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ECO-FRIENDLY RENEWABLE POWER GENERATION TECHNOLOGIES: AN OVERVIEW

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Abstract: Renewable energy technologies can help countries meet their policy goals for secure, reliable and affordable energy to expand electricity access and promote development. This paper examines biomass power generation technologies but also touches on the technical and economic characterization of biomass resources. There can be many advantages to using biomass instead of fossil fuels for power generation, including lower greenhouse gas (GHG) emissions, energy cost savings, improved security of supply, waste management/reduction opportunities and local economic development opportunities. However, whether these benefits are realised, and to what extent, depends critically on the source and nature of the biomass feedstock.

Keywords: Biomass, bio-power, renewable energy technology

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INTRODUCTION

Biomass refers to organic materials, either plant or animal, which undergoes the process of combustion or conversion to generate energy. Currently, the largest source of biomass is wood. However, biomass energy may also be generated from agricultural residues, animal and human wastes, charcoal, and other derived fuels. Biomass may be used either directly or indirectly. Direct use, more often termed as the traditional use of biomass, primarily involves the process of combustion. The energy that is generated is usually utilized for cooking, space heating, and industrial processes. Indirect use or the modern use concerns the more advanced processes of converting biomass into secondary energy. This includes gasification and electricity generation.

Biomass currently provides about 10% of the world's primary energy supplies, most being used in developing countries as fuel wood or charcoal for heating and cooking applications. Despite, the current minor contribution of modern bio-energy to the global energy mix, biomass has, in the long run, potential to contribute much more significantly to the global energy supply. India, being a tropical country, has tremendous potential for energy generation through biomass and its residues. Globally, India is in the fourth position in generating power through biomass with a huge potential of 16,000 MW [1]. Main barriers to widespread use of biomass for power generation are cost, low conversion efficiency and feedstock availability [2]. The energy situation in rural India is characterized by low quality of fuels, low efficiency of use, low reliability of electricity supply and access, leading to lower productivity from the use of land, water and human effort resulting in low quality of life and environmental degradation [3]. Biomass fuels include agricultural wastes, crop residues, wood and wood-wastes etc. Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon while growing. It is the cheapest eco-friendly renewable source of energy.

Economic aspects of biomass utilization

According to the Energy Future Coalition, "more than 2.4 billion people, generally among the world's poorest, rely directly on wood, crop residues, dung, and other biomass fuels for their heating and cooking needs". The modern or commercial use of biomass is more observable in industrialized countries such as the U.S. and in Europe [4]. Renewable energy technologies give rise to economic advantage for two fundamental reasons. First, renewable energy technologies are labour intensive whereas fossil fuels are more capital intensive. Furthermore, renewables can create three times as many jobs as the same level of spending on fossil fuels [5].

Modern use of biomass energy has been increasing worldwide. In many countries, it has been made a focal point of renewable energy plans and policies. This is because of several advantages that modern bioenergy offers compared to fossil fuels and/or other renewable energy sources. Biomass can provide all the major energy carriers—electricity, gases, liquid fuels for transport and stationary uses, and heat on a decentralized (standalone) basis at scales of 10s or 100s of kilowatts (kW) and upwards. It therefore has great potential to substitute fossil fuels or other energy supplies in many contexts. Modern bioenergy technologies can also replace traditional cooking fuels with clean, smokeless, efficient and easily controlled liquid and gas alternatives based on renewable biomass rather than fossil fuels. Substitution of fossil fuels by biomass can lead to significant dollar savings. The added value and income generation due to bioenergy systems is often retained locally, thereby helping reduce rural poverty. Indeed, modern bioenergy is viewed as a key means of promoting rural development [6].

In developing countries, modern bioenergy can provide a basis for rural employment and income generation. For many forestry and agro processing industries, biomass serves as an abundant, dependable and cheap fuel which can reduce energy costs. Since biomass production is labour intensive, feedstock production could be an important source of both primary employment and supplemental income in rural areas. Many farmers could sell farm residues or even purpose-grown wood. Biomass production can be a new source of revenue. Indirectly, other rural enterprises can benefit from biomass feedstock production activity especially providers of agricultural inputs such as fertilizer, suppliers of farm equipment, transporters and marketers of goods. Employment is also generated in processing biomass and working at the bioenergy conversion facility.

