# The Recycling of Waste Wood by Thermal Conversion

## A Report to Identify the Feasibility of Utilising Waste Wood as a Feedstock for Use in Bioenergy Technologies

Remade Scotland

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Report prepared by

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# Background

Wood in its many forms has played a significant role in sustaining all forms of life on our planet. It helps to provide the biotic and atmospheric conditions essential to the human species, principally by the biogeochemical recycling of carbon. Wood has been used to cook our food, heat our buildings and power our industries for many years. Since the Industrial Revolution, there has been much greater usage and indeed dependency on fossil fuels such as coal, oil and gas.

The emission of greenhouse gases has had a significant impact on the atmosphere. These gases include carbon dioxide ($CO_2$) and methane ($CH_4$), some of the principal products of combustion of fossil fuels. This impact is held responsible for global warming and the consequential changes in world climate patterns. The continued usage and indeed escalation in the combustion of finite quantities of fossil fuels has been accepted as unsustainable by the majority of the developed countries. Consequently, there is an identified need to develop clean and renewable forms of energy as long-term alternatives to the combustion of fossil fuels.

Wood has a strategic role to play, not least because it is a carbon based renewable source of energy. As a living plant, timber absorbs atmospheric $CO_2$ and stores it until natural biological or thermal degradation. When combusted or thermally degraded to produce usable energy, wood emits $CO_2$ to atmosphere. The overall balance of this chemical recycling is deemed to be "carbon neutral." Furthermore, replacing fossil fuel with wood fuel to generate usable energy typically reduces net $CO_2$ atmospheric emission levels by over 90%. This reduction level takes account of a Life Cycle Analysis (LCA) of timber, in relation to $CO_2$ emissions produced during the planting, harvesting, transporting and processing stages[1].

Forty five percent (45%) of the total energy use in the UK is heat related. Wood fuelled heating is the largest single source of renewable energy, accounting for some 30% of renewable energy used. The equivalent figure in Europe is 56%[2]. Although the usable heat released from the thermal treatment of wood waste residues is less than that from the contemporary fossil fuels of gas and oil, its comparative costs can make it both economically viable and a readily available source of heat or heat and electrical power. The growing competition for wood residues for other uses further up the waste hierarchy is anticipated to raise market value. However the projected increase in price over the coming years is anticipated to be lower than the rate and scale of increase of the traditional fossil fuels. The on-going development of new and improved technology and plant design and specification, with increased efficiency levels, is also anticipated to increase the viability of wood waste residues as a low carbon source of renewable energy.

[1] Dti/ETSU, Establishing Biomass Heating in the UK, Phase 2, 2000
[2] British Biogen, Response to the Government's Energy Review 2002

# 1. Context

To assess accurately the potential of wood waste as a feedstock in bioenergy technologies, it is necessary to appreciate the logistical context of wood waste within the wider timber industry.

## 1.1. Wood Supply and Consumption

In the UK, approximately 10% of the total landmass is accounted for by forestry related activities. Forestry management responsibilities rest principally with the government body Forestry Enterprise and the private sector, 40/60% respectively

Notwithstanding the above, almost 90% of the total annual UK timber requirement is imported, the majority of which has been pre-processed in its country of origin. In terms of overall UK consumption, paper and board applications account for more than 50% of the total used. Sawnwood accounts for another 33% of total consumption. Accurate statistical data on the quantities of wood grown within and imported into the UK are available. However, the detailed distribution of wood within UK industry and the residual elements with potential for energy production by thermal recycling has been less well researched to date.

UK Forestry industries produce a harvested yield of 10 million tonnes of timber per annum. This process is estimated to leave 5 million tonnes of residual wastes on the forest floor, comprising natural material derived from the felling, defoliating and trimming operations. Forestry residues are estimated to be capable of making a significant contribution to total renewable energy resources. The harvested yield is estimated to grow to 15 million tonnes by 2010[1].

The subsequent processing of the harvested timber produces 4 million tonnes approximately of off-cuts and sawdust residues annually in the UK. Some 480,000 tonnes of these residues are used as a fuel, the net energy content of which is 6 million GJ/year approximately. Of the total tonnage used annually, approximately 190,000 tonnes of wood is commercially marketed as a fuel for domestic, industrial and agricultural applications[2].

## 1.2. Sources of Wood Waste

An overview of the sources of wood waste and residues is plotted in the flow chart (Appendix 1). The principal sources are outlined below.

- Forestry residues
- Primary processing: Sawmilling processes
- Secondary processing: Furniture, panel, paperboard, ,joinery manufacture and construction
- Waste streams: Industrial, Commercial, Demolition and Domestic

### Primary Processing

Table 1 below outlines the categories of wood waste that arise from the total harvested yield, i.e. excluding wastage arising through forestry operations.

[1] British Biogen, Response to the Government's Energy Review, 2002
[2] Dti/ETSU, Energy from Biomass, 2000

**Table 1: Primary Processing Waste Wood Categories**

| Product | Percentage | Tonnage |
|---|---|---|
| Sawnwood | > 50% | > 1.3Mt/yr |
| Saleable Residues | > 40% | > 1.04Mt/yr |
| Other Residues | > 10% | > 0.26Mt/yr |

The Saleable Residues are utilised principally by panel, board and paper mills. The Other Residues comprise bark and low value wastes with high moisture and grit content, the former typically in excess of 50%. Approximately 10% of these low value wastes are utilised in-house/on-site for kiln drying sawn timber and also for the space heating of buildings. The volume of residue available and its intrinsic low value make it most suitable for on-site and local markets, e.g. rural domestic heating.

The primary processing of timber entails the removal of coarse material and natural contaminants that could reduce the quality and value of the timber in its identified market place. Typically, this comprises mechanical sawmilling to de-bark and cut the lumber into slabs and beams. Sawmills can be located within the immediate forest environment or within economic travel distance of the timber source. The wood waste and bark produced during these processes is routinely reduced in size for ease of handling and is known as hog fuel, with wide variations in size and moisture content. The more significant waste products are outlined below.

- **Bark** can represent 10-20% of log volume and is suitable for fuel production
- **Coarse Residues** include off-cuts, edgings, split slabs and stumps. They can be further reduced in size and dried to produce high quality fuel. They also have a value as pulp and particleboard furnish
- **Sawdust** produced from mechanical wood processing is not regarded as a prime pulping material due to its fine particle size but is acceptable for the manufacture of particle board
- **Planer Shavings** produced in the dimensioning and smoothing of lumber are considered suitable for particleboard manufacture and as fuel for use in kilns and driers

### *Secondary Processing*

The secondary processing industries are estimated to produce between 1and 1.4 million tonnes of wood waste residues per annum, on a distinct site and industry specific basis, in the proportions outlined below.

**Table 2: Secondary processing wood waste categories**

| Residue Source | Percentage | Tonnage |
|---|---|---|
| Panel and Paperboard Mills | > 33% | > 0.47Mt/pa |
| Re-Saw Mills | > 33% | > 0.47Mt/pa |
| Joinery Manufacturing | > 33% | > 0.47Mt/pa |

Of this 1-1.4 million tonnes of wood waste residue produced each year, approximately 10% is utilised on-site as wood fuel, at the source of production. Of this proportion, ie 100-140,000 tonnes, the larger industrial sites utilise 65-70% of the residue as fuel for boiler plant. Several identified case studies presented later, will illustrate the technology, scale and development potential of this type of resource management initiative.

**The secondary processing** of timber routinely entails the production or manufacture of structural, construction and consumer goods. The principal sources of wood waste are outlined below.

- **Cores** from plywood peeler logs can be used as pulp chips
- **Planer Shavings** are also produced during the finishing stages of manufacturing processes and provide fine dry residue suitable for use as boiler fuel
- **Sanderdust** is produced during the abrasive sanding of timber, plywood and particleboard during the finishing stages. Its size and low moisture content make it suitable for direct firing of boilers

### *Waste Streams*

These comprise industrial, commercial, demolition and domestic waste streams. The majority of domestic and non-hazardous wastes in the UK are currently disposed of to landfill. Only 3% of these wastes are incinerated or thermally degraded, of which only a small proportion is wood. For example, the construction industry produces some 72.5 million tonnes of mixed wastes each year, approximately 17.5% of total waste in the UK. Furthermore, the same industry produces 13 million tonnes of waste per annum that consists of unused construction materials. It is estimated that 25% of construction waste is wood based, providing a source of wood waste of considerable scale[1].

Until now it has been considered uneconomical to separate and recover the wood waste component from bulk waste specifically for the purpose of energy recovery/thermal recycling. The principal exception to this situation is within the pallet industry. It is estimated that there are between 0.8 and 1 million tonnes of pallets in circulation in the UK. The nature of their use provides a relatively stable supply of residual quantities of non-repairable materials, the majority of which is suitable for thermal recycling. However on-going legislative developments and integrated fiscal policies are intended to alter the economic balance to encourage more sustainable markets and practices. The principal examples include the EU Landfill Directive/Waste Diversion Targets, the Producer Responsibility Obligations (Packaging Waste) Regulations and the Landfill Tax.

As previously outlined, the harvested yield of timber is projected to grow by 50% to 15 million tonnes per annum by 2010. Currently however, there is a static or diminishing demand for sawmill co-products, *viz* a lack of a paying market for these residues. It has been reported by a major Scottish sawmill operation that they are reaching restrictions in their main sawn wood production activities, because of their inability to dispose of these production by-products, i.e. residual wood waste[2].

[1] Dti, Construction Best Practice Programme
[2] Dti, Construction Best Practice Programme

# 2. Technology Market

Of the developed economies, the US, Canada and the Scandinavian countries have a long-term heritage in utilising wood in its various forms as a source of energy. Current technologies produce systems designed to provide: -

- Heat only
- Electricity only
- Combined Heat and Power (CHP)

Within the UK market there is an established infrastructure of equipment and plant manufacturers capable of satisfying a range of customer needs. Areas catered for include agriculture, domestic, light and heavy commercial and industrial applications. The commercial range of combustion and generation plant extends from 15kW to 12,000kW, producing usable thermal and electrical energy. This range can be extended to include industrial scale mass biomass thermal treatment plants, such as the proposed Border Biofuels facility in Cumbria rated at 20 MWe[1].

