is best to assume a minimum practical size of 50 kW. Most boilers will turn down to a minimum operating output of around 20% of their rated output. Most also have automatic ignition, so they can be turned off during low points in a varying heat load. However, chip boilers do not have the flexibility of gas or oil boilers in meeting these variations, and it is therefore important to match the boiler to the load carefully. The larger and more consistent the load, the more likely it is that a chip boiler will operate effectively and efficiently.



A 50 kW wood chip boiler

The heat load at the property is large enough and consistent enough to work well with a chip boiler, particularly if all the buildings are connected to the same heating system. A typical system would comprise the following:

Fuel hopper – a tank or structure of several cubic metres, capable of receiving deliveries of chip from a tipper lorry or trailer

Auger – to feed chip automatically from the hopper to the boiler as required

Boiler – in self-contained boiler house with control systems, flue etc.

District heating circuit – a well insulated pipe circuit taking hot water from the boiler around all the buildings and then back to the boiler

Building heating circuit – this is a conventional wet radiator system, installed and controlled in exactly the same way as a gas or oil fired radiator circuit. It could be a separate circuit, heated by the heat main via a heat exchanger, or it could carry hot water direct from the heat main.

Other possible elements include:

Back-up boiler – an oil or gas boiler designed to provide heating if wood fuel is temporarily unavailable, to provide summer heating when the load is too small for the

wood boiler, to provide occasional peak heating when the load exceeds the wood boiler output, or some combination of these.

Accumulator – this is a large well insulated hot water cylinder, capable of storing enough energy to heat the buildings for several hours. In combination with automatic ignition, this can allow a wood chip boiler to operate successfully with smaller and more intermittent heat loads, and may obviate the need for a back-up boiler if wood fuel availability is not seen as an issue

The main advantages of this system are:

Virtually carbon neutral – the only fossil fuels used are those in fuel supply and handling, and the pumps and fans of the boiler and distribution circuits

Controllable – each building or part of a building can be controlled independently, in exactly the same way as a gas or oil system, giving complete flexibility in heating levels and timing.

Clean – an efficient wood chip system will produce no smoke during normal operation, often no visible plume at all, no soot and only small quantities of ash, which could be removed by the fuel suppliers or used as a fertiliser on site, or by any keen local gardeners

Cheap fuel – the wood chip fuel will probably be cheaper to buy than most other fuel types, leading to the possibility of cheap heating for the centre

The main disadvantages are:

High capital cost – the boiler and fuel handling systems are relatively expensive, as is the cost of retrofitting the district heating network and radiators (where not already present).

Significant operating costs – the cost of delivering the fuel, operating and maintaining the boiler can be significant, although good overall savings are often still possible

Large footprint – the combined size of the fuel store and boiler house can easily be over 10m², even for a very small system. This will require available land with suitable road access, close enough to the buildings to minimise pipe runs, but separate enough to avoid noise nuisance and interference with the flue.

3.2 Wood pellets

Wood pellets are made by compressing clean waste wood in a mill very similar to those used to make animal feed pellets. The lignin in the wood melts under pressure and binds the wood together to make a hard, durable pellet without the need for any additives. Pellets are typically 6 or 8 mm in diameter, can be mechanically handled by auger or pneumatic feed, have a moisture content below 10%, and are the most dense form of wood fuel available, making transport and storage easier and often cheaper. However, they do need to be kept dry at all times to avoid rapid deterioration. They are also generally the most expensive form of wood fuel.

Because of their small size and uniformity, pellets can be burnt in smaller boilers and heaters, and are the preferred fuel type for automatic wood heating systems for single homes across Europe. However, for any property large enough to justify a chip system, pellets are likely to be too expensive to offer a realistic solution. Pellets are therefore not considered further in this study

3.3 Logs

Logs may seem like an old fashioned fuel, but they offer all the low carbon benefits of other types of wood fuel, and there is an increasing range of options for using them

to heat buildings. Logs are the most variable fuel in terms of cost, moisture content, form of delivery and type of supplier, but in certain circumstances they can be the cheapest form of heating of all.

Log Stoves

Log stoves are available with or without back boilers. A simple stove heats only the space it occupies, as with the two stoves already installed at the field study centre. A stove with a back boiler heats both the space it occupies and the water in the boiler, which can be used to heat a hot water cylinder, or radiators, or both.

