

**Report on the Feasibility of
Wood Fuel Heating
North Powys**

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A report for Wood Fuel Wales

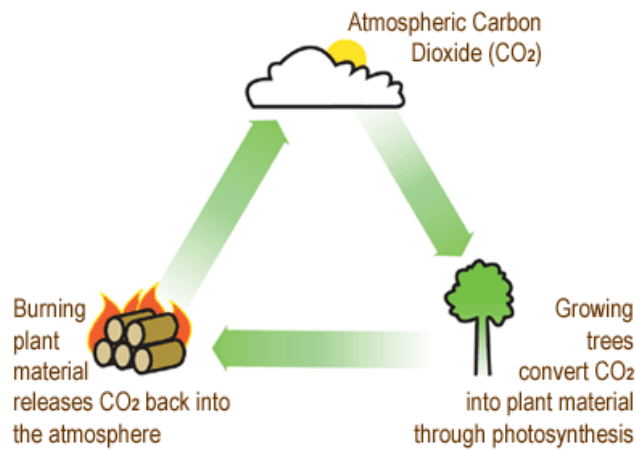
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1 Background

The Horne Energy Consultancy was commissioned by Wood Fuel Powys to undertake a feasibility study on the potential for heating this domestic property with wood fuel. The site was visited an assessment made, and this report presents the conclusions made.

Wood fuel is supported because it is a renewable fuel. Almost all wood produced in the UK comes from a sustainable source, which means that any carbon dioxide released in its combustion is balanced by the carbon dioxide absorbed by the tree during growing. No fossil carbon is released to the atmosphere, and so wood burning does not contribute to global warming.



2 The Property

The building is a semi-detached timber frame and timber clad building, with two bedrooms, living room, 2 studies, kitchen and bathroom. The building is currently very poorly insulated, with only a thin layer of fibreboard in the walls and roof, nothing under the floor, and poorly fitting single glazed windows and door throughout.

However, the current owners plan to improve insulation levels dramatically, including full loft, wall and floor insulation, and the replacement of all doors and windows with new sealed double glazed units. The level of insulation possible will vary from place to place within the building, and exact thicknesses are not yet known. However, the owners are aiming for a wall u-value of 0.25 W/Km², 200 to 300 mm of insulation in the roof, and 100 mm under the suspended floor which comprises most of the building's footprint.

The building is currently heated by an oil boiler, feeding radiators in all rooms except the kitchen and a pre-insulated hot water tank. The heat distribution system appears to be in good condition, but the controls are basic, with a mechanical time switch by the boiler (in the kitchen) and a room thermostat in one of the studies. There is an open fire with working flue in the living room, though this is not currently used. The building has other chimneys which are currently blocked off.

There is plenty of space outside the building for additional boiler house space or wood storage and processing, and a garage that is available for wood storage. The owners are familiar with log heating systems, and are confident of being able to obtain sufficient wood fuel at a reasonable price.

The owners are planning to install solar water heating at some stage.

3 Wood Heating Options

The property is too small for a wood chip heating system to be operated effectively. There are four properties at the site, and it would be technically feasible to heat all four with one wood chip boiler and a mini district heating system. However, such schemes are expensive to install and require considerable co-operation between the house owners and residents both during development and operation. This option is not within the remit of this report and is unlikely to happen unless strongly desired by all four householders. Wood chip heating is therefore not considered further.

Wood pellet heating would be technically suitable for one property alone. However, the fuel is relatively expensive, currently similar in price to oil. Given the owners' willingness to operate log systems, and the availability of cheap logs, it is assumed that pellet heating would not be attractive here, and it is therefore not considered further.

Log heating is the clear favourite for this site, but there a number of technical options for heating the building with logs.

Option 1 – Simple Log Stove

The owners are already considering installing a small log burner in the fireplace in the living room, to act in parallel with the central heating system. This would be used to provide top up heat in the living room, occasional evening heat without lighting the central heating system, and a pleasant feature.