## *2.1. Technological Processing Hierarchy*

Wood is a form of biomass, which is a generic terminology encompassing many naturally occurring raw organic materials and wastes from a diverse range of sources. As a resource, biomass is capable of being processed in a number of ways to produce more valuable and flexible forms of energy. This is an extremely important facility that realises a significantly greater potential for biomass than other forms of primary resource. Individual forms of biomass are capable of being up-graded by three distinct processes as outlined below.

- Biochemical conversion
- Thermochemical conversion
- Digestion

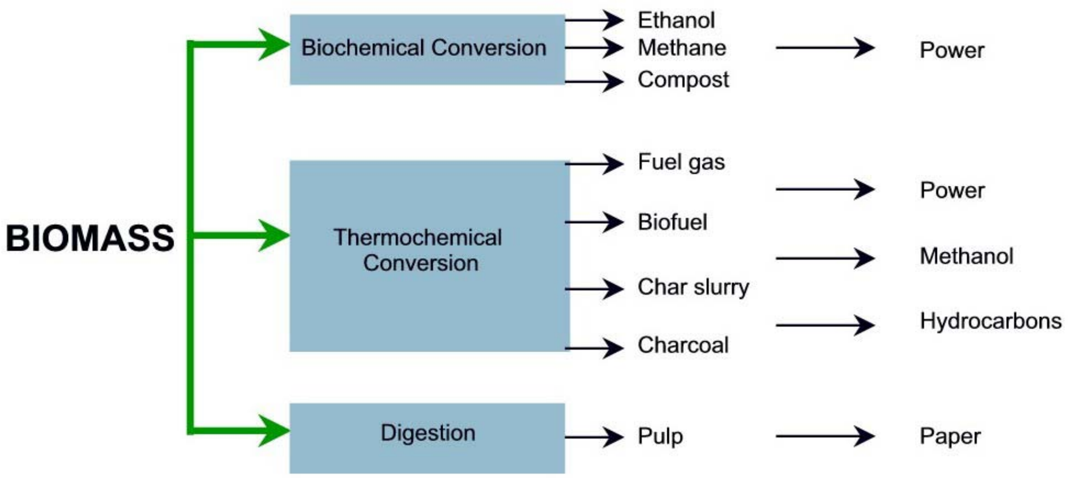


**Figure 1: Biomass Processing Options**

Processing options are determined by a number of feedstock material characteristics. These include those outlined below.

[1] Bidwells/APForestryAB, Renewable Energy from Wood, 2002

- Chemical composition
- Stock availability
- Energy output potential
- Net market value

It is important to appreciate that wood waste as a form of biomass is subjected to this critical analysis of its properties and potential before determining its preferred processing route(s). Waste wood from the **primary processing stage** offers a greater number of energy producing options due to its relative qualitative and quantitative stability in terms of the above listed criteria. However, waste wood from other **post consumer** sources such as the waste streams previously outlined, vary considerably in their chemical composition, stock availability, moisture content, energy output potential, all of which contribute to the net market value of the waste.

The UK technology market has taken on board this biomass and wood waste processing hierarchy. Due to the variation in the characteristics of wood waste, the currently preferred processing route is one of rudimentary thermochemical conversion. The principal processing options are outlined below.

- Direct Combustion/Oxidation
- Gasification
- Pyrolysis

In the case of wood waste, the market is currently dominated in favour of direct combustion, with energy raised for heat and also CHP. The detailed case studies illustrate this market situation.

**Case Study 1: Ikea, Glasgow** Ikea has an international reputation for embracing the principles of sustainable development. For example, the companies Environmental Policy recently revised their waste-recycling target from 65% to 75%. Approximately 30% of the audited waste stream comprises wood waste products, of which 10% is estimated to be recyclable quality material. Damaged furniture, sheet materials and timber are recovered, stored and distributed to education and community facilities to be recycled through woodworking repairs, etc. Materials incapable of being physically repaired and recycled are retained for thermal recycling. The principle sources of wood waste comprise damaged retail products arising from inadequate packaging, delivery and handling accidents and consumer returns. Pallets are returned through the delivery/haulage procedure and reused.

At the buildings design stage, process analysis identified the nature and volume of typical waste arisings. The company's appreciation of the waste hierarchy led to internal initiatives to reduce, reuse and recycle waste products and materials. This led to the installation of a Talbott C4 boiler, specified to accept timber, MDF and coated chipboard/plywood products. The feedstock is approximately 40 tonnes per month, of which 1 tonne is packaging waste. The feedstock is fed through a shredder to reduce physical size, through a magnetic separator to recover nails, wire, banding, etc., before being transferred to an enclosed silo of 3 tonnes capacity for storage prior to boiler feeding. The boiler operates on a 24-hour/6.5 day basis. Boiler ash is removed for recycling/final disposal by WM. Tracey and Co.

Heat recovery is an integral part of the design, providing sufficient thermal energy to heat the large warehouse, product stacking and customer checkout areas. This base load can be supplemented by a gas fired back-up system. The company estimates that as a waste management solution alone, the boiler payback period is 5 years. In terms of final costs, the Glasgow Ikea facility compares very favourably with both Edinburgh and London, being one third of the former and one fifth of the latter. At the building design stage, Combined Heat and Power (CHP) was considered but not considered viable at the outset. Ikea did not receive external financial support for the boiler and heat recovery installation.

**Case Study 2: Ainley Place Farm, Slaithwaite, Huddersfield** The principal steading for the above farm comprises three large detached stone built houses, a milking parlour and dairy and facilities for the storage of animal feedstuffs. The family owned business required efficient space heating to the individual houses and a hot water supply to the dairy. There was no rural gas mains supply. Through a local business network, the owner was aware of two sources of post consumer waste wood. The first source was a medium sized skip hire/reclamation company who supplies approximately two skip loads of non-recyclable low-grade timber and coated sheet products. This material is supplemented by damaged timber pallets from a local pallet manufacturing company. The physical size, continuity of supply and quantity and quality of the waste wood materials from these sources are variable. Further enquiries have been received from other skip handling businesses to access this facility although the owner has taken no action.

The owner installed a Teisen Farm HT60 boiler with water accumulator, with a network of underground insulated pipework to each of the buildings. The system has worked effectively since installation two years ago. The unit is housed in a large storage building, has vehicular access, and is manually fed 4-5 times per day. Smaller items of feedstock require shovelling while longer timbers, sheets, etc. require cutting. Total unit and installation costs were approximately £24,000 and are estimated to have a payback period of eight years. Electricity costs are minimal at £1 per day per household. This is based on no expenditure or income from the various waste wood transactions, the business partners accruing mutual benefits. These include reduced journey times and costs for skip movements, reduced landfill disposal and landfill tax costs and reduced heating costs resulting from the thermal recycling of wood waste.

The installation required a planning application to be submitted to the local authority and also a Clean Air Act exemption, as the farm is located within a confirmed Smoke Control Area (SCA). In this case, installation costs excluding the boiler capital costs, accounted for 75% of the total expenditure.

**Case Study 3: Palgrave Brown; Timber and MDF Producer, Stafford** This large scale MDF and finished building product manufacturer was experiencing an escalation in waste management costs. Waste reduction techniques had been implemented in the production facility, however transport, disposal and landfill tax costs were over £50,000 per annum. The company's response to this waste management problem was to install a Talbott C9 boiler, with a capacity of 85 tonnes per week, to combust the waste material. The waste material comprises timber off-cuts but is predominantly MDF off-cuts and fine dust. Total installation costs were approximately £250,000. Currently, only 20% of the total thermal energy produced is utilised to heat a section of the production area, replacing two gas fired heating units and saving £6000 on heating running costs. The company has estimated a payback period of 5-7 years, with the potential to reduce this by extending the space heating system to other areas. This would reduce existing heating costs by reclaiming the 80% of thermal energy currently vented to atmosphere.

The unit is located in a purpose built building; it has an automatic feeding system, with the computerised control system, including detailed emissions data being continuously recorded on a 24 hour basis. This IT system is linked via a modem directly to the local authority's Environmental Health pollution control unit. To date, the boiler has met all specified emissions standards.

**Case Study 4: Decorative Panels Ltd., Huddersfield** This company is a leading furniture and cabinet manufacturer located in a new purpose designed manufacturing facility. Part of the production process involves attaching laminate to particleboard. Wastes arising are predominantly MDF and timber off-cuts and mixed MDF/laminate dust. The company designed-in a waste management solution, comprising a Talbott C8 boiler, with shredder and enclosed conveyor system, located externally to the factory unit. The throughput of 30 tonnes per week is currently below maximum capacity. This produces 2,000kW/hr of medium pressure hot water, the heat from which is blown into the factory at high level. The company intends to utilise the heat produced in a more extensive way whenever the internal production facility reaches its designed capacity. Total installation costs were approximately £150,000.

Both gasification and pyrolysis technologies are currently regarded as "higher" technological solutions, with plant normally requiring economies of scale to be notionally viable.

- **Gasification technology** - entails heating of the fuel stock in a low oxygen atmosphere to produce a combustible gas. The gas principally comprises a mixture of carbon dioxide (CO2), hydrogen (H2) and methane (CH4). This gas can be utilised as fuel in a turbine or internal combustion engine to generate electricity. The technology is formally recognised as being at an advanced research and development stage. In the UK and indeed in other developed countries, the use of this technology for the production of electricity is currently at the demonstration stage of development. Investment costs for typical scale demonstration plant are £1800 - £3000/kW installed. Studies have forecasted that the wider scale deployment of this technology when proven, will reduce these costs to a level below current direct combustion technology costs, while offering the additional benefits of higher process efficiency levels.
- **Pyrolysis technology** - entails heating of the fuel stock in an oxygen free atmosphere to produce liquid oil, termed pyrolysis oil. The Border Biofuels proposal to develop a biomass plant near Carlisle, Cumbria, is designed to produce pyrolysis oil for use as a fuel at other satellite sites. The scale of this plant would require 450,000 green tonnes (225,000 odt[1]) of wood fuel to generate 20 MWe on site, with a non-fossil fuel obligation (NFFO) in place to accept the electrical output to the national grid.