Development of bio-power

Most states rely heavily on fossil fuels to operate their power plants. There are many compelling reasons to consider moving toward renewable energy sources for power generation instead of fossil fuels, including:

• Using fossil fuels to produce power may not be sustainable
• Burning fossil fuels can have negative effects on human health and the environment
• Extracting and transporting fossil fuels can lead to accidental spills, which can be devastating to the environment and communities
• Fluctuating electric costs are associated with fossil fuel-based power plants
• Burning fossil fuels may contribute to climate change
• Generating energy without harmful emissions or waste products can be accomplished through renewable energy sources.

Biomass consists of plant materials and animal waste used as a source of fuel. Biopower, or biomass power, is the use of biomass to generate electricity. Biopower system technologies include direct-firing, cofiring, gasification, pyrolysis, and anaerobic digestion. Most biopower plants use direct-fired systems which burn biomass directly to produce steam.

Co-firing refers to mixing biomass with fossil fuels in conventional power plants. Coal-fired power plants can use cofiring systems to significantly reduce emissions, especially sulfur dioxide emissions. Gasification systems use high temperatures and an oxygen-starved environment to convert biomass into synthesis gas, a mixture of hydrogen and carbon monoxide. The synthesis gas, or "syngas," can then be chemically converted into other fuels or products, burned in a conventional boiler, or used instead of natural gas in a gas turbine. Gas turbines are very much like jet engines, only they turn electric generators instead of propelling a jet. Highly efficient to begin with, they can be made to operate in a combined cycle, in which their exhaust gases are used to boil water for steam, a second round of power generation, and even higher efficiency. Biomass fuels can come from many different sources. While most all of these can be used to produce fuel, their suitability for specific conversion technologies must be assessed. Typically, biomass for energy generation comes from the following sources:

• Wood, including forest residue, primary and secondary mill residues, wood pellets, and briquettes
• Fast-growing energy crops grown specifically for energy use (fast-growing trees, grasses)
• Agricultural and animal residue
• Food waste.

The amount of energy that can be produced by a biopower system depends on several factors, including the type of biomass, the technology employed, and numerous economic factors. Biopower systems can be sized to supply internal energy needs only or sized larger to feed energy to the grid for sale.

Types of Bio-power Systems

Thermal Energy Only

Figure1 illustrates a thermal energy-only system. Biomass energy is converted to steam that is sent to a nearby steam customer that purchases the thermal energy in the steam for heating, cooling, manufacturing, or any other number of industrial uses.

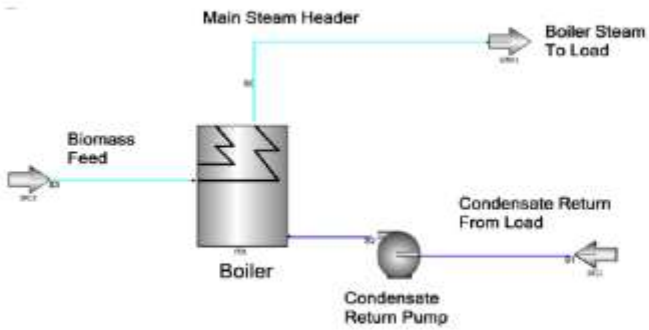

Fig. 1 Thermal only biomass energy system

Power Generation Only

Figure 2 illustrates a power generation-only system. In this case, biomass energy is converted into high pressure, superheated steam for introduction into a steam turbine. The turbine generates electricity at the most efficient rate practical, depending on the size of the system.

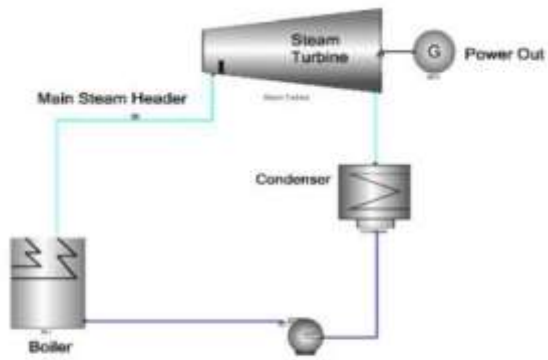

Fig. 2 Power generation biomass energy system

Biomass resource assessment

A resource assessment was performed, reviewing the availability of biomass fuel potential in the area [7].

