The Quest for Sustainable Energy

woodfuel

meets the challenge

- Renewable fuel is at the heart of Government energy policy
- Woodfuel has the potential to provide a major component of the UK's renewable energy commitment
- Woodfuel can provide heat and power – on demand
- Modern woodfuel technology is efficient and clean
- Woodfuel can be cheaper than other fuels

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Woodfuel is news again

Using wood for fuel is hardly a new idea, so why the recent upsurge in interest? With the drive for renewable energy in the UK woodfuel is experiencing a renaissance, providing an economical alternative to fossil fuels. Using woodfuel reduces our reliance on fossil fuels which, in turn, helps to lower carbon emissions. And woodfuel can play a major part in UK renewable energy production. ***Woodfuel meets the challenge*** is a guide to the overall benefits of woodfuel for anyone wishing to find out more about the potential of wood as fuel. The leaflet provides information on modern burners, boilers and woodfuel products, and the comparative cost-effectiveness of using wood as fuel. Developing woodfuel markets, sustainable management for woodfuel, and how you can take woodfuel forward are also explained.

Our forests are taking on a new role to provide a renewable fuel source that is sustainable, with wider benefits to society and the environment

What are the benefits?

We all use energy to heat and power our homes and can all therefore benefit from woodfuel. Here are some of the advantages:

- **Net carbon emissions can be reduced compared to fossil fuels.**
- **Modern woodfuel combustion technologies are clean and efficient.**
- **Given rising prices of fossil fuels, switching to woodfuel can actually reduce fuel bills.**
- **So long as forests are sustainably managed, woodfuel provides a renewable source of energy.**
- **Incorporating reclaimed clean wood into woodfuel systems helps to reduce the burden on landfill.**
- **Managing forests for woodfuel also benefits a wide range of other forest functions such as biodiversity.**
- **Financial returns from woodfuel can fund further woodland management.**
- **Using woodfuel contributes to UK renewable energy targets.**
- **Woodfuel businesses create and sustain rural jobs.**

Woodfuel technology is energy efficient

Woodfuel can be burned using sophisticated, modern technology to create energy efficiently. Technology has moved a long way from the traditional, small-scale use of wood on open fires. Appropriately prepared woodfuel can be burned in automatic, high efficiency boilers and power installations. Despite having lower woodland cover than many countries the UK still has a large under-utilised woodfuel resource. For example, in England an additional 2 million green tonnes per annum of wood for fuel could be produced given the right market conditions.

Woodfuel technology is clean

Modern woodfuel systems burn very cleanly when carefully controlled to ensure complete combustion, producing small quantities of ash, emissions and little smoke. The ash (typically less than 1% of the wood input, by volume), is not classed as a hazardous waste and can be disposed of with relative ease, for example for use as a fertiliser or as a raw product for block making in the building industry.

Wider benefits of using woodfuel

Using wood as fuel helps to enable landowners and farmers to bring woodlands under improved management and carry out thinning economically. This helps to safeguard the future of our forests and woodlands and all the functions they provide including recreation, biodiversity, landscape and carbon sequestration. And, as indicated, with rising costs of fossil fuels woodfuel is now an economically viable alternative for heat and power generation.

Wood is a renewable fuel

UK woodfuel production is supported by good management and conservation practices, as specified in the UK Forestry Standard and supporting guidelines. Government regulations strictly control the felling of trees and woodland owners need permission to carry out felling operations. Areas that are harvested are usually then replanted as a condition of the felling licences.

A limited input of fossil fuels is generally required to harvest, process and transport woodfuel but these inputs are low when compared with energy generated using fossil fuels as an energy source.