It can be seen from the above data that wood waste that has arisen from both forestry and primary processing has the potential to be utilised in several ways.

- At or near source, in small or bulk quantities. This allows application options including heat only and local CHP and also large scale electricity generation
- Further from source, in bulk and in secured supply chains. This may allow larger scale CHP and the generation of electrical power on a commercially viable basis

It can also be concluded that waste wood arising from secondary processing and the specified waste streams have a different level of potential than the above. This can be summarised as below.

- At or near source, in small or bulk quantities. This would routinely be at the location of manufacturing plant, on construction and demolition sites and also from segregated and mixed general wastes from industrial, commercial and domestic sources. This allows application options in line with the waste hierarchy, including material re-use and reprocessing/recycling, either on-site or locally
- At the end of this waste hierarchy is the option to thermally recycle the residue. In the UK, case studies indicate that the production of usable heat from a direct combustion process is the principal output.

In all cases, any additional segregation, separation, storage, processing, decontamination or transportation measures taken will raise net costs and lower the net value of the waste wood material to the potential user. It is essential to minimise the scale of these measures in the design of energy

[1] Oven dried tonnage

recovery systems in order to maximise the net financial and environmental benefit to the operator/consumer.

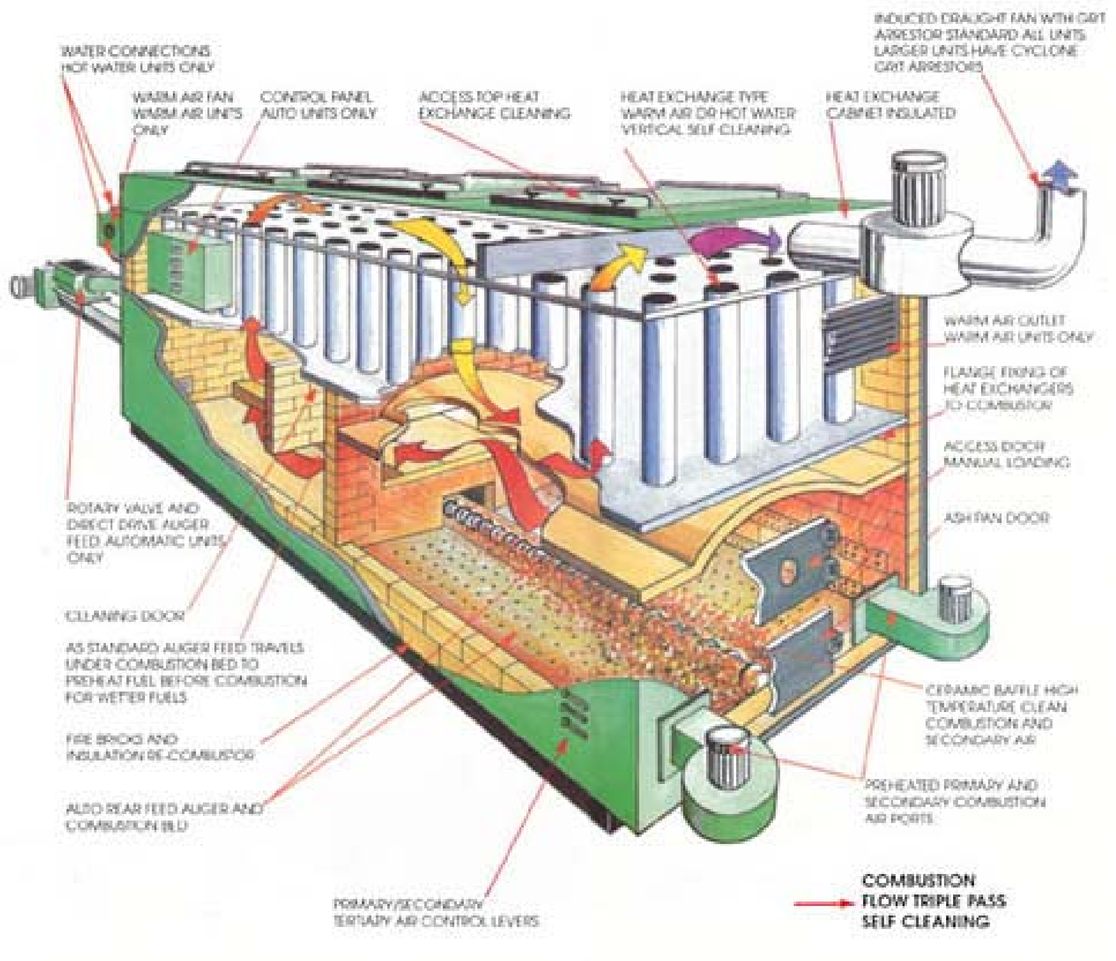


**Figure 2: Typical Combustion Unit** (Courtesy of Talbott's Heating Ltd www.talbotts.co.uk/)

## *2.2. Combustion Plant Suppliers*

An industry funded trade association, British Biogen, represents the UK bioenergy industry. British Biogen provides a comprehensive range of services including, strategic leadership and guidance, supplier and manufacturer networks, membership access to examples of industry best practice, opportunities to expand biomass related markets and a forum for coordinating industry views to help inform political decision making.

A list of biomass combustion plant suppliers is provided in Appendix 2 of this report. This list represents those appliance manufacturers who are members of British Biogen and is not exhaustive in its composition.

# 3. Wood as a Fuel

As a renewable resource, wood offers many options for productive usage at the various stages from cradle to grave. The waste hierarchy of **Reduce - Re-use - Recycle** prioritises the options available to waste wood/products, prior to final disposal of residues. The above three elements of the waste hierarchy quite properly do not regard wood waste exclusively as a fuel but as a resource to be managed. Wood waste would normally only be regarded as a potential fuel for thermal treatment as part of a mass balance approach. Any thermal treatment process entails the release of some or all of the retained energy in the wood. The intention and ability to capture the maximum quantity of this energy for productive use can be regarded as thermal recycling.

## *3.1. The Thermochemical Process*

As previously outlined, wood can be thermally treated or conditioned by several technological processes. Each of these processes produces different proportions of by-products, each of which is important in terms of the nature of the energy released and also its potential impact on atmospheric emissions. In general terms, in the production of electricity, bioenergy has life cycle emissions of up to 80g $CO_2$/kWh. This compares extremely favourably with fossil fuels such as coal with life cycle emissions of 955g/kWh and gas (CCGT) with emissions of 446g/kWh[1].

In the **direct combustion/oxidation process**, wood is provided with sufficient quantities of oxygen to burn cleanly until all usable energy is released. The by-products of combustion are carbon dioxide, water, ash (inorganic components) and heat. The complete combustion of this hydrocarbon allows oxygen to combine with the carbon in the ratio of two oxygen atoms to one carbon atom. Oxygen also combines with the hydrogen in the ratio of two hydrogen atoms to one oxygen atom. As a result carbon dioxide ($CO_2$) and water ($H_20$) are formed as the principal by-products. The heat from combustion breaks down the chemical bonds between the complex hydrocarbons in wood, while the combination of the resultant carbon and hydrogen with oxygen produces the heat. Thus the process is a complete loop and drives itself. This process would be typical of a wood fuelled domestic or light commercial stove.

Once burning has started, it is possible to restrict the volume of oxygen available to the wood fuel, while allowing the combustion process to continue. In this **gasification process**, one atom of oxygen combines with one atom of carbon, while the hydrogen will sometimes combine with the oxygen and sometimes will not combine at all. This results in the formation of carbon monoxide (CO), water ($H_20$) and hydrogen ($H_2$). Other compounds and elements are produced, e.g. carbon, (smoke). This process still produces enough heat to break down the wood; the fuel gases have the potential to continue the combustion reaction and release heat since they are not completely burned at that stage. This ability to produce a gaseous fuel from solid wood can provide an increased level of flexibility and convenience in terms of fuel storage and transportation.

In the third thermochemical process, **pyrolysis or destructive distillation,** wood is contained in an enclosed container, with no oxygen present and heat applied indirectly. A high temperature ensures that the chemical bonds holding the carbon and hydrogen together are broken. The products of this process will be dependent on a number of factors, including the chemical composition and moisture content of the wood fuel and the temperature to which it is heated. The chemical composition can comprise alkaloid poisons, minerals, organic solvents and oils. In general terms, the by-products in such circumstances will be methane gas, methyl gas, hydrogen, carbon dioxide, carbon monoxide, wood alcohol, carbon, water and other trace elements. Methane gas ($CH_4$) can make up 75% of these by-products, has a high heat value and is relatively simple to handle.

Both of the above gas producing processes results in a fuel that can be utilised as a direct replacement for fossil fuel gases, e.g. natural gas or liquefied petroleum gas (propane and butane). With safety

[1] British Biogen, 2002

provisos, wood gas will work in standard burners and also in internal combustion engines. The latter has the ability to generate electrical power.

This brief overview of the thermochemical process is intended to provide an appreciation of the fundamental requirement to match the characteristics of the fuel with the technological capability of the boiler. The most significant issue with a heat producing biomass plant relates to the relatively low and inconsistent quality of the feedstock. The establishment of long-term viable heating systems fuelled by wood waste, in its many forms, can be achieved by specifying the appropriate form of wood fuel, specific to the design of the technology and the management systems and objectives.