Biomass Types Assessed

The following types of biomass assessed were forest residue, primary mill residues, urban and secondary mill residues, and fast-growing energy crop residues.

Forest Residue- This category includes logging residues and other removable material left after carrying out silviculture operations and site conversions. Logging residue comprises unused portions of trees, cut or killed by logging and left in the woods. Other removable materials are the unutilized volume of trees cut or killed during logging operations

Urban and Secondary Mill Residues- This category includes wood residues from municipal solid waste (MSW) (wood chips and pallets), tree trimming residues from utilities and private tree companies, and construction and demolition sites.

Fast-Growing Energy Crop Residues- This category includes the following crops: corn, wheat, soybeans, cotton, sorghum, barley, oats, rice, rye, canola, dry edible beans, dry edible peas, peanuts, potatoes, safflower, sunflower, sugarcane, and flaxseed. The quantities of crop residues that can be available in each county are estimated using total grain production, crop to residue ratio, moisture content, and taking into consideration the amount of residue left on the field for soil protection, grazing, and other agricultural activities.

Following table 1 indicates the thermochemical and biochemical conversion processes for biomass feedstock [8].

Table 1: Biomass power generation renewable technologies

Thermochemical process	
1. Combustion	The cycle used is the conventional rankine cycle with biomass being burned (oxidised) in a high pressure boiler to generate steam. The net power cycle efficiencies that can be achieved are about 23% to 25%. The exhaust of the steam turbine can either be fully condensed to produce power or used partly or fully for another useful heating activity. in addition to the exclusive use of biomass combustion to power a steam turbine, biomass can be co-fired with coal in a coal-fired power plant. Direct co-firing is the process of adding a percentage of biomass to the fuel mix in a coal-fired power plant. it can be co-fired up to 5-10% of biomass (in energy terms) and 50-80%6 with extensive pre-treatment of the feedstock (i.e. torrefaction) with only minor changes in the handling equipment. For percentages above 10% or if biomass and coal are burning separately in different boilers, known as parallel co-firing, then changes in mills, burners and dryers are needed.
2. Gasification	Gasification is achieved by the partial combustion of the biomass in a low oxygen environment, leading to the release of a gaseous product (producer gas or syngas). The resulting gas is a mixture of carbon monoxide, water, CO2, char, tar and hydrogen, and it can be used in combustion engines, micro-turbines, fuel cells or gas turbines. When used in turbines and fuel cells, higher electrical efficiencies can be achieved than those achieved in a steam turbine. it is possible to co-fire a power plant either directly (i.e. biomass and coal are gasified together) or indirectly (i.e. gasifying coal and biomass separately for use in gas turbines).
3. Pyrolysis	Pyrolsis is a subset of gasification systems. in pyrolysis, the partial combustion is stopped at a lower temperature (450°C to 600°C), resulting in the creation of a liquid bio-oil, as well as gaseous and solid products. The pyrolysis oil can then be used as a fuel to generate electricity.
Biochemical conversion	
Anaerobic digestion	Anaerobic digestion is a process which takes place in almost any biological material that is decomposing and is favored by warm, wet and airless conditions. The resulting gas consists mainly of methane and carbon dioxide and is referred to as biogas. The biogas can be used, after clean-up, in internal combustion engines, micro-turbines, gas turbines, fuel cells etc,.

Bio-power Economics and Performance

The installed cost of biomass power generation systems is estimated based on several key factors, including the equipment arrangement, plant size, and geographical factors. These costs include permitting, engineering, equipment, construction, commissioning, and all soft costs such as development fees and the costs for financing. The economics of a biopower system depend on incentives, plant costs, labor costs, biomass resource costs, and the sales rate for electricity and thermal energy. Operational costs are a key component. These facilities offer good quality job opportunities to the local community. The economy of scale is critical with regards to operating costs. While larger plants are more efficient, cost per kilowatt is also lower due to labor costs. For example, a 20-MW biopower facility may only have a few more employees than a 10-MW facility.

CONCLUSIONS

Biomass energy benefits the local and regional economic development through creation and perpetuation of jobs since biomass fuel is locally produced, harvested, and processed. It also leads to development of new local markets by adopting new ways of utilizing forest byproducts for fuel. The potential benefits of biomass energy are extensive. This review has seen a generally positive trend in the macroeconomic indicator (GDP) with biomass share, whereas a number of employment opportunities can be achieved from the industry.

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