CLEARWATER POWER TECHNOLOGY

INTRODUCTION TO BIOMASS & PELLETISED FUELS

How is biomass used to create energy?

Biomass energy systems can be based on a wide range of feedstock. They use many different conversion technologies to produce solid, liquid and gaseous fuels. These can then be used to provide heat, electricity and fuels to power vehicles; using burners, boilers, generators, internal combustion engines, turbines or fuel cells.
Power can be generated by:

- co-firing a small portion of biomass on existing power plants;
- burning biomass in conventional steam boilers;
- biomass gasification; and
- anaerobic digestion

The same power plants that produce power also yield useful steam and heat in combined heat and power (CHP). Biomass can be used in furnaces and kilns for direct heating or industrial process applications.

Unlike other renewable energy sources, biomass can be converted directly into liquid and gaseous fuels, or used as the primary fuel source for steam generation – hence electricity production.

What are the main forms of biomass used for energy production?

Biomass includes the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste

The main biomass sources in use for energy production are: forest residues, agricultural residues, pulp and paper operation residues, animal waste, landfill gas and energy crops.

Overview of the technology

<u>Various aspects of the technology and its applications</u>

Many of the techniques employed for exploiting biomass have been used for a number of years (e.g. stokers for combustion) while others are only just being tested, demonstrated and commercialised (e.g. integrated gasification combined cycle power generation). Others appear to have good potential for becoming conceivable future techniques, although they have not yet been fully developed (e.g. ethanol from lingo-cellulose).

The techniques of greatest current global interest are:

- Direct combustion in boilers
- Advanced thermal conversion of biomass into a secondary fuel by thermal gasification or pyrolysis, followed by use of the fuel in an engine, turbine or fuel cell.
- Biological conversion into methane by anaerobic bacterial digestion
- Thermochemical or biochemical conversion of organic material into hydrogen, methanol, ethanol or diesel fuel.

In summary, different technologies can be applied to biomass to generate the commodities tabulated below.

PROCESS	PRODUCT	APPLICATIONS	USE
Anaerobic digestion	fuel gas	boiler, gas engine gas turbine, fuel cell	heat power/heat
Fermentation extraction	liquids	oil burners, liquid motor fuels, fuel cells	power/heat transport
Combustion	hot exhaust gas	boiler/steam engine	space heating, process heat, hot water, power/heat
Gasification	fuel gas	boiler, gas engine gas turbine, fuel cell	heat power/heat
	synthesis gas	synthetic natural gas, liquid motor fuels, chemicals, heat	heat, transport
Pyrolysis	gas (fuel)	Engine	power/heat
	Liquids (fuel oil) char (solid fuel) boiler engine		power/heat

Although all these technologies are in use, not all are fully developed. Some obstacles remain to be overcome before some technologies can advance to the stage in which they can be developed commercially.

What are the key advantages of biomass technology?

Biomass fuels are sustainable. The green plants from which biomass fuels are derived fix carbon dioxide as they grow, so their use does not add to the levels of atmospheric carbon. In addition, using refuse as a fuel avoids polluting landfill disposal.

Biomass can pay a dual role in greenhouse gas mitigation, both as an energy source to substitute fossil fuels (bioenergy) and as a carbon sink.

What is the future potential of biomass technology?

Current use of biomass, which stands at about 12% of the total energy supply to the world, is primarily used in combustion for immediate use. This may be for domestic cooking in daily living, or to provide heat or power in biomass industries that have captive residues: such as sawdust and bark in the wood industries; black liquor in the kraft pulping industries; and bagasse in the world sugarcane processing sector. A very small fraction of the biomass supply is used in a marketplace of commodity biomass supplies, which serves widely distributed consumers with modern energy forms such as gas, electricity or liquid fuels.

In order to address society's modern energy needs, the biomass feedstock supply should be available on a sustainable basis, respect biodiversity and be economic. After conversion to a secondary energy form - preferably one that is fungible with the existing channels of energy distribution - it needs to be economical compared with alternatives.

What does biomass offer specifically?

Agricultural and forest residues, as well as purpose-grown energy crops, are among the major global energy resources.