## *3.2. Characteristics of Wood Fuel*

Wood waste is a term that can encompass a range of products, from physically large logs of various tree species, unseasoned and of high moisture content, to fine sawdust particles containing a mixture of contaminants resulting from a production or postproduction process. The bioenergy industry through British Biogen has devised a pragmatic system to describe and categorize woodfuel, in an attempt to ensure a more effective matching of fuel stock to heat generating appliance. The two principal criteria are outlined below.

- Physical size
- Moisture content

### *Wood Fuel Categories*

Wood fuels for the retail market are categorised below.

- Log wood
- Pellets
- Wood chip
- Specialist wood fuels; compressed logs, faggots and kindling

It is normal retail practice to sell wood fuel by volume, e.g. bag or load. However, the wood density would normally be required to value the load accurately, as this characteristic varies with timber species. A summary of the wood fuel categories as they relate to the criteria of physical size and moisture content is outlined in the section below.

### *Physical Size*

- **Log Wood -** A standard log can be described as of 30cm maximum length, 25cm maximum width, with a minimum of 75% of logs in the load over 15cm long
- **Pellets -** The use of densified fuels such as pellets and briquettes are projected to become the predominant biofuel in the UK. Pellets are suited to use in automatic fuel feed domestic boilers and in converted domestic oil fired boilers. It is significant that both fuel suppliers and boiler manufacturers are currently developing their respective production capacity and heating technology in a more integrated manner[1].

Pellets as a manufactured product have a greater density than unprocessed wood chips and correspondingly have a higher calorific value. European standards for both pelletised fuels and pellet burning appliances are currently being developed and completion is anticipated by 2005. Until such time as these BSEN standards are finalised, British Biogen members have agreed to comply with an interim voluntary standard for both pellets and appliances, known as the British Biogen Codes of Good Practice (COGP) for: -

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[1] British Biogen, 2002

- Biofuel Pellets and
- Biofuel Pellet Burning Roomheaters <15kW.

A copy of this Code of Good Practice is included as Appendix 3. A summary of the two main categories and their characteristics is outlined below.

**Table 3: Wood Pellet Code of Practice/Quality Standards**

| Class | Premium Biofuel Pellets | Recovered Fuel Pellets |
|---|---|---|
| Size | >4mm -20mm | >10mm- <20mm |
| Ash | <1%, 3% or 6% | <1%, 3% or 6% |
| Moisture Content (MC) | <10% | <10% |
| Calorific Value | >4.7kWh/kg | >4.2kWh/kg |
| Bulk Density | >600kg/m$^2$ | >500kg/m$^2$ |
| Sulphur | <300ppm | <300ppm |
| Chloride | <800ppm | <800ppm |

Some of the criteria that can be applied to the COGB are:

- Additives are limited to lignin as a binder and trace elements of vegetable oil as a die lubricant. The use and quantity of any additive shall be disclosed
- The volume of ash arising from the burning of any fuel must be taken into account in the design of the appliance and all COGB pellets shall be labelled as below.
  - <1% ash: Premium
  - <3% ash: Standard
  - <6% ash: High Ash

### *Wood Chip*

Wood chip size grades are regarded as important. Chip burning plant operates with material between 2 and 25mm maximum dimension. It is widely accepted that the fuel production process produces a wider range of particle size. Any grading system will recognise that limits require to be set for fine particles that inhibit combustion and also long strand-like material that can block feed systems.

The wood chip grading system has been produced in conjunction with both fuel and appliance manufacturers to reflect the variation in fuel tolerance and in combustion processes. A harmonised standard is currently under review. Wholesale suppliers and purchasers may also wish to agree on specifications to suit their particular needs.

Retail wood chip is categorised in three grades outlined below.

**Table 4: Wood Chip Quality Standards**

| Size | <2mm | 2 – 25mm | 25 – 50mm | 50 –100mm | 100 -200mm |
|---|---|---|---|---|---|
| **Description** | **Dust** | **Small** | **Medium** | **Oversize** | **Slivers** |
| Super | <15% | Any | 0% | 0% | 0% |
| Fine | <15% | Any | 10% | 2% | 0% |
| Coarse | <15% | Any | Any | <30% | <2% |

- **Super Grade Wood Chip -** This is a very accurately defined wood chip, with a total absence of fine material to avoid blockages in specific types of combustion appliance. Specialised chipping and screening facilities are required for its production
- **Fine Grade Wood Chip -** This is likely to be the most widely used retail grade of chip, being suitable for use with the majority of small to medium scale wood fuel appliances. Specialised chipping and screening facilities are required for its production
- **Coarse Grade Wood Chip -** This is likely to be most popular in the self-supply sector and in some retail sectors. This grade can be used in automatic feeding appliances although some blockages may occur. The lower price and ready availability of this grade will compensate for any extra intervention required. A wide range of chipping equipment including many mobile chippers can produce fuel to this grade without any screening requirements.

### *Traditional Wood Fuels*

These traditional wood fuels include faggots, bavins, kindling and charcoal

- **Faggots**: Bundles of small diameter sticks <50mm dia.; 120cm long; <200mm across; tightly tied with butts together, using two combustible ties
- **Bavins:** As faggots, 60cm long
- **Kindling:** Maximum length 30 cm; maximum width 5 cm; MC 20% (dry material)
- **Charcoal:** Various grades according to use

Details of equipment suppliers and supplier's networks relevant to the production and use of these fuels can be provided by British Biogen.

### *Moisture Content*

- **Log Wood -** The moisture content of logwood can be reduced by proper stacking, airing and covering in winter. Logs of diameter <15cm should be split to assist seasoning. Logwood may be described as Green, Seasoned or Well Seasoned.
- **Wood Chip -** Moisture content (MC) is described as a percentage, e.g. if the moisture content is 30%, no more than 10% of any load should exceed the moisture content (by weight on a wet basis) for that load; i.e. MC 35%; no more than 10% of the load should exceed 35% moisture content
- **Pellets -** Pellets are manufactured by compressing dry biomass material, usually sawdust based, and pressing it through a ring die. As the pellets are extruded from the die they typically have a temperature of 95-1000C. This process results in a uniform fuel with moisture content of less than 10%. Pellets must be stored under dry controlled conditions to prevent moisture absorption.

### 3.3. *The Heat Output Value of Wood Waste*

All combustible materials have a heating value normally expressed as gross calorific or higher heating value. This heating value is a function of the thermal energy that can be obtained by combusting one unit mass of the material. Unprocessed wood is accepted as having an average calorific value of around 20 MJ/kg, bone dry (BD). However both factors described above, namely moisture content and particle/physical size, have a significant effect on the realisable thermal potential of wood waste. Furthermore, this thermal potential requires to be "managed" by integrated combustion systems designed to extract and deliver this thermal potential as efficiently as possible.

Consequently, any accurate analysis of wood waste materials to identify its gross heating value must take into account the undernoted factors.

- The heat content per unit of waste according to its moisture content
- The efficiency of the energy conversion process

A comparative analysis of a range of wood wastes and typical fossil fuel alternative energy sources is provided in Table 5 below.

**Table 5: Net Heating Value Comparison**[1]

| Fuel | | As fired Gross Calorific Value (MJ/kg) | Typical Burner Efficiency (%) | Useable Net Heating Value (MJ/kg) |
|---|---|---|---|---|
| Wood: | 0% mc | 19.8 | 80 | 15.8 |
| | 10% mc | 17.8 | 78 | 13.9 |
| | 20% mc | 15.9 | 76 | 12.1 |
| | 30% mc | 14.5 | 74 | 10.7 |
| | 40% mc | 12 | 72 | 8.6 |
| | 50% mc | 10 | 67 | 6.7 |
| Anthracite: | | 31.4 | 83 | 26.1 |
| Lignite: | | 26.7 | 80 | 21.4 |
| Heavy Fuel Oil: | | 42.6 | 82.5 | 35.1 |
| Light Fuel Oil: | | 43.5 | 82.5 | 35.9 |
| Butane: | | 49.3 | 79.0 | 38.9 |
| Propane: | | 50.0 | 78.7 | 39.4 |

### *Impacts of Moisture Content*

The moisture content of wood waste residues arising from primary and secondary processing varies considerably. Furthermore, this can also vary within product manufacturing areas, depending on whether there have been any induced drying processes carried out and at what stage. For example, sanding dust residues arise from plywood and particleboard manufacturers following the drying and hot pressing stages, at which point moisture content can be lower than 10%. Table 6 provides a range of typical wood waste characteristics.

As can be seen in Table 5 above, high moisture content in wood waste has the direct effect of lowering the as-fired value of the waste as well as detrimentally affecting the overall combustion efficiency. This occurs due to the large amount of energy required to heat significant quantities of excess air and to vaporise the moisture in the wood waste, which together with the moisture formed as part of the thermochemical combustion process itself, is lost as latent heat when vented to the atmosphere.

[1] The Potential use of Wood Residues for Energy Generation; www.fao.org

**Table 6: Typical Wood Waste Characteristics**

| Waste Residues | Size | Moisture Content | Ash& Dirt Content |
|---|---|---|---|
| | (mm) | (%) | (%) |
| Sander dust | >1 | 2-10 | 0.1-0.5 |
| Shavings | 1-12 | 10-20 | 0.1-1.0 |
| Sawdust | 1-10 | 25-40 | 0.5-2.0 |
| Bark (Hogged) | 1-100 | 25-75 | 1.0-2.0 |
| Log-yard debris | <100 | 40-60 | 5.0-50 |
| Forest residuals | Needles to stumps | 30-60 | 3.0-20 |

### *Impacts of Physical Size*

The range of physical size and structural content of typical wood wastes is outlined in Table 6 above. The size and physical form of the wood waste are critical to both the handling characteristics and to the burning efficiency of residues. These factors play a leading role in determining the design and operation of processing, handling and combustion plant. For example, fine sander dust and lighter wood shavings can be burned in suspension. Wood waste of larger dimensions, such as large chips and coarsely hogged waste are burned lying on grates, with a much longer chamber dwell time. It is apparent that the minimisation of both size and moisture content will help to maximise the generation and transfer of useable energy. Practical measures to achieve this objective include the provision of effective storage and the utilisation of flue gases to contribute to the maintenance of low residual moisture in the feedstock and to the optimisation of combustion efficiency.

