Renewable Biomass Energy

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***Abstract*-- This paper discusses biomass as a renewable energy source. The paper defines the resources as well as the ways biomass energy is converted into electricity, technologies involved in extracting power from biomass as well as the advantages and the disadvantages of using of biomass as a source of energy. The paper also reviews a few biomass projects in the United States and some other parts of world and discusses the future of biomass.**

1. INTRODUCTION

Biomass is a term used to describe all organic matter produced by photosynthesis, existing on the earth's surface. They include all water- and land-based vegetation and trees, and all waste biomass such as municipal solid waste (MSW), municipal biosolids (sewage), and animal wastes (manures), forestry and agricultural residues, and certain types of industrial wastes. The world's energy markets have relied heavily on the fossil fuels. Biomass is the only other naturally occurring energy-containing carbon resource that is large enough in quantity to be used as a substitute for fossil fuels [1].

Through the process of photosynthesis, chlorophyll in plants captures the sun's energy by converting carbon dioxide from the air and water from the ground into carbohydrates, i.e., complex compounds composed of carbon, hydrogen, and oxygen. When these carbohydrates are burned, they turn back into carbon dioxide and water and release the sun's energy they contain. In this way, biomass functions as a sort of natural battery for storing solar energy.

The exploitation of energy from biomass has played a key role in the evolution of mankind. Until relatively recently it was the only form of energy which was usefully exploited by humans and is still the main source of energy for more than half the world's population for domestic energy needs [2]. One of the simplest forms of biomass is a basic open fire used to provide heat for cooking, warming water or warming the air in our home. More sophisticated technologies exist for extracting this energy and converting it into useful heat or power in an efficient way. In the mid-1800s, biomass, principally wood biomass, supplied over 90% of U.S. energy and fuel needs, after which biomass energy usage began to decrease as fossil fuels became the preferred energy resources. This eventuality of fossil fuel and the adverse impact of fossil fuel usage on the environment are expected to be the driving forces that stimulate the transformation of biomass into one of the dominant energy resources.

Unlike fossil fuels, biomass is renewable in the sense that only a short period of time is needed to replace what is used as an energy resource. Biomass also is the only renewable energy source that releases carbon dioxide in use. However the release is compensated by the fact that the biomass grown uses the carbon dioxide from the atmosphere to store energy during photosynthesis. If the biomass resource is being used sustainably, there are no net carbon emissions over the time frame of a cycle of biomass production. Figure 1 shows a biomass energy cycle and the way biomass is utilized for energy generation in an environmentally friendly scheme [2].

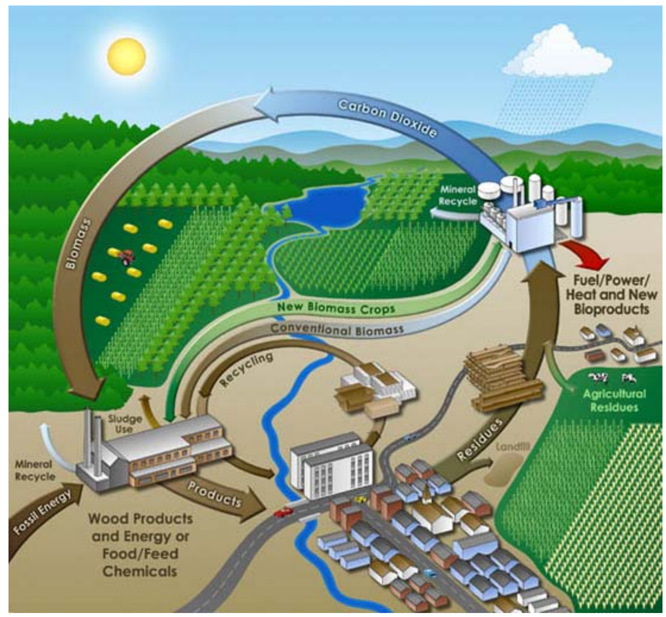

Figure 1: Biomass Energy Cycle

2. METHODS OF EXTRACTING BIOMASS ENERGY

Biomass can be converted to thermal energy, liquid, solid or gaseous fuels and other chemical products through a variety of conversion processes. Biopower technologies are proven electricity-generation options in the United States, with 10GW of installed capacity [5]. All of today's capacity is based on mature, direct-combustion technology. Future efficiency improvements will include co-firing of biomass in existing coal-fired boilers and the introduction of high-efficiency gasification, combined-cycle systems, fuel cell systems, and modular systems [5].