Low value timber extracted with 'low-tech' machinery: sustainably managed woodlands provide a renewable timber resource for fuel which in turn allows them to be economically managed

Modern woodfuel burners and boilers

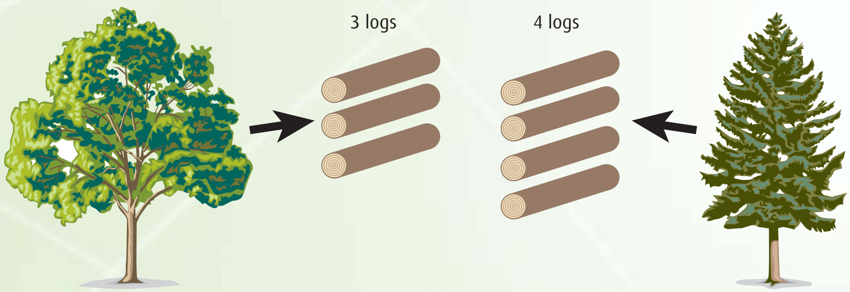
Woodfuel burners range in size and technical sophistication from small domestic units to large power stations. They can produce heat or generate electricity; in combined heat and power (CHP) plants, both heat and electricity are produced. Different systems have different tolerances for type of fuel and its moisture content and consistency (see Modern woodfuel products, below, and Developing woodfuel markets, page 6).

Modern woodfuel products

A range of woodfuel products have been developed (typically including log, chip and pellet) to be burnt in specific boiler types with the aim of optimising energy production. Different levels of processing require varying energy inputs; processing log fuel for instance requires lower energy input than pelletising wood. Each woodfuel product has a different energy budget depending on the level of processing involved.

Logs require a low level of technical sophistication to produce and burn, but offer less opportunity for mechanised infeed than alternative fuels and therefore require more regular refuelling. Generally, hardwood logs are denser requiring less frequent refuelling than softwood logs (as illustrated below). Chip or pellet size and moisture content must match the requirements of the burner system; chips are best suited for medium to large-scale burner systems. Pellets are well suited to domestic heating as they offer great flexibility through automation, require less storage space and can be easier to handle. Like chips, pellets can produce heat on demand at the push of a button.

For the same amount of heat use:



Hardwood
For example: oak, ash, beech, birch

Softwood
For example: spruce, pine, fir

Proportion of woodfuel from hardwood and softwood to generate equivalent energy (adapted from Keighley, 1996).

Modern woodfuel technology can achieve burner efficiencies of 90%. In order to burn wood efficiently the smallest fire box that will meet your requirements should be chosen. The chimney should be insulated to make sure that the temperature at the outlet is greater than 100°C in order to prevent the steam given off during combustion from condensing. If smoke can be seen from the chimney this can indicate inefficient burning. Comparison of burning efficiency for a range of fuel types is shown in Table 1.

Table 1 **Burning efficiency and typical emissions by fuel type.**

Fuel type	Percentage efficiency	Emissions kg CO_2 per kWh
Wood logs	70% in simple free-standing stoves 85% + in modern boiler systems	0.025
Wood chips	85% +	0.025
Wood pellets	90% + achievable with a range of units	0.025
Coal	35% in fire places 60% in central heating boilers	0.291
Mains gas	65% in central heating boilers 90% in modern condensing boilers	0.194
Oil	65% in central heating boilers 90% + in condensing boilers	0.265

Log fuel can be produced and burnt using 'low-tech' equipment

Logs

Of all woodfuel options logs require least processing. Ideally logs should be less than 10 cm in diameter to aid drying; this also helps burning because wood is a poor conductor of heat. The boiler or stove dimensions will determine log length. At a domestic scale logs should be moved under cover in autumn to prevent water reabsorption. It is an advantage to bring logs indoors a few weeks prior to use to become 'house dry'.

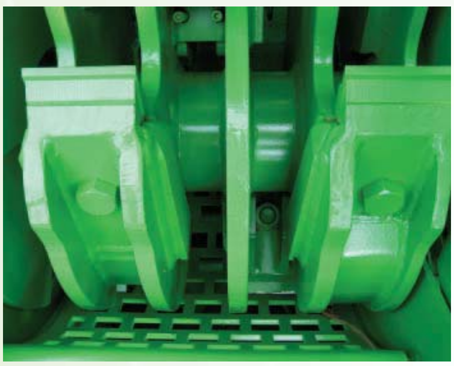
Split logs stacked for drying

Modern woodfuel chippers are designed to give a uniform chip

Wood chips

Wood chips vary in size, typically from 2 mm to 5 cm. Wood can be chipped in the forest, at a central processing point or at the point of use. It is more efficient to transport logs as they are less bulky than chips so chip transport distance should be minimised. Chips can be moved from the storage hopper to the boiler by an automated process, e.g. an auger feed. European standards have been produced governing the specification of wood chips produced for fuel to make sure they are of uniform dimension and moisture content, appropriate for a woodfuel burning system.