# 4. Financial Aspects of Wood Fuel

The versatility of wood as a fuel is evident, subject to the previously outlined criteria of availability, characteristics, categorisation and combustion technology. However, wood as a fuel has to be market competitive in terms of the financial criteria outlined below.

- **Unit valuation** - The unit value of wood fuel is determined by its physical specification (size/quality) and by its energy content. The energy content is in turn determined by **the moisture content (MC) and the "oven-dried weight."** The oven-dried weight of wood is measured in oven-dried tonnes (odt) and is the measure of the combustible component of wood, excluding the moisture content. However a delivered load of wood to a specified oven dried weight does not indicate its ease of use or the proportion of latent energy that can be released as heat.
- **Base and sale price** - Wood fuel suppliers are encouraged to provide customers with both a **base price** (£/odt) and a **sale price** (£/$m^3$) for each category of wood fuel. The base price indicates the charge per unit (weight) of solid wood being supplied, allowing comparison with other wood fuels and fossil heating fuels. The base price of processed denser and drier wood fuels is higher than unprocessed less dense wood, the latter with higher moisture content. However, in practical terms it is often more efficient to supply wood fuel by volume rather than weight. In this instance, the sale price is calculated from the base price by a conversion factor that takes into account the density of the wood.
- **VAT treatment** - Suppliers of wood fuel sell their product(s) to a variety of domestic, agricultural, commercial and industrial users. The same product may be labelled differently for different markets. This can give rise to different interpretations on the products liability for value added tax (VAT). The most significant example is where wood chips are clearly invoiced/labelled etc. as intended for use as a **domestic heating fuel,** when they are currently liable to VAT at the same rate as other fuels intended for domestic use, (viz. 5%). The bioenergy industry is of the opinion that renewable fuels will ultimately receive more favourable fiscal treatment through government energy policies, for example by the zero rating of VAT for approved domestic fuels.
- **Cost comparison with non-renewable energies** - The critical test in terms of market competitiveness is the direct cost comparison of wood fuel(s) with non renewable energies. The standard unit of measure is the cost in pence per kilowatt hour (p/kWh), also called the pence per unit. A cost comparison of four wood fuel products and five fossil fuel sources of energy are outlined in figure 3 below[1].

[1] British Biogen 2002

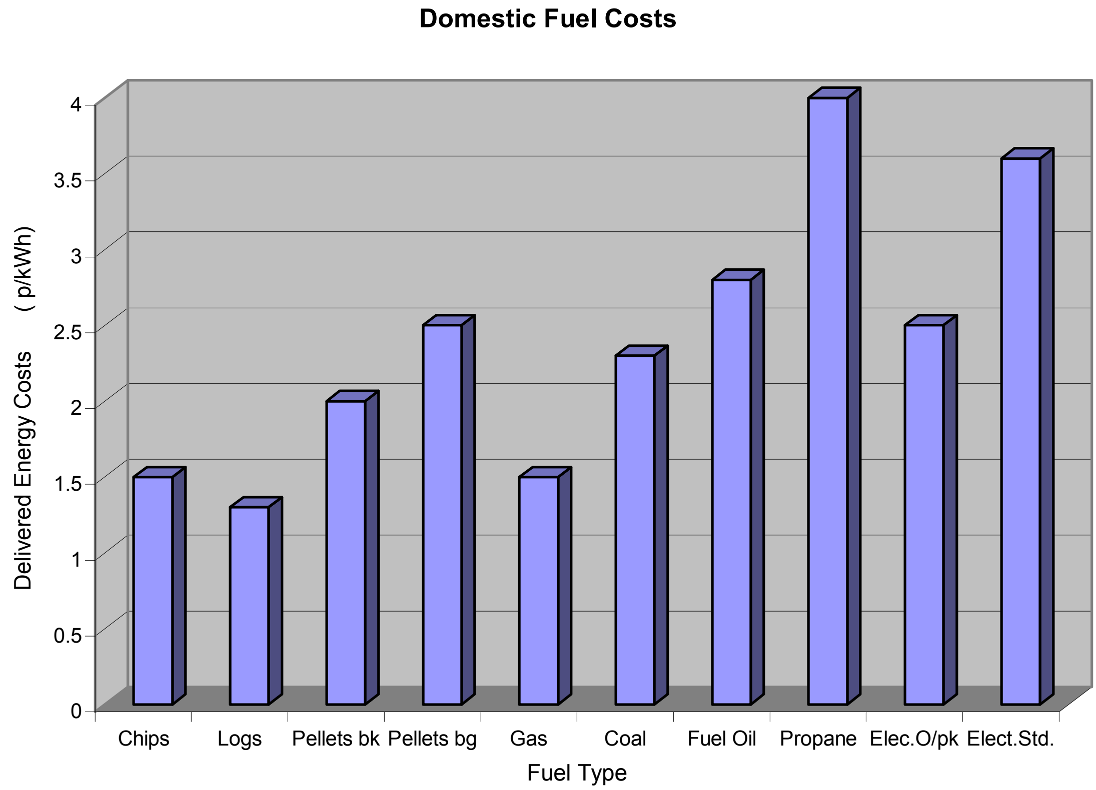


**Figure 3: Typical Domestic Fuel Costs**[1]

- The graph illustrates that wood fuel in its various forms is among the cheapest fuels for domestic heating. Wood, which is self-generated and/or owned, would lower the net unit cost appreciably. In price stability terms, wood fuel is relatively constant when compared with the other fossil fuels. Several of these fossil fuels, e.g. heating oil and propane gas are at their lowest real price for many years and in the longer term are projected to rise considerably. This would indicate an opportunity for increased competitiveness in the energy fuel market for wood fuel products. However the infrastructure and marketing required to stabilise the supply of wood fuels is recognised as requiring strengthening.

[1] British Biogen 2002

# 5. Process Regulation

Since the late 1980's, public awareness of the factors that detrimentally impact on the environment has increased significantly. International, national and regional response to demands for greater levels of environmental protection has inevitably resulted in legislation designed to prevent, minimise and also remediate sources of environmental degradation. In the UK the Environmental Protection Act 1990 laid a new foundation for integrated pollution control, waste management, genetically modified organisms and nature conservation. This and other legislation is subject to on-going up-dating. Recent legislation which impacts on the processes inherent in the biomass and wood waste combustion industry includes the Pollution Prevention and Control (Scotland) Act 1999, PPC Regulations 2000, the EU Landfill Directive (99/31/EC) and the impending EU Waste Incineration Directive (2000/76/EC) (WID).

## *5.1. Regulatory Procedures*

In the UK, plants that produce power and/or heat are required to meet progressively higher environmental emission standards and need prior approval from the appropriate regulatory authority. For example, under Part 1 of the Environmental Protection Act 1990, existing smaller scale wood fuel plants required formal **authorisation** from the local authorities, while larger plants required authorisation from the local authorities or in Scotland from SEPA. These are termed Part B and Part A processes respectively. However, the establishment of the PPC Act 1999 and the subsequent PPC Regulations 2000 introduced a system of **permits** based on the **best available technology** (BAT). A permit is required for an installation as defined in Schedule 1 of Part 1 of the PPC Regulations 2000. It is intended that a single permit will "manage" all PPC-liable activities at the same location. The relevant regulatory authorities have made guidance available to existing and potentially new operators, on the web and in print. For example, SEPA provides guidance through "The Pollution Prevention and Control (Scotland) Regulations 2000: A Practical Guide: PPC Part A."

The EU Waste Incineration Directive (WID) is intended to be implemented by member states by the end of December 2002, although the precise legislative vehicle to achieve this in the UK has not been confirmed. In Scotland for example it may be appropriate to integrate the requirements of the WID into the PPC Regulations 2002. It is also anticipated that some existing smaller Part B processes will be redesignated under Part A and become subject to the more onerous emission requirements. **It is extremely important to note that a number of specified plants are to be exempted from the requirements of the WID, including plants that treat only one generic waste category, one of which includes "Certain wood wastes."** Again, the relevant regulatory authorities have made guidance and advice available to operators.

The Framework of the PPC Part A Regulatory Package is provided by SEPA in the form of a flow chart. It can be seen from this flow chart that PPC Part A Guidance is at third tier level and takes the form of three individual categories of guidance: -

- Introduction and Further Advice: eg. Eligibility; Permits
- Sector Guidance: eg. Energy Supply Techniques
- Horizontal Guidance: eg. Energy Efficiency

The PPC Regulations 2000 are designed specifically to take a more integrated holistic view and responsive attitude towards the causes and effects of environmental impact. Of direct relevance to the combustion of wood waste is the Horizontal Guidance Note on Energy Efficiency (IPPC H2), which states, "The aim of the energy efficiency requirement of the IPPC Directive is to minimise pollution arising from the consumption of energy in industrial processes and thereby reduce the associated impacts." This includes consideration of a cost benefit benchmark in terms of £/tonne of $CO_2$ and the provision of conversion factors for assessing the environmental impact of energy consumption.

Also of immediate relevance to the combustion of wood waste is the Sector Guidance provided in conjunction with the Horizontal Guidance. The Energy Supply Techniques Guidance Note (Section 2.7.3) "requires operators to demonstrate that they have considered alternative, more efficient forms of the supply of electricity and heat," according to a set of detailed guidelines. This requirement covers both the efficiency of energy generation and its consumption, where the efficiency of conventional electricity generation is approximately 40%.

To comply with this new duty imposed by the above section of the sector guidance, the applicant is required to provide data and analysis to the regulator in each of the following areas.