Use of home-grown resources can significantly reduce a country’s need to import oil and other fossil fuels and at the same time increase a secure energy supply.

The use of biomass contributes to reducing emissions that contribute to climate change, in accordance with the Kyoto Agreement.

Fuels derived from biomass contain less sulphur. Properly designed systems using biomass can also reduce other atmospheric pollutants, and thus improve local air quality.

Using residues will also improve the local environment, while at the same time planting energy crops on land not required for food production can generate jobs, improve rural economies and help maintain agriculture and forestry.

What are the future applications of biomass?

Because biomass energy systems can be based on a wide range of feedstock and use many different conversion technologies to produce solid liquid and gaseous fuels, the spectrum of their future applications is large.

In addition to the current applications, in the future, biomass could play an increasing role throughout combined heat and power (CHP) and transport applications.

As the cost of heating with natural gas and fuel oils continues to rise business is being pushed towards the use of biomass fuels for heat generation.

This gives the user two major tasks to undertake – sourcing of an economic, readily available biomass fuel and sourcing of the required firing equipment to burn this fuel.

Clearwater Power Technology recognise this and offer the complete biomass solution for industry, providing the client with an economic biomass fuel systems and the latest in biomass power generating equipment (steam and electricity).

We can undertake the complete project delivery process from initial proposals through complete installation to long term fuel supply contracts.

As Fuel

Wood pellet has become one of the most economic biomass fuels the world can provide. Unlike fossil fuels, biomass fuels are a managed renewable resource.

Wood pellet is a carbon neutral fuel solution which is exempt from the Climate Change Levy and can attract financial incentives in the form of grants that can be used to mitigate initial capital investments of equipment installation and ongoing running costs.

Biomass fuels are carbon neutral as they do not add CO2 to the atmosphere because the same amount of CO2 released during the burning process is absorbed whilst growing.

Wood pellet is formed from good quality wood waste, allowing more complete and effective utilisation of the world’s forestry resource.

Pelletising involves the compaction of biomass at very high pressures. The biomass particles are compressed in a die to produce pellets. The product has significantly smaller volume than the original biomass and therefore has a higher volumetric energy density (VED), making pellets a more compact source of energy, which is easier to transport and store than natural biomass. The pellets can be used directly on a large scale as direct combustion feed, or on a small scale in domestic stoves or wood heaters. They can also be used in charcoal production.

The Pelletising Process

The wood waste is dried and pressed together in a pellet mill. The temperature produced in this process causes woods natural polymer, lignin, to be released from the wood which binds the pellet without the need for additional binding agents.

This produces a biomass fuel that is consistent, homogenous, easy to transport, store, dose and extremely clean burning.

The pellets have a low moisture content (4 – 6%). They will not freeze in storage and can be stored outside in vertical silos. This allows for easy delivery and discharge, whilst maximising available storage space.

The pellets also have a very low ash content (typically in the region of 0.2% - 0.5%) compared to other solid fuels (coal 8 – 12%). The resultant ash (potash) can be used as a fertiliser thus eliminating waste disposal costs.

One load of wood pellet contains the same amount of energy as fifteen equivalent loads of ordinary wood waste.

Steam Generation for Process or Power

In conjunction with specialist boiler manufacturers, Clearwater Power can engineer and install highly efficient, low maintenance, compact wood pellet burning boilers, ranging in single unit heat outputs typically of 1 to 10 MW. Other options outside of this range and multiple unit installations are also available.

The pellets are automatically fed from the silos into the large water cooled combustion chamber of the boiler by a specially designed flex auger system and intermediate storage bin positioned adjacent to the boiler from which the pellets are fed into the burner by a feed system.

The boilers have a stand alone computer control system which can be connected to external boiler management system (BMS) or environmental control systems.

Flue gases are passed through a highly efficient cyclone before being emitted ensuring that emissions are as clean as possible and that they will meet with the most stringent of local authority standards.

Electricity Production

Another major attraction of biomass combustion technology is that it can be supplied to a specification which enables it to produce steam in the heating process – this steam can be utilised to drive steam turbines enabling electricity to be produced for either on site requirements, sale back to the national grid or both, dependant on boiler size and electrical load requirements.