Woodfuel chippers have been developed to produce uniform chip that meets standard specifications of boilers. By contrast, chippers manufactured to dispose of forestry arisings are generally unsuitable for wood chip production as they produce inconsistent chips that are not suited to automated delivery systems.



A chipper designed specifically for woodfuel production with built-in screens below the blades to produce chips of standardised dimensions

Wood pellets – a high density wood product with correspondingly high calorific value. They can be burned in appliances that offer a high degree of automation to provide heat on demand

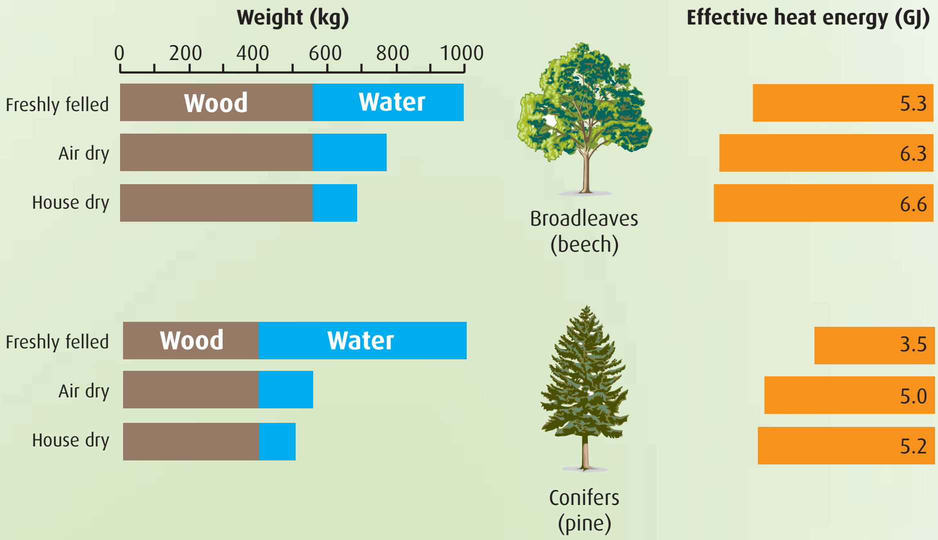
Wood pellets

Wood pellets are made by compressing sawdust and wood shreds produced in sawmilling or manufacturing. Pellets are compact and well suited to automated feed systems because they are flowable. They also have a high energy value because of their density and low moisture content (typically 8–10%). The energy density of pellets by volume is also more consistent than logs or chips, making them an easily tradable commodity. From an energy balance perspective pellet production is usually only justifiable if the sawdust raw material is a by-product of another process.

Small-scale wood pelletiser unit used to produce wood pellets for fuel

Moisture matters

When we burn wood we want to do so as efficiently as possible. The efficiency of the combustion process is heavily influenced by moisture content. Therefore it is best to reduce moisture content before the wood is burnt so that a greater proportion of the energy from burning the wood goes into useful heat rather than converting moisture in the wood to steam.



Moisture content of 1 m³ of wood and resulting impact on effective heat energy when burned (adapted from Keighley, 1996). For conversion purposes 1 GJ = 277.7 kWh.

The diagram above shows how moisture content changes during drying for 1 m³ of freshly felled timber and gives the corresponding effective heat energy over a range of moisture contents, from freshly felled to air dry to house dry. The fuel specification varies with the boiler or burner; some units can use wood with a greater moisture content than others, and this should be taken into account when specifying fuel from a supplier.