This technology is relatively cheap and, if operated correctly with dry fuel and a suitable flue, will burn cleanly and provide heat efficiently. Stoves such as this will require regular stoking throughout the day and frequent de-ashing, and cannot be kept in overnight without compromising combustion efficiency and flue life.

A simple stove at this location would provide some heat to the rest of the building once the insulation measures have been carried out. However, it is unlikely that it could provide adequate heat to other rooms without providing excessive heat to the living room. The only way to provide full house heating with this technology would be to install multiple stoves throughout the house, which would be excessive in terms of both capital cost and management effort.

If a log stove is to be fitted to an existing chimney, it will generally be necessary to line the chimney with an insulated flue liner to ensure safe operation and conformity with building regulations.

Option 2 – Log Stove with Back Boiler

A larger stove could be fitted in the same location, with a back boiler to provide hot water for the heating circuit and cylinder. This system would allow balancing of the heat output around the house, with some heat given off directly into the living room and the majority being fed to the radiators and controlled like any other central heating system.

It would be important to select a model with a large wrap around back boiler, so that direct heat output to the living room is limited. This would limit the risk of overheating the living room. There should be no risk of underheating the living room, as there are two good sized radiators in the room which, if suitably controlled with thermostatic radiator valves, would automatically provide top up heat as required.

This is the simplest, and therefore the cheapest, technology for providing full house heating with wood fuel. Additional plumbing would be required to connect the back boiler to the hot water cylinder and the radiator circuit. However, if this were carried out at the same time as installation of the underfloor insulation, then additional disruption would be minimised.

The stove would provide the same visual feature and feeling of immediate warmth in the room as a simple stove, but would be bigger in size.

Log stoves with back boilers have all the limitations of simple log stoves, only more so. They are designed to provide more heat and so they require more stoking and more de-ashing. They are also more likely to experience inefficient combustion, because the back boiler cools down the all important combustion area. Sensible operation and dry wood are therefore doubly important with a back boiler stove, and attempting to keep the stove in overnight is particularly risky.

A log stove with back boiler in the living room would require constant movement of wood fuel and frequent de-ashing in the house's prime living space, which may not fit in with the owners' requirements. All log stoves with back boilers give out a significant amount of heat directly to their surroundings, so it would not make sense to site one elsewhere in the building.

This type of stove would have the same flue requirements as the simple stove described above.

Option 3 – Simple Log Boiler



It would be possible to replace the existing oil boiler with a simple log boiler. These are larger than their oil and gas equivalents, but it could fit in the kitchen where the existing boiler is without significant disruption. Alternatively, it could be sited in a new lean-to directly outside the current boiler location, in which case a small day store of logs could be kept alongside it.

Simple log boilers operate in a similar way to stoves with back boilers, in that they require stoking throughout the day and regular de-ashing. However, most modern log boilers have a more efficient arrangement inside, and are often described as a “downdraft” or a “gasifying” boiler. In essence, the combustion area is physically separated from the boiler area. The boiler does not therefore cool down the combustion process, and so combustion efficiency is generally higher. This leads to fewer emissions, fewer deposits in the flue, less wood fuel requirement and considerably less ash production.

It is possible to control the burn rate of a modern log boiler to a reasonable extent. Minimum sustained output may be as low as one third of the peak output, and this may make it possible to keep the boiler in overnight without disastrous results. However, combustion efficiency will drop off with output, so re-lighting the boiler daily will lead to better overall operation.

Such a system would easily run the central heating and hot water systems, and could heat the house with or without the log stove in the living room to help. The frequent stoking would still require carrying a lot of wood fuel through the house (if sited in the kitchen) or regular trips to the lean-to (if sited outside). However, boiler fire boxes are generally quite a bit bigger than the largest stoves, so stoking will be less frequent than for a stove.