Gasification & Pyrolysis

Biomass gasification - a technology that transforms solid biomass into syngas for use in advanced conversion technologies - offers the route to an integrated bioenergy concept, which is necessary in order to modernise and expand the global use of biomass on an industrial scale.

Combustion

At the much larger, multi-MW scale, systems such as biomass-fuelled cogeneration units are challenged by the larger concerns of air pollution and increasingly stringent local and national regulations. In the USA, for example, the costs of combustion technologies are increasing for SOx, NOx, CO, particulate matter smaller than 2.5 microns, and HAPs (Hazardous Air Pollutants), with their requirement to handle large volumes of flue gas with contaminant levels of only one part per million. For biomass the problems of SOx and - from a greenhouse gas control perspective - the emissions of non-biogenic CO2 are relatively minor. NOx and particulates, however, are more difficult to address as many biomass sources contain significant amounts of fuel nitrogen, and increasingly there is evidence of the production of a large fraction of sub-micron fine particulates. New technologies are under development to address these issues, some of them biologically based (eg. flue gas denitrification)

Generation efficiency

Combustion and the inherent Rankine cycle based generating process materials technologies limit electric generation efficiency to around 50% - typically in very large-scale super-critical units of around 600 MW. The majority of boilers in the world's biomass industries frequently have efficiencies of less than 65%, and poor-quality steam leads to thermodynamic restrictions on the efficiency of steam turbine electricity generation, such that a lot of electricity generation has higher heating value (HHV) efficiencies of less than 25%. Electricity generation via integrated gasification combined cycles (IGCC) for both fossil fuels and biomass offers first-generation efficiencies of greater than 35%, with 45-50% as a reasonable near-term goal. Advanced concepts involving combined cycles with fuel cells as the primary converter could attain greater than 60% efficiency at relatively modest 5-10 MWe scales.

Conversion of syngas to liquid fuels

Chemical conversion of syngas (hydrogen and carbon monoxide mixtures produced from carbonaceous fuel gasification, after additional process steps such as reforming and shifting) to liquid fuels and eventually to hydrogen is an extremely active development arena. This is especially true for 'shut-in natural gas fields' - remote gas reserves that will not justify the installation of pipelines or LNG production, but are still commercially significant if they are converted to liquid fuels or chemicals (such as methanol or Fischer Tropsch hydrocarbons) and are then transported by tanker to markets.

Biomass gasification

With its high efficiency and capability of outstanding environmental performance at reasonable cost, biomass gasification is an enabling technology that provides routes to electricity, liquid fuels and chemicals. However, what is likely to be of even greater value is its ability to enable integrated biomass use. This will lead to the creation of competitive biomass feedstock supply systems, while serving modern, highly efficient secondary energy markets beyond the captive industry and local uses that predominate in both the industrial and developing country sectors today.

Gasification technology development

Biomass gasification is at a relatively early stage of development compared with developments using coal and petroleum residue, which are or have entered full deployment in the past few years. For example:

- The Buggenum 250 MWe coal gasifier, has demonstrated good fuel flexibility through more or less continuous operation over the last two years, with a coal to electricity efficiency of 43%.
- The Pernis refinery has three Shell gasifiers that have reached individual availabilities of 90%, thus assuring a continuous supply of hydrogen from petroleum upgrading, using refinery residues, and generating power.
- Three projects in Italy are using the Texaco quench technology on fuels such as asphalt to generate power and fuel gases.

This base of commercial experience is leading to project proposals at much larger scales - for example the Shell coal gasification process at Buggenum, operating on 2000 tonnes/day of coal, is proposed for a doubling of scale in a Sardinian coal project. The quest for scale has come about mainly because the major competitor, on both energy cost and environmental performance, is pipelined natural gas.

Conclusion

Biomass represents a major fuel source for many applications requiring attractive power generating costs and good environmental credentials. It represents a major growth area in developed and emerging economies.

Although some elements of the required technologies remain only semi-commercialised, there are plenty of well-proven technologies already in existence to make biomass-based energy generation an economically viable and environmentally desirable option. Future demand growth for low-cost biomass and the energy systems to convert biomass into direct energy or intermediate liquid or gaseous fuels and feedstock is already very significant and is set to become a major trade factor globally.