A well managed stove can offer the cheapest way to heat a building from a renewable source. However, the work involved in storing and moving logs, feeding the stove, and removing the ash, should not be underestimated. Increasing the reliance on log stoves at the property is not consistent with staff requirements at the centre, and additional log stoves are not therefore considered further.

The existing log stoves could either be retained or removed, with little impact on the viability or performance of any new heating system for the buildings.

Log Boilers

A log boiler is a relatively large piece of equipment and, much like a chip boiler, is therefore usually installed in a shed, outhouse or cellar. The boiler will require manual stoking, as with a log stove, but the frequency of stoking can be greatly reduced, and sensible siting of boiler and fuel store can minimise the work and mess involved in fuel and ash handling.



50kW log boiler with 2,800 litres of accumulator

Although a degree of automation can be included in the system to make it as user friendly as possible, the reliance on regular stoking is incompatible with staff expectations at the centre, and log boilers are not considered further.

4 Other Renewable Energy Technologies

4.1 Heat Pumps

Under normal circumstances, heat will always flow from a warmer place to a cooler place. A heat pump is a device that “pumps” heat in the opposite direction, moving heat from a cooler place to a warmer place. Energy is needed to drive the heat pump, and this usually comes from mains electricity.

Heat pump technology is very well established, and forms the basis of most fridges, freezers and air conditioning systems. More recently, heat pumps have become increasingly used for space heating purposes, where they take heat energy from some ambient source and up-grade it to heat at a higher temperature to run a heating system. Such systems are generally not fully renewable because of the electricity used to drive the heat pump, but the majority of the energy output comes from the ambient source and so heat pumps are often described as renewable systems, and the carbon emissions can be very low.

Occasionally, a renewable electricity generator is installed alongside a heat pump to provide 100% renewable heating. However, this is generally restricted to sites with a very specific renewable resource, such as a small hydroelectric site.

The key parameter used to describe a heat pump’s operation is the Coefficient of Performance or COP. This is the ratio of the total heat output to the electrical energy input. Because the electrical energy is all converted to heat, the COP is always greater than one, but how much greater will depend on the circumstances it is operating in. In particular, the greater the temperature difference between the heat source and the heat output, the lower the COP. As this temperature difference is likely to vary over time, then the COP will also vary, and the key parameter for assessing a heating system is therefore the seasonal COP, or average COP during the heating season.

Many heat pumps will claim a peak COP of 4 or even 5, but the seasonal COP could easily be less than 3. If the seasonal COP is significantly less than 3 then it may be that a conventional gas or oil heating system would be cheaper to run and would produce lower CO₂ emissions.

Heat pumps are also relatively expensive to install and, given the centre’s high purchase cost for electricity, a heat pump system would definitely be more expensive to run than a conventional oil or LPG system, and far more expensive than a wood chip system. Heat pumps are not therefore considered further.

4.2 Solar Water Heating

Solar Water Heating panels convert the energy from the sun to heat. Because the solar resource is so poor in the winter these systems are most effective during the summer months. They are therefore generally used to contribute to hot water use, and not to space heating. A typical system, where hot water use is consistent throughout the year, will provide 50 to 60% of the annual hot water demand, with the remainder usually provided by the main heating system.

Where there is a space heating system with heat storage, it may be worth arranging the solar system so that it contributes to the space heating at times. The contribution will be small, but it will lead to the least possible running cost for the overall heating requirement.

Solar water heating can be used with any heating system that involves a hot water cylinder. They work well with conventional gas or oil systems provided combination boilers are not specified. They can also be used alongside heat pumps, and they work particularly well alongside wood heating systems where the summer peak limits or does away with the need to light the wood boiler during periods of warm weather.

Collector Types

There are two types of solar water heating panel that are suitable for domestic hot water supply. These are flat plate and evacuated tube.

4.2.1 Flat Plate Solar Collectors

Flat plate solar collectors consist of an absorbing surface with a system of water channels built into the body of the absorber. To minimise heat loss, the back of the panel is insulated and the front has a clear cover. They have the advantage that they are relatively cheap to construct although prices vary enormously and they can be integrated into the roof thus reducing the visual impact of the installation.

The two systems shown in figure 1 are examples of roof integrated systems: the left hand photo is of a system in Wales; the right is a similar installation on a listed building in Appledore, Exmoor.



4m² Roof Integrated Filsol Flat Plate Collector

4.2.2 Evacuated Tube Collectors

In an evacuated tube collector the air is removed from a glass tube and the absorption surface placed inside the vacuum. This makes for a more efficient collector as the heat losses through the vacuum are extremely small. However the cost of manufacture is much higher and so there is usually little advantage in using evacuated tube systems unless roof space is limited. An evacuated tube system would be typically less than 70% of the size of an equivalent flat plate system.