Flues for log boilers are generally purpose built, passing through the wall and then up to some height above the eaves.

Log boilers do not give off significant amounts of heat, and so do not heat the room they are located in. A log boiler in the kitchen will not therefore heat the kitchen unless a small radiator is added to the circuit.

A simple log boiler such as this has to be matched very closely to the heat load to operate well. It is possible that the proposed insulation measures will make the heat load too small for successful operation of the smallest log boilers available (see Section 6 below).

Option 4 – Log Boiler with Accumulator

This is the most technically advanced option. A boiler is installed much like the one described above but a bit bigger. It would almost certainly be located outside the existing house, in a new lean-to or similar structure. The boiler is designed to be filled up and fired perhaps twice a day at most, often only once and maybe less often than that.

The heat from the boiler passes to an accumulator, which is essentially a well insulated hot water tank only bigger. The heat in the accumulator is then used to run the central heating circuit as required and to heat the hot water cylinder.



This system has several advantages:

- There is no need ever to run the boiler at less than full output, so it always burns cleanly and at maximum efficiency.
- The boiler only requires stoking around once a day on average, and infrequent de-ashing due to the consistently high combustion efficiency.
- The central heating will run off the accumulator as long as there is heat in the accumulator and the heating controls tell it to run. The heating can come on at any time of the morning without anyone getting up to light anything.
- There is a very large heat store, so the chances of running out of hot water are much lower.
- It is possible to connect the solar thermal system to the accumulator, and so get increased solar storage, and possibly some solar input to heating at certain times of the year.

However, the system also has two major disadvantages:

- It is the most expensive option of all, with a bigger boiler, one or more accumulators and more complicated plumbing, pumps and controls.
- The system is physically very big. The boiler is bigger still, and a standard 1000 litre accumulator is bigger than most fridge freezers. Many domestic systems make do with one 1000 litre accumulator, but the technically ideal system would have two or three.

In practice, there are possibilities with varying degrees of complexity between Option 3 and 4. A boiler sized for Option 3 but with a small accumulator added will operate much more effectively than the boiler alone, but without the low frequency of stoking of the full Option 4.

Option 5 – Log Range

It is possible to buy range cookers that are specifically designed to run on logs. They are different from multifuel ranges, which may run on wood at a pinch but will never be satisfactory without constant stoking, and usually a bit of coal to help out.



Such a stove, installed in the kitchen in place of the boiler, would provide heat for the central heating, heat for the hot water cylinder, direct heat to the kitchen and heat for cooking. It is possible to manage all of these things at once, but the stoking rate may be considered excessive. The amount of heat given off to the kitchen may also be excessive, and will not be controllable.

Log ranges are expensive – there are none made in the UK, and very few are imported. If used well they can burn fairly cleanly and efficiently, but they cannot match a well used downdraft boiler for efficiency.

Cooking on solid fuel ranges is very different from cooking on conventional cookers – some people love it and some do not. The choice to be made is one of personal preference rather than technical suitability. If the owners like the idea of having a range, then they should consider a wood fired one. Otherwise, they should stick to the various boiler options.

4 Solar Water Heating

This report is not about solar water heating *per se*, but it is important ensure that the two options are not considered entirely separately. Solar water heating is possible in conjunction with any of the wood heating options described above.

Most retrofitted solar water heating installations include replacement of the hot water cylinder with something larger to make better use of the sun when it is available. These cylinders have two coils in them, one for the solar and one for the other heat source, which in this case is the wood boiler.

If an accumulator is included in the wood heating system, it may be worth feeding the solar input to this rather than directly to the hot water cylinder. This will greatly increase the amount of solar heat that can be stored, so making the best use of the heat available on the hottest days, which may be enough for several days' hot water use.

With such a system, it is also possible that the solar input will occasionally provide a contribution to the space heating. However, to make much use of this the solar system will have to be larger than normal, and preferably an evacuated tube system which will operate more effectively in cold weather. This will increase the cost of the solar installation significantly, which may not be worth it given the cheap and renewable nature of the log fuel that would be displaced.