Generally, the prominent biopower technologies are comprised of direct combustion, co-firing, gasification, pyrolysis, anaerobic digestion, and fermentation.

1. Direct Combustion

This is perhaps the simplest method of extracting energy from biomass. Industrial biomass combustion facilities can burn many types of biomass fuel, including wood, agricultural residues, wood pulping liquor, municipal solid waste (MSW) and refuse-derived fuel. Biomass is burned to produce steam, the steam turns a turbine and the turbine drives a generator,

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producing electricity. Because of potential ash build-up (which fouls boilers, reduces efficiency and increases costs), only certain types of biomass materials are used for direct combustion.

2. Gasification

Gasification is a process that exposes a solid fuel to high temperatures and limited oxygen, to produce a gaseous fuel. The gas produced by the process as shown in Figure 2 is a mix of gases such as carbon monoxide, carbon dioxide, nitrogen, hydrogen, and methane. The gas is then used to drive a high-efficiency, combined-cycle gas turbine. Gasification has several advantages over burning solid fuel. One is convenience – one of the resultant gases, methane, can be treated in a similar way as natural gas, and used for the same purposes.

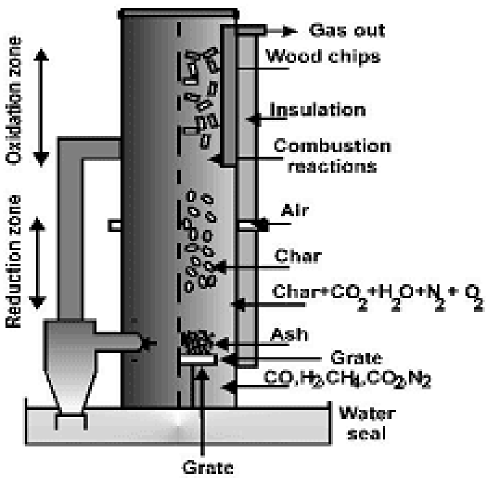

Figure2: Gasification Process

Another advantage of gasification is that it produces a fuel that has had many impurities removed and could therefore cause fewer pollution problems when burnt. Under suitable circumstances, it can also produce synthesis gas, a mixture of carbon monoxide and hydrogen which can be used to make hydrocarbon (e.g., methane and methanol) for replacing fossil fuels. Hydrogen itself is a potential fuel without much pollution which can conceivably substitute oil and petroleum in a foreseeable future [7].

3. Pyrolysis

In its simplest form, pyrolysis represents heating the biomass to drive off the volatile matter and leaving behind the charcoal. This process has doubled the energy density of the original material because charcoal, which is half the weight of the original biomass, contains the same amount of energy, making the fuel more transportable. The charcoal also burns at a much higher temperature than the original biomass, making it more useful for manufacturing processes. More sophisticated pyrolysis techniques are developed recently to collect volatiles that are otherwise lost to the system. The collected volatiles produce a gas which is rich in hydrogen (a potential fuel) and carbon monoxide. These compounds are synthesized into methane, methanol, and other hydrocarbons. The steps involved in this process are illustrated in Figure 3 [7].

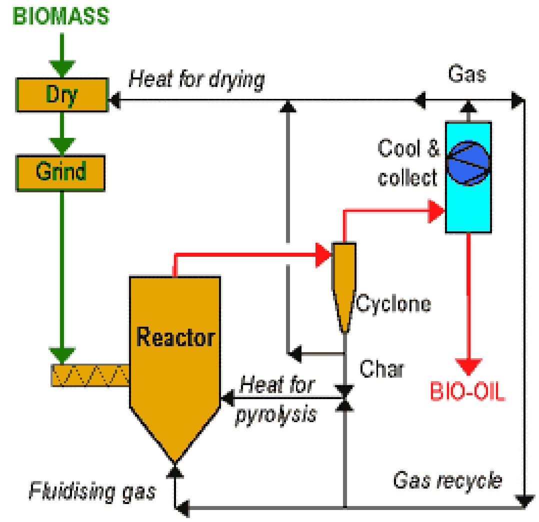

Figure 3: Pyrolysis Process

Flash pyrolysis is used to produce bio-crude, a combustible fuel. Heat is used to chemically convert biomass into pyrolysis oil. The oil, which is easier to store and transport than solid biomass material, is then burned like petroleum to generate electricity. Pyrolysis can also convert biomass into phenol oil, a chemical used to make wood adhesives, molded plastics, and foam insulation.