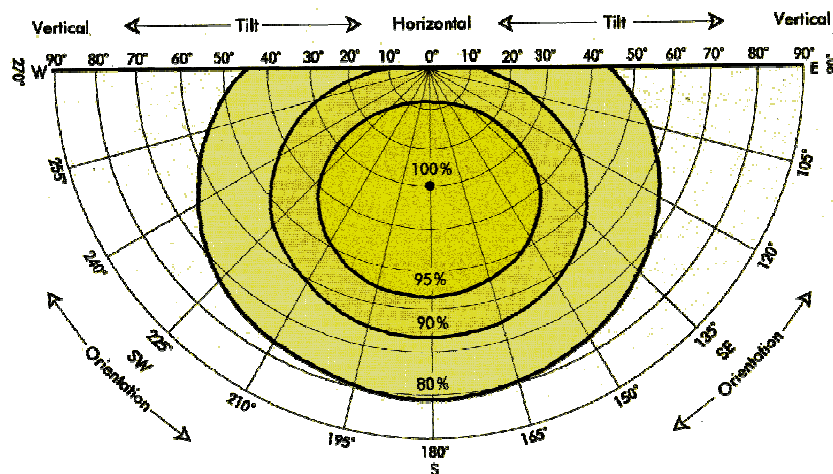


Evacuated Tube Collectors – West Barn, Malham

Evacuated tubes do perform better than flat plate collectors when the air temperature is low. If the system were designed to contribute to space heating at all, then it may be worth considering evacuated tubes, despite the extra cost.

4.2.3 Collector Siting

Solar thermal collectors can be mounted in virtually any un-shaded site, as long as it is not too far from the hot water cylinder. However there are clear benefits in orientating the collectors well. Ideally the collector should point any where between southeast through south to south west, at an angle of 10-40° to the horizontal.



Orientation losses for a solar thermal system

The figure above shows the losses associated with mounting collectors at different orientations and angles to the horizontal in the UK. Fortunately this requirement fits well with our general rule of orientating buildings to face south. The optimum angle would be about 36° from horizontal, and facing due south. This is not always possible, as the systems are typically mounted on the roof, and this angle and orientation are fixed. Therefore allowances must be made as to the lower efficiencies as shown above.

The other key consideration on a solar system is any shading. This should be avoided as much as possible by choosing locations with little annual shading from trees and nearby buildings. The levels of shading will change throughout the year, and therefore a site that is partially shaded in winter may still be viable, whereas one shaded in summer or all year probably will not.

4.3 Renewable Electricity Generation

Electricity can be generated at a small scale using wind power, solar power and, at some sites, hydroelectric power. Wind power is highly site specific, and is generally more cost effective for larger installations. The site is relatively sheltered by surrounding hills and trees, and is not a good site for installation of small scale wind turbines.

Solar electricity is generally possible wherever there is a suitable south facing roof or other site for installation. However, the cost of installation is generally too high to justify use of this technology unless strong non-economic drivers are in place.

Hydroelectric power can be very effective and cost effective in certain locations. However, the obvious resource at this site has already been developed.

It is not therefore recommended that generation of electricity from renewables be pursued at the field study centre.

5 Technically Appropriate Options

The technically most appropriate renewable energy system for the property is a wood chip fired boiler to provide space and water heating for all the buildings via a mini district heating circuit. There are a number of technical variations to be considered, including various options for the inclusion of solar water heating. It would also be possible to consider solar water heating on its own, if the wood chip boiler were not to be pursued at this stage.

The main variants are described below, with a brief description of how they would operate.

5.1 Wood chip with oil back-up

There is ample space for a wood chip installation between the annex and the staff house, immediately to the west of the parking area. A single new building could be constructed to house a wood chip boiler, back-up oil boiler and wood chip store. The chip store would be filled on a regular basis by tipper truck or tractor and tipping trailer. From here, chip would be fed automatically into the chip boiler as required.

The chip boiler would heat water which would be pumped around a mini district heating circuit to the main house, annex and staff house. The heat main would provide heat for the radiators in the annex and the staff house, via new heat exchangers in place of the existing oil and LPG boilers. The heat main would also provide heat for new radiators in the main house, for the existing hot water cylinders in the annex and kitchen, and for new hot water cylinders in the staff house and the accommodation end of the main house.