The important thing to be considered is that, if solar water heating and wood heating are being installed at different times, then the first system to be installed is designed to accommodate the second with the minimum of additional work. Most wood heating installers are familiar with solar technology too, and should be able to advise on this.

5 Choosing an Option

There is no clear technically correct option. All of the above are possible, though the option of heating just with simple log stoves is probably impractical if modern comfort levels are required. A number of factors will be involved in making the decision, including:

- capital cost
- ease of operation
- comfort level provided
- system efficiency
- whether the owners like the idea

The following table attempts to quantify the first four factors. It should be remembered that system efficiency is unlikely to be the most significant factor, given the cheap renewable fuel and the small variation between options.

Capital costs are shown as an estimate of the total installed cost. Please note that this is an estimate for comparison purposes only. Actual quotes from installers will be required before budgeting for the installation. All other factors have been given a score from 1 to 10, with 10 being the best.

Option	Capital cost	Ease of operation	Comfort level	System efficiency
Several simple log stoves	£6,000	1	3	8
Log stove with back boiler	£4,000	4	7	6
Simple log boiler	£6,000	5	8	8
Log boiler with small accumulator	£7,000	6	10	9
Log boiler with large accumulator	£10,000	8	10	10
Log range	£8,000	3	6	7

It would be possible to install a simple log boiler at present, and then add a small accumulator at a later date provided the plumbing was designed for this from the start. It would not be possible to add the larger accumulator at a later date, as this option requires a larger boiler.

Grants are currently available from the Low Carbon Building Programme towards the cost of all the boiler options, but not towards the stoves or ranges. The grant available is £1,500 or 30% of the total eligible cost, whichever is the lower.

6 Sizing the Heating System

Some rough measurements were taken of the building envelope to estimate the heat loss and so provide some indication of the size of boiler required for the heating system. Assuming an internal temperature of 21°C, and a sustained minimum outside temperature of -4°C, the building as it stands has an estimated peak heat loss of 18 kW. A boiler of 20 kW would therefore have sufficient spare capacity for heating water even at the coldest times.

However, if the building were insulated to the levels suggested by the owners, the peak heat loss would be reduced to 7 kW, implying that a 10 kW boiler would be ample. In practice, the smallest log boiler currently accredited for the Low Carbon Building Programme is 14.9 kW (the Künzel HV 15), and there may well be nothing smaller available outside the scheme either.

The implications are that, if the proposed insulation levels are achieved in practice, then Option 3 above will not be possible. However, Option 3 would be possible if lesser insulation levels are achieved in practice, and it is quite possible that the proposed levels are not achieved due to physical limitations, particularly in the pitched ceiling areas. Also, the intermediate option of log boiler with small accumulator would work successfully if the insulation levels are achieved, because the low heating requirement would mean that even a small accumulator would provide a good level of buffering.

All other options described above are compatible with heat loads as low as 7 kW, though they need to be matched well to the actual heat loss achieved.

It is estimated that the house as it stands would require about 6.5 oven dry tonnes of wood per year, equivalent to about 13 green tonnes. If insulated as proposed, the house would only require about 2 oven dry tonnes or 4 green tonnes per year.

7 Recommendations

The following recommendations are made:

1. The proposed insulation improvements are installed as a matter of course, and that estimates of the new U-values achieved are made to allow more accurate sizing of the heating system.
2. The owners should consider the suitability of the log stove with back boiler, log boiler with and without accumulator, and log range.
3. Multiple quotes should be obtained from Low Carbon Building Programme installers for the preferred option or options.

If the log boiler only option is to be pursued, then the system should be designed for retrofitting of an accumulator in case the heat load proves to be too low for continuous operation of the boiler.

Any system installed should be designed to accommodate solar water heating if this is not being installed at the same time.