UNEP

Bioenergy

Bioenergy is derived from *biomass* - a term that generally refers to any plant or animal matter. Bioenergy in the form of heat or electricity can be produced by using biomass directly as a fuel or by converting it to biogas or liquid biofuels. This factsheet describes the commercial energy uses of biomass.

Residues from crops can be gasified and combusted to provide heat and power. (Photo courtesy Warren Gretz and NREL.).

The Technology

The main sources of biomass include:

- *Industrial and agricultural wastes and residues*, such as sugar cane waste (bagasse), wood waste from forestry operations, and residues from other short rotation crops such as straw and husks
- *organic wastes* from animal husbandry
- *energy crops*, such as sugar cane, corn and trees grown in short-rotation plantations.

The main processes for utilizing these biomass sources include:

- *direct combustion,* usually of solids, in boilers or furnaces
- *gasification* via a physical or chemical conversion process to a secondary gaseous fuel, followed by combustion in an engine, boiler or turbine
- *biological conversion,* via bacterial anaerobic digestion to methane-rich biogas for use as a gaseous fuel
- *chemical or biochemical conversion* to produce methanol, ethanol or other liquid fuels.

Many combinations of biomass source, process and technology are possible. In general, materials with high moisture content (such as sugar cane) are more suited to biochemical conversion and anaerobic digestion than to other forms of conversion. Direct combustion is the most fully developed process.

A bioenergy project can often be designed to co-generate both heat and electricity, increasing its overall energy efficiency and financial viability. Such projects may also create a cost-effective solution to the disposal of agricultural or industrial wastes that may otherwise become potential environment problems.

Bioenergy projects can be built in a wide range of sizes and for a wide range of applications. Projects can be as large as 100 megawatt (MW) power stations generating both electricity and heat. Bioenergy projects can also be small enough to produce the lighting and cooking energy for a single household or village. At this level, one of the most common technologies to utilize bioenergy is a cookstove.

The keys to an economically viable bioenergy project are the type, quantity required and cost of the biomass re-

Costs

Direct combustion:	*$0.06-0.10/kWh**
crop residue:	*$2.5-3.0/GJ**
plantation crops:	*$1.6/GJ (Brazil)*
	$3.0/GJ (US)
Transport fuels:	
ethanol from sugar	*$15-25/GJ*
ethanol from cellulose	*$10-15/GJ*
methanol	*$11-13/GJ*
hydrogen	*$ 8-10/GJ*

** kWh = kilowatt-hour, GJ = gigajoule*
sources: World Energy Assessment and IEA

Key Points:

- *Biomass is a widely distributed but variable resource that can be converted to bioenergy in the form of heat and electricity.*
- *Bioenergy can be produced in a wide variety of processes using a number of technologies to meet both large-scale and small-scale needs.*
- *Biomass is renewable and carbon-neutral only if it is grown at the same rate it is harvested.*
- *Biomass resources may not be sufficient to ensure continuous operation and their availability can be influenced by natural events such as weather and pests.*
- *Political motivations to reduce atmospheric carbon may create new market opportunities for bioenergy.*

source. Projects are generally more cost-effective when waste products from some production process are utilized (such as sugar bagasse or sawmill residue). For many bioenergy applications, however, big is not necessarily better as transporting the biomass fuel or feedstock over larger distances can decrease the economic viability of projects.

In addition, some agricultural wastes are available only during certain times of the year and may have to be stored if they are to be used as a continuous fuel. This can be difficult, expensive and require special equipment or storage facilities. An alternative to storing biomass is to use other fuels, such as natural gas, during these periods. This may allow a more efficient, continuous and profitable operation, but will also usually increase the project's capital cost.

The intermittent availability of a biomass resource is an issue for many bagasse-fired electricity plants that operate only during sugar harvesting periods. The liberalization of electricity markets in some countries has created an economic opportunity to invest in facilities and equipment that allows such projects to generate electricity in non-harvesting periods, thus generating higher revenues.

Energy systems powered by biomass have several potential environmental advantages and disadvantages. Biomass resources are generally renewable, but only if the resource is harvested at the same rate it is grown and soil nutrients are not depleted. Growing biomass absorbs as much carbon from the atmosphere as is released when it is combusted or converted to biofuels. Practically, some system losses occur, however, and bioenergy projects are not strictly carbon neutral.

The low net carbon outputs of bioenergy developments makes them less risky in a global political climate that increasingly favors carbon reductions. There may also be economic advantages if carbon-trading schemes become a prominent means of meeting carbon reduction targets. In addition to potential greenhouse abatement benefits, bioenergy projects can address many other environmental issues such as decreasing soil erosion, controlling nitrogen run-off, and protecting watersheds. The correct selection of plant species can result in the profitable production of energy-crops in marginal or degraded areas. Additional environmental benefits may include increased food-crop yields and decreased fertiliser use with some species.

The potential disadvantages of bioenergy projects include unsustainable impacts on soil and water resources. The inappropriate selection of species or management strategies, for example, can lead to land degradation. Impacts on air quality may also be a potential issue for combustion-type bioenergy projects and may require lengthy environmental assessments before such projects are approved. The use of energy crops to produce methanol, for example, requires pretreatment of the feedstock, its conversion to a gas, and a process to remove some pollutants from the gas before the final conversion to methanol.

> ***Project Risks***
> ***Technology****: Technologies for combustion, fermentation, and anaerobic digestion are proven and in wide scale use.*
>
> ***Environmental****: Land use changes can present some risk through impacts on soil, water and air quality, and biodiversity.*
>
> ***Planning****: Resource security can be the biggest risk. In addition to regulatory approvals that may require lengthy planning and environmental assessments, the availability of a biomass resource can be greatly influenced by weather and natural disasters. Power purchase agreements are usually standardized for bioenergy power plants.*

Other issues that may influence the viability of a bioenergy project, particularly larger projects, include competition for land-use, public resistance to proposed land-use changes, and the complexity of co-ordinating a range of activities and institutions (farmers, utilities, transport companies, etc). For these reasons, an intensive planning and management process is usually required and may also need to address these issues at local, regional and national levels.

The Industry and Market Trends

Biomass accounts for about 15 percent of global primary energy use and 38 percent of the primary energy use in developing countries where fuelwood is used for cooking and heating. The largest and most successful energy crop programmes are the US effort producing ethanol from corn (4 billion litres in 1999) and the Brazilian effort producing ethanol from sugar cane (14 billion litres in 1999).

About 14,000 MW of biomass-fired power generation is currently in operation with about half this capacity located in the US. Many of these power projects, however, operate on steam-turbine technology introduced about 100 years ago. Often these plants have a low conversion efficiency that can be significantly improved with new technology. As fossil fuel prices rise, bioenergy projects to create electricity or liquid fuels are becoming increasingly competitive.