The wood chip boiler would provide the bulk of the space and water heating throughout the year. However, in times of particularly high heat use, the oil boiler would fire up automatically to provide top up heating. This is known as “peak lopping”. Also, during the summer when no space heating is required, the oil boiler might be used to top up the hot water cylinders without having to light the chip boiler. The oil boiler would also serve as a back-up should there be any problems with the chip boiler, such as temporary shortage of suitable wood chip.

The heat main circuit would operate continuously during the heating season. In the summer, it would probably only operate for a few hours a day, with the four hot water cylinders providing enough storage to ensure hot water throughout the day. If necessary, immersion heaters could be used for occasional top up if hot water was exhausted before the heat main came on again. However, if this happened frequently it would be worth increasing the operating hours of the heat main to avoid excessive electricity use. It may also be necessary to replace the kitchen hot water cylinder with a larger one.

With this system, the wood chip boiler is designed to stay on permanently while there is a space heating load. The wood boiler output will modulate up to a point to meet variations in heat demand. However, the wood boiler should be sized at less than the maximum expected demand, so that it can operate successfully at times of fairly low heat demand. The oil boiler will be available to make sure that peak heating demands are met.

The wood boiler capacity might therefore be 50 kW, which is slightly less than the peak space heating demand. The oil boiler should be somewhat bigger if it is intended to provide adequate back-up for the whole site (say 70kW), or a little

smaller (say 35 kW) if it is only intended to provide peak lopping, summer heating and some level of emergency back-up.

We would expect the wood chip boiler to provide between 80% and 95% of the total annual heat requirement, depending on how much of the summer hot water load can be met successfully by the wood boiler. This will depend on the characteristics of the boiler, on the pattern of hot water use, and on the number of days per year when beds are let but there is no space heating requirement.

We estimate that this system would require between 18.5 and 22 oven dry tonnes of wood per year, and between 500 and 2,000 litres of oil per year.

5.2 Wood chip with accumulators

Much of the infrastructure would be the same as above, but there would perhaps be no oil boiler. The chip boiler would have automatic ignition and would provide heat to an accumulator or bank of accumulators. The accumulator would provide heat in turn to the district heating circuit, which would provide heat to the radiator circuits and hot water cylinders as described above.

The advantage of the accumulator is that it provides a buffer between how much heat the boiler is giving out at any time, and how much heat the buildings require. Thus the building heating systems draw heat from the accumulator as they require it, depending on heating controls, temperatures, hot water use etc. When the accumulator temperature drops to its minimum allowable temperature, the wood chip boiler automatically fires up and runs until the accumulator reaches its maximum allowable temperature. In times of extreme cold, the wood boiler will run continuously, but for much of the year it will run for a few hours and then turn off when the accumulator is replenished.

With this system, the wood boiler can continue to provide hot water during the summer, no matter how low the demand gets. The district heating circuit can operate intermittently at this time, as with the system described above.

The system can be designed to operate without a back-up boiler altogether. The wood chip boiler would be larger than for the system above, say 70 kW, and therefore capable of providing space heating at peak times, with additional capacity for hot water provision.

Of course, with no back-up boiler, there is no alternative heat source if wood chip is unavailable. Some systems are therefore installed with a back-up boiler in any case, though some are installed and successfully operated without.

The size of the accumulator will depend on the desired operating strategy, which will partly be determined by the characteristics of the boiler, and how short a firing cycle it is happy with. As an example option, a 12,000 litre bank of accumulators could provide hot water for the site for an estimated three days, and could then be reheated in four hours by a 70 kW wood boiler at full output.

The estimated annual wood requirement for this system is 23.5 oven dry tonnes.

5.3 Solar Water Heating

Solar water heating panels could be installed on any or all of the buildings, provided hot water cylinders are there to take the solar input. Generally, larger cylinders are

installed if solar is to be included, and the cylinder will require a separate heating coil for the solar input. It is therefore usually necessary to replace the existing tank where there is one already in place.

The annex has a roof that is well suited to a solar water heating installation, with a large area of sloping roof facing just west of south. The main house is fairly well oriented, with a steeper roof facing just east of south east. The staff house has the worst orientation, with one pitch facing just south of east, and significant shading to the east. This building also has the least expected hot water requirement.