Timber stack organised into a corral, showing logs stacked on bearers and covered with impermeable sheeting to prevent re-wetting

Woodfuel drying

Trees should ideally be felled in winter to provide for the following winter's fuel. The felled wood should be stacked on a sunny site with good exposure to the wind to air dry until autumn. Covering the logs with waterproof sheeting and raising the stack off the ground using bearers will help to reduce the chances of re-wetting from above and below. Creating corrals (segregated enclosures) in storage areas provides a convenient way of organising timber in chronological order following felling to monitor the length of time that the timber dries before subsequent processing, either chipping or splitting. A good way to accelerate drying is to split the logs before stacking. Drying logs before chipping has the advantage of producing chips with a lower moisture content that are easier to store but has the disadvantage of greater wear on chipper blades. Chips produced from freshly felled logs have a higher moisture content; care is needed with storage to prevent composting, particularly if any green matter is present.

Costs compare favourably

In many instances woodfuel can be a cheaper source of heat than other fuel types. For many years natural gas has been the cheapest energy source in most parts of the UK but recent price increases by gas suppliers makes it possible for woodfuel to out-compete gas in many situations. Woodfuel installations often have a higher purchase price than fossil fuelled alternatives but the payback period for a woodfuel installation is less than in previous years as running costs have fallen compared with fossil fuelled alternatives. Table 2 shows how to calculate the price per gigajoule (GJ) of a variety of fuel types based on your local energy prices, for comparison purposes. The overall cost of the system must be taken into account, including the installation cost of the boiler when comparing alternative heating sources.

Table 2 **Comparing fuel costs (adapted from Keighley, 1996).**

Fuel	Unit of Supply	Effective heat energy* GJ/unit	Units of fuel for 1 GJ A	Cost per unit of supply (£) B **	Cost per GJ (£) A X B ***
Smokeless fuel and house coal	tonne	16.4	0.061	Local price =	
Mains gas	therm	0.062	16.200	Local price =	
Propane	kg	0.031	33.200	Local price =	
Butane	kg	0.030	33.600	Local price =	
Oil	litre	0.023	43.100	Local price =	
Electricity	kWh	0.0032	309	Local price =	
Woodfuel: beech/oak (27% MC wet basis)	m^3	6.3	0.160	Local price =	
Woodfuel: pine (27% MC wet basis)	m^3	5.0	0.200	Local price =	

* Effective heat energy = calorific value x burning efficiency % based on domestic central heating systems at winter loading.
** Enter cost – based on your local situation.
*** This calculation gives your local cost per GJ.
For conversion purposes 1 GJ = 277.7 kWh.

Small-scale domestic woodfuel burner
(courtesy of Stovax, Exeter: www.dovre.co.uk)

Medium-scale commercial boiler

Developing woodfuel markets

Nearly a third of the energy consumption of the UK is used to heat buildings and this provides a huge opportunity to use woodfuel rather than fossil fuels.

Small scale: domestic woodfuel burners and boilers

Burners and boilers in the 5–25 kW output range are ideal for dispersed rural dwellings which are often sited near woodlands and may not have mains gas. At this scale both processing and burning equipment can be 'low-tech' and comparatively low cost.

Medium scale: community heating projects and district heating schemes

The 20–500 kW output range of systems are suited to large country homes, farms, schools and leisure facilities as well as medium to large commercial and industrial units.

Large scale: purpose-built heating and electricity plants and co-firing power stations

Boilers rated over about 500 kW are appropriate for large heat consumers such as hospitals, blocks of flats or major industrial processes. The development of purpose-built biomass electricity plants or the burning of biomass in combination with coal (co-firing) in existing power stations can generate electricity on a large scale. These facilities can combine electricity production with heat generation. Using both heat and electricity is more efficient than producing electricity on its own. Combined heat and power (CHP) plants offer potential to provide local communities and industries with district heating and hot water as well as electricity.

Woodfuel from a variety of sources

Woodfuel from forests and woodlands

Woodfuel can be produced from forests, for example roundwood from thinnings and branchwood from mature broadleaves, and forest residues can also be used as fuel sources. Forestry Commission Technical Note 9: *Small-scale systems for harvesting woodfuel products* gives detailed information on harvesting woodfuel in forestry.