- **Heat Supply Options -** Thermal energy in its various forms is often an integral component of IPPC installations. Permit applications are required to provide information on the combustion and thermal efficiency of heat supply systems and demonstrate that an appraisal has been carried out on the alternative options for heat supply. The Sector Guidance Notes provide specific energy efficiency guidance for combustion plant. The Energy Efficiency Best Practice Programme (EEBPP) also provides published technical guidance.
- **CHP Feasibility -** Combined heat and power systems are recognised as being inherently efficient and can save 20-30% of a site's primary energy and is therefore one of the most important energy saving technologies to be assessed. In general feasibility terms, CHP may not be the most beneficial option in a number of circumstances: -
    - The use of waste to energy schemes, e.g. waste wood
    - The unavailability of gas
    - A low steam demand to electricity consumption ratio
    - The scale of the installation is too small to substantiate a gas turbine
    - The lifespan of the plant provides an insufficient payback period
    - Existing supply systems are more efficient

In general terms, the currently accepted viability threshold for CHP installations is 4000-5000 hours per year of heat and electricity requirement. The Energy Efficiency Best Practice Programme (EEBPP) again provides published technical guidance.

- **The Use of Renewable Energy Sources -** The use of renewable energy sources are formally recognised in the guidance as reducing environmental impact. Applications are required to identify the opportunities and describe the feasibility of using on-site renewable energy sources or the purchase of electricity generated from renewable energy sources, ("Green electricity"). Biomass conversion for heat and power generation in the context of business initiatives is a quoted example in the guidance.
- **Combustion of Process Waste -** The guidance is clear in that it requires the option of energy recovery from the incineration of process waste for heat and power to be assessed, and to justify any decision not to recover energy by this means. Co-incineration of other wastes and joint schemes with other IPPC installations should also be investigated and considered. These energy-producing initiatives reduce the volume of waste presented to landfill, reducing direct disposal and landfill tax costs to the operator.

To ensure that a net environmental benefit is achieved the following is required.

- An analysis of alternative energy supply options should be made

- Reference must be made to relevant guidance on waste incineration and combustion processes. This will include the impending Waste Incineration Directive (WID) when transposed into UK legislation in 2002.

Energy from waste may not be the most beneficial option overall for several reasons.

- Process waste is more valuable further up the waste hierarchy
- The waste has a relatively low calorific value and/or useable net heating value
- The combustion process impacts detrimentally on other pollutants
- A gas powered plant offers better overall performance

## 5.2. *Technology Options: Design and Practical Considerations*

Currently the technology utilised in the UK thermal recycling market relates principally to direct oxidation/combustion. A summary of the main types of combustion appliance and their salient features is outlined below.

**Stand-alone Wood-fired Boiler**

- Designed to accommodate peak loads, the appliance will operate below this level for the majority of the time
- Control mechanisms will be simple
- Boiler failure or fuel shortage results in no heating
- Boiler response times are slow
- Summary: A basic heating system with limitations in operational flexibility and output requirements

**Stand-alone Wood-fired Boiler with Accumulator Tank**

- Peak loads are covered by the accumulator, allowing the boiler to be downsized
- This option is most suited to heat emission systems that have a requirement for heat well below boiler output temperatures. Examples of systems include wet/radiator systems and underfloor heating designs. Accumulators are not routinely specified for use in medium and high temperature systems without expert advice, design, etc
- Accumulators are space intensive, expensive and give rise to expansion capacity issues
- Boiler failure or fuel shortage results in no heating when stored heat has been exhausted
- Summary: Better than the basic system but usually less viable than Hybrid systems

**Multiple Wood-fired Boilers**

- More flexible than a single unit
- Boiler capacity must be equal to or exceed peak load
- The higher specific cost of two units does not help to realise economies of scale
- Control systems require manual intervention or automatic ignition to accommodate peak loads

- Summary: Not the best option for the UK environment

**Hybrid Wood/Oil or Gas**

- The wood boiler is designed to accommodate base load; normally 50-65% of peak load
- The oil or gas boiler(s) accommodate peak loads
- Oil storage capacity can be designed to accommodate potential downtime of the wood boiler
- Back-up capacity provided at minimal cost
- A variable proportion of fossil fuel will continue to be utilised
- Thermostatic controls can manage two boiler systems. More complex requirements necessitate the use of sequencers
- Summary: The most flexible and applicable option, particularly where fossil fuel capacity exists. The scale and dimensions of the wood boiler compare favourably with fossil fueled appliances

**Hybrid with Accumulator tank**

- Provides the same facilities as the Wood/Oil/Gas Hybrid, with the advantage of a minimised fossil fuel burn requirement
- The Accumulator provisos applicable to the more basic system above apply
- Summary: The most sophisticated option, requiring expert design and installation inputs due to the various constraints

## *5.3. Technology Innovations to Minimise Potential Emissions from the Combustion of Waste Wood*

- Research in recent years in North America has lead to the development of new techniques to minimise potential atmospheric emissions from the combustion of waste wood impregnated with preservatives containing chromated copper arsenic (CCA). These known carcinogens have been used in the preservation of manufactured timber products intended for outdoor use, i.e. decking, porches, structural beams, garden furniture, etc.

  When CCA-treated wood is combusted, the vaporised arsenic forms particles less than one micron in diameter, which can allow them to pass through gaseous arrestment filters into the atmosphere. The controlled introduction of limestone into the combustion process allows the arsenic to combine into larger particles with the limestone. The arrestment of these particles and their subsequent landfill disposal as an ash product has been assessed as a lesser risk to potential groundwater contamination than the smaller arsenic particle size.

- In Vancouver, British Columbia, researchers at First American Scientific Corporation (FASC) have produced the technology to transform wood waste, viz wood chips and bark, into fuel for utilisation in co-generation systems designed to produce electricity. These systems produce energy from gas-fired, coal and wood burning furnaces/boilers that produce steam and hot water.

  The new technology transforms waste wood into an efficient burning dry powder, by processing it through a device called a Kinetic Disintegration System (KDS). When the wood is placed within the device, it is traumatised to destruction by a combination of high intensity sound waves and kinetic energy. The device bombards the wood with sound waves, destabilising it while simultaneously a chaining mechanism induces a high-speed spin. The wood collides with other material in the chamber helping it to disintegrate. The result is coarse, corn-like sawdust, with a high calorific value. Tests to date have shown significant reductions in the generation of the pollutants normally associated with coal burning appliances. The equipment has the potential to provide a clean burning fuel source for creating electricity from waste wood residues from various sources and also an “additive” in a co-generation system to ameliorate the known potential of coal to cause atmospheric pollution.

- CCA treated wood may ultimately prove to be safe to burn in line with the research outcomes previously outlined. However, it is necessary to identify wood products treated with this preservative in order to remove it from the general waste stream. This segregation would prevent its potential incineration with less noxious materials when toxic chemicals may be produced within the smoke and ash.

  A joint research and development programme between the Universities of Miami and Florida has produced a laser-based instrument to aid in the sorting of treated wood. A conveyor passes wood waste through an on-line laser known as a Laser Induced Breakdown Spectroscope (LIBS). LIBS create laser-induced plasma within which a portion of the target area is vaporised. The atoms from the vapour produce light; at which point the distinct wavelengths of light from the chromium atoms identify the wood as CCA-treated. This allows the treated wood waste to be removed and disposed of directly to an engineered, lined landfill.

## *5.4. Land Use Planning Implications*

A power generating plant using biomass or waste wood as a fuel stock is deemed to be an industrial development, whether sited in urban or rural locations. Relevant planning issues include the proposed scale of the development and the potential impacts on the environment. For example, small scale plants easily incorporated into existing agricultural buildings may not require a specific planning consent, if the plant is considered ancillary to the main use of the site. Larger plants generating both heat and power are almost certain to require planning permission, with the local planning authority (LPA) giving consideration to the scale of impact in the following areas.

- Visual intrusion (e.g. chimneys)
- Noise from traffic, plant and equipment
- Local ecology
- Plant induced traffic flows

Further advice is available through Planning Policy Guidelines (PPG’s), National Planning Policy Guidelines (NPPG’s) in Scotland and Planning Advice Notes (PAN’s). The principal documents are detailed below.

- NPPG 6 (Revised 2001): Renewable Energy
- PAN 45 (Revised 2002): Renewable Energy Technologies

# 6. Market Development

## 6.1. *Policy Drivers to Market Development*

International concern about changes in global climate patterns caused by emissions to atmosphere has now led to legally binding emissions targets. The Kyoto Protocol has set targets for the EU which, when transposed to the UK Climate Change Programme requires an emissions reduction of six greenhouse gases to 12.5% below 1990 levels by 2008-12. To achieve this overall target the UK government is committed to a 20% reduction in $CO_2$ levels by 2010, with a target of 10% of electrical energy generated from renewable energy sources within the same timescale. In Scotland, a commitment has been made to a target of 17.5% by 2010 of electricity generated from renewable sources. These are relatively unambiguous objectives that are projected to be delivered in a deregulated energy generation environment and subject to market forces.