The “standard” approach to solar water heating would be the same, whether wood chip heating is installed or not. Flat plate collector arrays would be installed to feed into new hot water cylinders in the annex, the kitchen, the accommodation end of the main house and, possibly, the staff house. The cylinders would get most of their heat from the solar arrays, with the remainder coming either from the wood chip district heating circuit or from the existing oil and electricity systems.

Exact sizing of the arrays is difficult, as we can only estimate hot water usage. However, a size of half a square metre per occupant for the accommodation areas, and a kitchen array as big as the other two combined, may be appropriate. This would equate to 12m² for the annex, 6m² for the main house accommodation and 18m² for the kitchen. At the field study centre, where there is greater occupancy during the summer months than during the winter, we would expect more than 60% of the hot water in the main house and annex to come from solar. The staff house would not perform so well due to its poor orientation.

The economic and environmental savings from this approach would be very significant if compared to the existing hot water systems. If solar were installed along with wood chip heating, then the financial and environmental benefits are less, but how much less will depend on the exact nature of the various systems. For example, if solar panels are installed with the wood chip and oil back-up combination, they will displace a far higher proportion of the oil than of the wood, due to the expected low wood contribution during the hottest months. The solar panels could also allow the district heating circuit to be turned off entirely when space heating is not required, saving on pumping costs.

5.4 Wood chip heating with central solar water heating

It would be possible to install solar water heating on the new wood chip boiler house, and feed the output directly into the district heating system. This approach would be particularly effective with a system that included accumulator storage. In this case, it would be possible for the solar panels to make some small contribution to the space heating requirement, especially if evacuated tubes were used. Evacuated tubes offer better performance in times of low air temperature, making them more likely to be able to contribute at times when space heating is required, or will be required in the very near future.

It would be possible to design and orient the boiler house to create an ideal angle for the solar array. If a contribution to space heating is desired, then the optimum angle would be steeper than the 36° mentioned above. A steeper angle would capture more of the winter sun, and slightly less of the mid summer sun, when an array that was sized to provide more than just hot water would be more likely to produce excess heat.

Sizing of this type of system is even harder, as the possible contribution to space heating will depend very much on the local microclimate and the exact pattern of usage and heating strategies. In the analyses below, we have assumed that an array of 30m² of evacuated tubes would provide 70% of the hot water requirement and 10% of the space heating (including drying).

6 Options Assessment

The above options have been assessed for their possible financial and environmental performance. We have estimated total capital costs for each option, and likely financial savings, and from these we have calculated the expected simple payback period.

CO₂ savings have also been calculated, and the value for money in terms of kilogrammes of CO₂ saved per pound invested. This latter figure has been calculated over a fifteen year system life.

N.B. All these estimates are based on a number of assumptions, and on our assessment of what is likely to be happening at the centre and what might happen in the future. The figures are given in good faith, and they represent the best estimate available with the current information. However further details, especially installers' quotes for capital costs and performance figures for new systems, should be obtained before any final investment decisions are made.

Throughout the assessment, we have assumed that wood chip can be delivered to the site at £80 per oven dry tonne, and that a 40% grant is available towards the total capital cost of each system.

6.1 Wood chip with oil back-up

We have assumed 10% of total heating is provided by the oil back-up.

Capital costs estimates:

Boiler, flue, controls	£10,000
Oil back-up and store	£3,500
Wood fuel store	£5,000
Boilerhouse	£4,000
Heat main	£6,000
New radiators	£7,500
New HW cylinders	£1,000
Total	£37,000
Grant rate	40%
Net capital expenditure	£22,200

System performance estimates:

Annual financial saving	£6,312
Simple payback (years)	3.5
CO ₂ saved (t/a)	31.4
kg CO ₂ saved per £	21.2

6.2 Wood chip with accumulators

We have allowed for 6,000 litres of accumulator, and no oil back-up.

Capital costs estimates:

Boiler, flue, controls	£11,000
Wood fuel store	£5,000
Accumulators	£5,000
Boilerhouse	£4,000
Heat main	£6,000
New radiators	£7,500
New HW cylinders	£1,000
Total	£39,500
Grant rate	40%
Net capital expenditure	£23,700

System performance estimates:

Annual financial saving	£6,578
Simple payback (years)	3.6
CO ₂ saved (t/a)	34.0
kg CO ₂ saved per £	21.5

6.3 Solar Water Heating with no wood system

We have assumed systems are installed for the main house accommodation, the kitchen and the annex, but not for the staff house, and that total annual solar contribution is 65%.