Woodfuel from energy crops

Woodfuel can be grown as dedicated energy crops under short rotation coppice (SRC) or short rotation forestry (SRF) systems, typically using fast growing poplar or willow species, or eucalyptus species for SRF. There are two main systems for harvesting SRC. The first involves cutting and chipping in one operation. The second involves cutting the crop with the stems left intact to air-dry; chipping is then carried out as a separate operation at a later date. Harvesting SRF uses similar systems to conventional forest harvesting.

The Forestry Commission provides information on SRC willow and poplar at a dedicated website and has also published a report on SRF *(A review of the potential impacts of short rotation forestry)* – see Woodfuel information, page 8.

Woodfuel from co-products

Sawmilling produces large quantities of co-products such as slabwood, offcuts and sawdust that can be processed into fuel.

Woodfuel from arboricultural arisings

The arboricultural sector and local authorities produce thousands of tonnes of arisings from amenity and street trees every year. Much of this material is either chipped and left to rot or disposed of to landfill at a cost; this material has the potential to provide a useful fuel source.

Woodfuel from waste wood

Many different sources of clean used wood (i.e. untreated or uncontaminated with chemicals, paint and other materials) can be burned as fuel. Sources of clean waste wood include unpainted scrap pallets, packaging timber and loose wood used in the transport of goods, often referred to as dunnage, as well as reclaimed timber from the waste cycle.

Roundwood from forest thinnings, dried and ready for chipping

Producing bales from branchwood left over from tree felling at a scale suited to large-scale woodfuel energy production

Willow short rotation coppice

Slabwood, a sawmilling co-product, well suited to woodfuel

Taking woodfuel forward

Sources of grant funding

Funding is available to assist with woodfuel installations in the form of grants and interest free loans from various organisations including the Department of Trade and Industry (DTI), the Carbon Trust and the Department for Environment, Food and Rural Affairs (Defra).

For information about the DTI Low Carbon Buildings programme, visit the DTI website: www.dti.gov.uk or call the free helpline on 0800 915 0990.

The *Woodfuel information pack* (see Selected publications below) contains further information on sources of grant funding for woodfuel installations.

Woodfuel information

- For impartial advice on growing and processing woodfuel and on burner systems contact the Forest Research Woodfuel Research Centre through their website at www.forestresearch.gov.uk/woodfuel
- The Forestry Commission also provides information through the Biomass Energy Centre at www.biomassenergycentre.org.uk
- The Forestry Commission provides regularly updated information on producing short rotation coppice (SRC), including yield data, at www.forestry.gov.uk/src. For SRF, the report *A review of the potential impacts of short rotation forestry* can be downloaded at www.forestry.gov.uk/pdf/SRFFinalReport27Feb.pdf/$FILE/SRFFinalReport27Feb.pdf
- For information about regional woodfuel strategies and harvesting trees for woodfuel, contact your local Forestry Commission Conservancy Office via www.forestry.gov.uk/forestry/HCOU-4U4J23
- Further woodfuel information is provided by Defra at www.defra.gov.uk/farm/crops/industrial/energy/index.htm
- Information on a range of woodfuel issues is also provided by Forestry Commission Wales at www.woodenergybusiness.co.uk and www.woodfuelwales.org.uk and by Forestry Commission Scotland at www.usewoodfuel.co.uk. Forestry Commission England provides information at www.forestry.gov.uk/england-woodfuel and www.bioenergygroup.org

Selected publications

Establishment and management of short rotation coppice by I. Tubby and A. Armstrong. Forestry Commission Practice Note 7. Forestry Commission, Edinburgh, 2002.

Small-scale systems for harvesting woodfuel products by A. Hall. Forestry Commission Technical Note 9. Forestry Commission, Edinburgh, 2005.

Wood as fuel: a guide to burning wood efficiently by G. Keighley. Forestry Commission, Edinburgh, 1996.

Woodfuel information pack by D. Ireland, A. Hall and D. Jones. Forest Research, Farnham, 2004.

The Forestry Commission co-ordinates its woodfuel outputs under the single flame logo.

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