Prior to setting regional or sectoral emissions reduction targets, it is imperative to have detailed knowledge of the sources of existing greenhouse gas emissions. A disaggregation of the UK emissions data has allowed a Scottish inventory to be compiled that will now be up-dated annually. Table 8 below provides the scale and sectoral split of greenhouse gases, for the periods 1990, 1995 and 1998, and allows a UK and Scottish comparison. (Source: Scottish Executive; The Scottish Climate Change Programme 2000)

**Table 8: Sectoral Emissions in the UK and Scotland**

| **Sector** | **Mt C in Scotland & % of Scottish Total** | | | **Mt C in UK & Scottish % of UK Total** | |
|---|---|---|---|---|---|
| **Year** | **1990** | **1995** | **1998** | **1990** | **1998** |
| Energy | 6.0 (25%) | 6.6 (28%) | 6.8 (30%) | 74.2 (8%) | 59.0 (12%) |
| Business | 4.6 (19%) | 3.4 (15%) | 3.0 (13%) | 54.3 (8%) | 49.0 (6%) |
| Transport | 2.4 (10%) | 2.5 (11%) | 2.4 (10%) | 34 (7%) | 35.7 (7%) |
| Domestic | 2.0 (8%) | 2.0 (9%) | 2.0 (9%) | 22.0 (9%) | 23.5 (9%) |
| Agriculture, Forestry, | 8.5 (36%) | 8.5 (37%) | 8.5 (37%) | 23.9 (36%) | 21.8 (39%) |
| Public | 0.4 (2%) | 0.2 (1%) | 0.3 (1%) | 2.6 (15%) | 2.9 (10%) |
| Total | 23.8(100%) | 23.2(101%) | 23.0(100%) | 211.0 (11%) | 191.9 (12%) |

It should be noted that the business sector in Scotland is the only area in which there has been a consistent reduction in greenhouse gas emissions. This data provides an overview of the "emissions market" and is utilised by the government and Scottish Executive to develop agencies and programmes that are focused on the sectors with the potential to maximise emission reductions. For example, throughout the UK the Energy Savings Trust (EST) has been established to improve domestic energy efficiency. In Scotland, the Scottish Energy Efficiency Office (SEEO) works with business and the public sector.

## 6.2. CHP Targets

The UK Climate Change Programme has set a target to deliver 10,000 $MW_e$ of CHP by 2010. At present, Scotland produces approximately 350 MW of CHP, around 11% of the total installed capacity in the UK with the potential to expand significantly.

## 6.3. Renewable Energy Targets

The UK target of 10% and the Scottish target of 17.5% of electrical energy generated from renewable sources by 2010 have been introduced under the auspices of new and parallel Renewables Obligations on all licensed electricity suppliers. The higher target in Scotland reflects the differences in the respective current baselines, where Scotland produces 11% of electricity supply from existing hydro schemes. In Scotland it is intended to encourage the generation of approximately 2,000GWh of additional renewables output. This represents an emissions reduction of between 220 kt C and 530kt C, the actual reduction being dependent upon the type of generation feedstock replaced.

# 7. The Wider Market Environment

The identification of sectoral emissions and the establishment of broad-based clean energy generation options provide the context within which the potential of the market can be developed. However, the context as summarised above is single dimensional. The market driven environment established in government policy provides the opportunity to develop a more holistic or multi-dimensional approach to the objectives of the climate change programme. This entails an appraisal of national waste management policies and their ability to encourage waste as a resource and subject to a flexible hierarchy of use. The various case studies observed to date have been driven by an identified need to deal with long-term waste management issues principally relating to wood waste that were impacting directly on profitability. This situation had arisen directly from national policies designed to minimise the volume of waste being disposed of by landfill, with attendant landfill gas emission reductions.

A summary of the market drivers that directly influence the potential of waste wood is outlined below. The ability of individuals and organisations to understand and integrate the component parts of these drivers is crucial to the development of a sustainable market for the combustion of wood waste.

- EU and National Legislation
- National Policies and Strategies
- Fiscal Policies

## *7.1. EU and National Legislation*

As previously outlined, the Kyoto Protocol and targets have been transposed into the Climate Change Programme and its Scottish equivalent. The Environmental Protection Act 1990 established the "Polluter Pays" principle, the Duty of Care requirement and a robust regime for Waste Management Licensing. The PPC Regulations 2000 will continue to develop and up-date the management and technical approaches to environmental protection. The EU Landfill Directive has set diversion targets and timescales and local authorities have been set waste recycling targets. The Producer Responsibility Obligations (Packaging Waste) Regulations also sets sector targets for recycling. The impending Waste Incineration Directive and its interpretation by the market and the regulatory bodies will be a crucial factor in realising the potential of waste wood as a source of energy and in the identification of a landfill diversion route.

## *7.2. National Policies and Strategies*

The UK strategy for Sustainable Development: A Better Quality of Life provides a vision and a context for sustainable development and provides a direction for the achievement of objectives. It confirms the target setting roles of: -

- The Climate Change Programme
- The National Waste Strategy
- The National Transport Strategy

**The EU Landfill Directive** (99/31/EC) requires member states to reduce the amount of biodegradable waste, of which wood waste is one, going to landfill. In the UK this translates to a reduction of 25% of these wastes by 2010, a reduction of 50% by 2013 and a reduction of 65% by 2018.

**The National Waste Strategy** will reach the National Plan stage in the autumn of 2002. This will confirm the strategic direction to be taken by the constituent local authorities within eleven geographic areas in managing the waste arisings. Research work on an extensive list of Priority Waste Streams will help to inform each area plan of the Best Practical Environmental Option (BPEO) for individual wastes.

**The Landfill Directive and the National Waste Strategy** are the strategic drivers in the future management of biodegradable and other wastes. The way in which local authorities, business and industry, waste collection, treatment and disposal contractors decide to fulfil the requirements of these instruments will determine the availability of waste wood residues. The availability of waste wood within a stabile supply chain is crucial to the further development of the waste wood combustion market.

## *7.3. Fiscal Policies*

The government has adopted a number of fiscal initiatives with the overall objective of reducing greenhouse gas emissions. These initiatives are structured to achieve this objective by two distinct approaches.

- **Direct taxation or obligation**, to financially penalise current emission related practices
- **Financial allowances or grants** to encourage and support changes in current emission related practices

In effect, the direct taxation option is the stick and the financial support option is the carrot.

### *Direct Taxation or Obligation*

**The Climate Change Levy** applies from April 2001 to energy used by business, commerce and the public sector. It represents a direct tax on users of fossil fuel based energy, including electricity and can add up to 30% to business energy costs depending on process usage requirements. However, exemption from the levy is available for electricity generated from renewable sources (Green electricity). Similarly, heat only schemes are also exempt from the levy when renewable sources are utilised. This is important to waste wood fuel stocks. Revenue from the levy will be recycled in two principal ways: -

- A 0.3% reduction to business in the main rate of National Insurance Contribution
- £50 million of levy revenue will support energy efficiency advice, the promotion of both low carbon technologies and renewable energy projects.

**The Renewables Obligation (Scotland)** came into force in January 2002 and places an obligation on electricity suppliers to purchase a minimum proportion of electricity generated from non-fossil fuel and renewable fuel sources, such as biomass. The proportion of electricity generated from these sources will escalate in line with requirements to meet European, National and Regional targets.

**The Landfill Tax** was established in October 1995 at £7/tonne for biodegradable waste and £2/tonne for inert waste. In 2002 the tax is £13/tonne with a structured annual increase until 2004 when biodegradable waste will be taxed at £15/tonne. Recent pronouncements from the Treasury for the period beyond 2004 indicate that substantial increases in taxation levels are likely to be incurred.

### *Financial Allowances or Grants*

In August 2001 a new **Enhanced Capital Allowances Scheme** was introduced. The key features are summarised below.

- 100% capital allowance against tax in the first year for specified technologies
- All businesses are eligible to claim retrospectively against taxable income, for new installations, irrespective of size, commercial or industrial sector

- Qualifying technologies require to meet defined energy saving criteria, provided in an expanding Energy Technology Product List (ETPL), published and updated by DEFRA. Manufacturers must apply to DEFRA to have their individual products placed on the ETPL. This can provide manufacturers with a distinct marketing advantage both in terms of enhanced capital allowance and in market placement terms by selling energy related products and services to a captive audience.

The government had intended to announce in April through the **New Opportunities Fund** a financial support package for biomass type energy initiatives for commercial/business operations only. Although final details have not yet been released, it is anticipated that approximately £3 million will be made available for smaller installations and £33 million for larger scale plant. These sums will be released in the form of **grant aid** and will be subject to qualification criteria.

**The Energy Savings Trust (EST) and the Carbon Trust** manages the **Community Energy Programme (CEP)** on behalf of the Scottish Executive, DEFRA and Transco, the joint funding partners. The opening **Pathfinder** round of CEP makes available £50 million for bids for capital grant for the refurbishment of existing community heating schemes or the installation of new schemes. Households and small and large businesses are eligible. Since 1999 the concentration has been on the evaluation and installation of smaller scale CHP with various housing providers. 88 smaller scale schemes have been established by this means and now non-residential schemes are being included. This offers opportunities for developers, business and suppliers to access an alternative-funding route, as only 25,000 households currently benefit from CHP while the government has set a target of 10,000 $MW_e$ by 2010.

**The Low Carbon Innovation Programme (LCIP)** will be the principal vehicle for developing low carbon technology, both in the medium and long term. This is subject to European Commission State Aids approval and the programme will act within State Block Exemption procedures. The Carbon Trust would act as: -

- An informed investor
- A co-ordinator of support for low carbon technologies, attracting sources of funding and operating throughout the programme

LCIP is being designed to provide a flexible support network to accommodate applications from blue sky research to near-market exploitation. **Financial support in the form of grants, guarantees and loans, to equity, convertible debt and carbon credit schemes will be provided** to meet the specific needs of applicants and partners within the chain.

The Carbon Trust will act like a Venture Capital company but with the intention of realising **a carbon return** and not a financial return. It is anticipated that existing technologies will deliver short-term carbon savings while longer-term savings will emanate from new and emerging technologies. LCIP will also support projects that do not achieve a carbon return in their own right but which maintain and extend the low carbon base.

This programme has the potential to stimulate both the supply and demand sides of the market, perhaps by partnership agreements and integrated initiatives.

## *7.4. Market Development Initiatives*

**The Woodheat concept** takes a number of forms, some of which were originally piloted in SW England. In outline terms the concept involves the provision of a **"total heat package"** by a supplier to a customer. This model could consist of a heat facilities contractor supplying and maintaining plant, equipment and fuel supplies for a contract price and term. The customer could be a single domestic occupier, a group of domestic properties or a large leisure, education, commercial or industrial facility.