Capital costs estimates:

Solar panels	£15,750
New HW cylinders	£1,900
Total	£17,650
Grant rate	40%
Net capital expenditure	£10,590

System performance estimates:

Annual financial saving	£1,458
Simple payback (years)	7.3
CO ₂ saved (t/a)	5.4
kg CO ₂ saved per £	7.7

6.4 Wood chip heating with accumulators and central solar water heating

We have allowed for 6,000 litres of accumulator, and no oil back-up.

Capital costs estimates:

Boiler, flue, controls	£11,000
Solar panels	£29,400
Wood fuel store	£5,000
Accumulators	£5,000
Boilerhouse	£4,000
Heat main	£6,000
New radiators	£7,500
New HW cylinders	£1,000
Total	£68,900
Grant rate	40%
Net capital expenditure	£41,340

System performance estimates:

Annual financial saving	£67,014
Simple payback (years)	5.9
CO ₂ saved (t/a)	34.2
kg CO ₂ saved per £	12.4

7 External Funding

There are a number of possible sources for external funding for a project of this type. Some are related specifically to renewable energy systems and their environmental benefits, while others may be more to do with general educational or tourism funding. Below are some possible sources specific to renewable energy, which centre staff may not be familiar with.

The nature and availability of these sources will vary over time, and the following is merely an indication of what may be available at the time if the centre proceeds with an installation in the relatively near future.

7.1 Wood Energy Business Scheme

This is a funding scheme operated by the Forestry Commission and is specifically for wood fuel heating systems in non domestic buildings. The current scheme is about to close, and was not available in some parts of South East Powys in any case. However, a second phase is planned, and is likely to have different availability and different eligibility requirements. One of the key recommendations in the assessment of the first phase was that the second phase should be more widely available if possible.

Under the original scheme, funding was available for up to 49% of the total eligible cost, depending on geographical area. It is unlikely that such a high rate will be available in any future scheme.

Web site: www.woodenergybusiness.co.uk

7.2 Low Carbon Building Programme

This is a UK government grant for renewable energy systems. Public sector and charitable organisations are eligible for support under Phase 2, which offers up to 35% support for wood heating systems and up to 30% support for solar thermal installations. Organisations can apply for up to three technologies at any one site.

Phase 2 has just commenced and should be open until late 2009.

Web site: www.lowcarbonbuildingsphase2.org.uk

7.3 Brecon Beacons National Park

The park provides funding for other organisations to make environmental improvements, including the development of renewable energy systems, from the National Parks Sustainable Development Fund. Whether the Field Study Centre could benefit from such funding will depend, amongst other things, on the future relationship between the centre and the park.

7.4 Local Energy Funding

A local group is using funds from the community hydroelectric scheme adjacent to the centre to support the development of other sustainable energy initiatives in the area. Although the total amount of funding may be relatively small, it is possible that a small contribution from this organisation could match one or more of the other sources to provide a meaningful contribution.

7.5 The Carbon Trust

This UK wide body does not provide grants as such, but it does provide interest free loans for the installation of carbon saving measures, and could potentially be used in combination with one or more grant bodies to provide 100% of the funding. This may be a way forward if it is not possible to raise the balance of the capital required from one or more of the bodies involved in owning and managing the centre.

8 Conclusions

A wood chip boiler providing space heating and hot water to all three buildings is clearly a viable option. Given the economic benefits, and the lack of any other technical solution that offers anything like the same economic performance, there is no conceivable reason for not proceeding providing the capital can be found.

The environmental benefits of installing such a wood heating system are also highly significant, and they would come at no cost to the centre in the long term.

The inclusion of solar water heating would increase the payback period somewhat but, at under 6 years, this may still be considered acceptable. The combined wood and solar option is the best option environmentally, and also leads to the lowest running costs in the long term. If additional funding were available to support an innovative system with solar contribution to the space heating, then this might be the preferred option.

If such funding is not available, and the pressure for a good return on capital investment is high, then one of the wood heating options with no solar would be the preferred option. It is not possible to recommend a specific option, as the difference between projected performance figures is too small to favour one over the other given the likely error in the estimates.

Solar water heating on its own performs fairly well economically, but has a much lower impact both in terms of environmental benefit and in terms of the centre's running costs.

We would recommend that commercial quotations be sought for installation of a wood chip heating system, with or without oil back-up and solar water heating, and that a final decision be made once quotes have been received and assessed. Further investigation of external funding should be carried out at the same time.

This process should commence as soon as possible to allow installation before the next heating season. Any delay will cost thousands of pounds in unnecessary electricity bills.