In assessing the viability of a Woodheat model on a site-specific basis requires consideration to be given to a number of factors.  These include the existing and projected needs of end users, the availability of grant support mechanisms, the availability and security of fuel supplies and the discrete benefits and their non-financial value that each or all of the local stakeholders would perceive to acquire from adopting a Woodheat model.  This integrated approach may offer the advantage of delivering "added value," in that some of the elements of the project may not appear viable individually but could become viable collectively.  For example sourcing small quantities of waste wood to supply to a small number of individual customers, on an ad hoc basis or on individual short-term contracts does not offer the levels of stability that the supplier and the customer require. In this environment a higher level of risk and a lower level of investment will predominate. The Woodheat model could make this scenario viable by simultaneously lowering the risk and increasing the potential for investment across the entire facilities chain.  This may offer "win-win" situations where none currently exist.

# 8. Appendix 1: Sources of Wood Waste and Residues

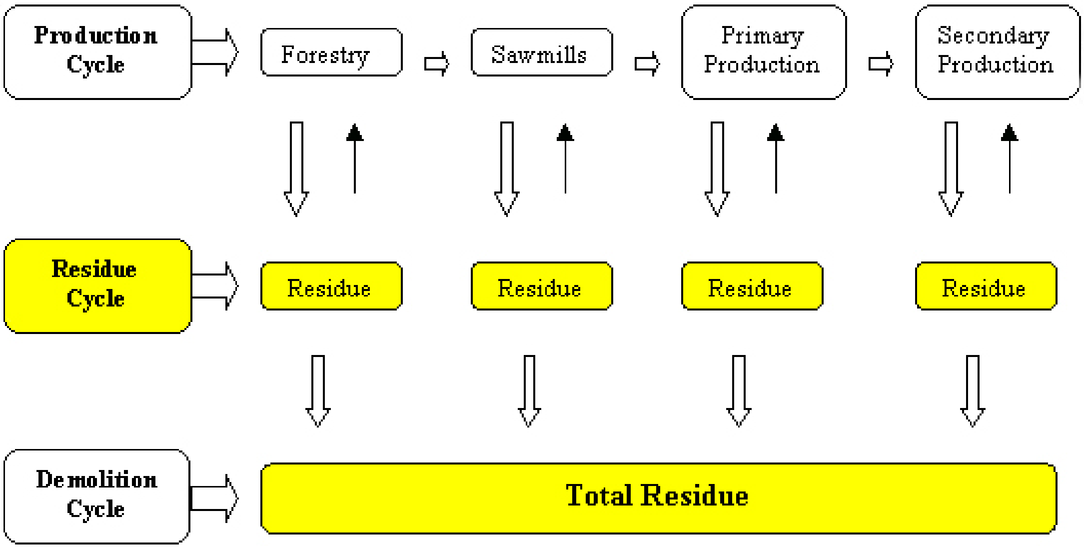


**Figure 4: An overview of the sources of wood waste and residues**

# 9. Appendix 2: Combustion Plant Suppliers

The undernoted list of Biomass Combustion Plant Suppliers are all members of British Biogen, the recognised industry body. The list is up-dated periodically and is not exhaustive. Suppliers have a range of appliances and communicate directly with potential customers.

Bioenergy Technology Ltd.

Cornwell Heat

Dragon Biomass Heating Systems

Foundation Business Centre

Fuelwood Harvesting

Renewable Heat and Power

Talbotts Heating Ltd.

Teissen Products Ltd./Farm 2000

Third Generation

Welsh Biofuels

# 10. Appendix 3: British Biogen Codes of Practice

- For Biofuel Pellet Burning Roomheeters <15kW
- For Biofuel Pellets

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# The British BioGen Code of Practice for Biofuel Pellet Burning Roomheaters <15kW

**FINAL** Version 2.3 February 2001

## Introduction

These COGPs are to ensure that the biomass industry develops a good reputation with customers for quality equipment, installations and fuels that work. The codes are voluntary but all members of the industry are strongly encouraged to comply with them. This COGP will be revised from time to time in line with the development of new Euro Norms and in light of industry experience. It is advisable to contact the BioGen office to ensure that you have the latest version.

### 1.0 Appliance Integrity

1.1 All pellet roomheaters made in the UK or imported into the UK shall have been awarded a CE Mark and shall be so labeled.

1.2 All pellet appliances made in the UK or imported into the UK shall have been tested in accordance with ASTM E 1509-95 or the relevant P Mark test of the Swedish National Testing Institute. These tests may be performed in any accredited testing laboratory and the appliance shall be properly labeled in accordance with the respective standard.

### 2.0 Appliance Safety

2.1 All appliances made in the UK or imported into the UK shall have been tested in accordance with either ASTM E 1509-95 or the relevant P Mark and shall be so labeled.

### 3.0 Appliance Emissions

3.2 For appliances which rely on ASTM E 1509-95 under headings 1.2 and 2.0 above, the appliance shall be type tested in an accredited laboratory for CO emissions in accordance with prEN 13240 and shall achieve a Class 2 rating until June 2003, thereafter Class 1.

### 4.0 Appliance efficiency

4.1 For appliances which rely on ASTM E 1509-95 under headings 1.2 and 2.0 above, the appliance shall be type tested by an accredited laboratory for efficiency in accordance with prEN 13240 and shall achieve a Class 2 rating until June 2003, thereafter Class 1.

### 5.0 Appliance Noise

5.1 Pellet roomheaters which rely on ASTM E 1509-95 under headings 1.2 & 2.0 above may be type tested for noise under ISO 3741 (EN23741) with the fans & feed motor(s) running at the mid point of the speed-range, and if they achieve a rating of less than 45dBA may bear the legend "complies with British BioGen noise test". This legend may also be used for heaters that have been awarded a P Mark.

## 6.0 Quality Assurance & Miscellaneous

6.1 All appliance manufacturers shall operate a quality assurance procedure to a standard satisfactory to British BioGen.

6.2 All appliances shall prominently state in their instruction manual the size of pellets for which the appliance is designed and what ash content it will tolerate. This information shall also be labeled on the appliance so as to be plainly visible when refilling the fuel hopper.

6.3 All appliances on sale in or promoted for sale in Smoke Controlled areas must be approved under the Clean Air Act.

6.4 Any appliance which conforms in all respects to the foregoing, and upon supplying documentation to British BioGen in support of this, may be labeled, "*This appliance complies with the British BioGen Code of Good Practice for pellet burning roomheaters*".

## 7.0 Venting & Chimneys

7.1 All appliances shall be installed in accordance with the manufacturer's instructions and with relevant sections of the Building Regulations, by installers generally recognized as competent within the meaning of forthcoming regulations on that subject. Chimneys shall conform to BS 4543 or prEN1856 and flexible liners shall be approved by TUV or CSTB.

7.2 This section shall also apply to requirements for venting with respect to provision of combustion air.

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# The British BioGen Code of Practice for Biofuel Pellets

**FINAL** Version 2.3 February 2001

## Introduction

These COGPs are to ensure that the biomass industry develops a good reputation with customers for quality equipment, installations and fuels that work. The codes are voluntary but all members of the industry are strongly encouraged to comply with them. This COGP will be revised from time to time in line with the development of new Euro Norms and in light of industry experience. It is advisable to contact the BioGen office to ensure that you have the latest version.

## 1. Pellet Raw Materials

1.1 The COGP recognizes only one grade of pellets: "Premium Biofuel Pellets". British BioGen also recognizes that there are other grades of recovered fuel pellets but these are subject to the Waste Incineration Directive and outside the remit of this COGP.

1.2 The materials used in the manufacture of Premium Biofuel pellets shall be limited to those listed in the draft EU Mandate for European Standards for Solid Biofuels, as it may be amended from time to time. These are currently:

- products from agriculture and forestry
- vegetable waste from agriculture and forestry
- vegetable waste from the food processing industry
- wood waste with the exception of:
  - wood waste that may contain halogenated organic compounds or heavy metals as a result of treatment
  - treated wood originating from building and demolition waste
- cork waste

All of the above materials fall outside the Waste Incineration Directive.

1.3 This COGP acknowledges that CEN is currently forming a new group to consider the question of all "recovered fuels" (such as paper and cardboard) and the outcome of their deliberations may require amendment of 1.2.

1.4 This COGP strongly suggests that manufacturers of pellets should not promote or package pellets other than Premium Biofuel Pellets into markets where appliances have not been tested for performance and fitness of purpose with pellets not conforming to this COGP.

## 2 Physical and chemical attributes of pellets

2.1 SUMMARY OF COGP STANDARDS FOR PELLETS

| Class | Size | Ash | MC | Calorific Value | Bulk Density | S | Cl |
|---|---|---|---|---|---|---|---|
| **Premium Biofuel Pellets** | >4mm-20mm | <1%, 3% or 6% | <10% | >4.7kWh/kg | >600kg/ $m^3$ | <300ppm | <800ppm |
| **Recovered Fuel Pellets** | >10mm-<20mm | <1%, 3% or 6% | <10% | >4.2kWh/kg | >500kg/ $m^3$ | <300ppm | <800ppm |

2.2 The only additives that may be used in COGP pellets are lignin as a binder and trace amounts of vegetable oil as a die lubricant. The use and amount of any additive shall be disclosed.

2.3 The amount of ash resulting from burning any fuel must be taken into account in the design of the appliance and all COGP pellets shall be clearly labeled as follows:

<1% ash, "Low Ash"
<3% ash, "Standard Ash"
<6% ash, "High Ash"

### 3. Quality Assurance & Miscellaneous

3.1 All fuel manufacturers shall operate a quality assurance procedure to a standard satisfactory to British BioGen.

3.2 Bags or boxes of pellets for retail sale shall be clearly marked "Premium Biofuel pellets", with the sub-heading 'wood', 'straw' etc as appropriate. Size and ash content shall be prominently shown. The legend "These pellets conform to the British BioGen Code of Good Practice for Premium Biofuel pellets" shall also appear.