4. Digestion

Biomass digestion works by utilizing anaerobic bacteria. These microorganisms usually live at the bottom of swamps or in other places where there is no air, consuming dead organic matter to produce methane and hydrogen. We put these bacteria to work for us. By feeding organic matter such as animal dung or human sewage into tanks, called digesters, and adding bacteria, we collect the emitted gas to use as an energy source. This process is a very efficient means of extracting usable energy from such biomass. Usually, up to two thirds of the fuel energy of the animal dung could be recovered. Another related technique is to collect methane gas from landfill sites. A large proportion of household biomass waste, such as kitchen scraps, lawn clipping and pruning, ends up at the local tip. Over a period of several decades, anaerobic bacteria at the bottom of such tips could steadily decompose the organic matter and emit methane. The gas can be extracted and used by capping a landfill site with an impervious layer of clay and then inserting perforated pipes that would collect the gas and bring it to the surface [7].

5. Fermentation

For centuries, people have used yeasts and other microorganisms to ferment the sugar of various plants into ethanol. Producing fuel from biomass by fermentation is just an extension of this process, although a wider range of plant material from sugar cane to wood fiber can be used. For instance, the waste from a wheat mill in New South Wales is used to produce ethanol through fermentation. Ethanol is then mixed with diesel to produce diesehol, a product used by trucks and buses in Australia [7].

Technological advances will inevitably improve the method. For example, scientists in Australia and the U.S. have substituted a genetically engineered bacterium for yeast in the fermentation process. The process has vastly increased the efficiency by which waste paper and other forms of wood fiber is fermented into ethanol.

Biofuels: Biomass is converted into transportation fuels such as ethanol, methanol, biodiesel and additives for reformulated gasoline. Biofuels are used in pure form or blended with gasoline.

Ethanol: Ethanol, the most widely used biofuel, is made by fermenting biomass in a process similar to brewing beer. Currently, most of the 1.5 billion gallons of ethanol used in the U.S. each year is made from corn and blended with gasoline to improve vehicle performance and reduce air pollution.

Methanol: Biomass-derived methanol is produced through gasification. The biomass is converted into a synthesis gas (syngas) that is processed into methanol. Most of the 1.2 billion gallons of methanol annually produced in the U.S. are made from natural gas and used as solvent, antifreeze, or to synthesize other chemicals. About 38 percent is used for transportation as a blend or in reformulated gasoline.

Biodiesel: Biodiesel fuel, made from oils and fats found in micro-algae and other plants, is substituted for or blended with diesel fuel.

3. BIOMASS ENERGY GENERATION

3.1 BENEFITS OF BIOMASS ENERGY:

Some of the advantages of using biomass as a source of energy are illustrated below.

1. Biomass energy is an abundant, secure, environmental friendly, and renewable source of energy. Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel.
2. One of the major advantages of biomass is that it can be used to generate electricity with the same equipment or in the same power plants that are now burning fossil fuels.
3. Biomass energy is not associated with environmental impacts such as acid rain, mine spoils, open pits, oil spills, radioactive waste disposal or the damming of rivers.
4. 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.
5. Alcohols and other fuels produced by biomass are efficient, viable, and relatively clean burning.
6. Biomass is easily available and can be grown with relative ease in all parts of the world.

3.2 CONSTRAINTS TO BIOMASS ENERGY USE:

1. Biomass is still an expensive source of energy, both in terms of producing biomass and converting it into alcohols, as a very large quantity of biomass is needed.
2. On a small scale there is most likely a net loss of energy as a lot of energy must be used for growing the plant mass; biomass is difficult to store in the raw form.
3. One of the disadvantages of biomass is that direct combustion of biomass can be harmful to the environment as burning biomass releases carbon dioxide, which contributes to the warming of the atmosphere and possible climatic change. Burning also creates soot and other air pollutants.
4. Over-collecting wood can destroy forests. Soils bared of trees erode easily and do not hold rainfall. Increased run-off can cause flooding downstream.
5. When plant and animal wastes are used as fuel, they cannot be added to the soil as fertilizer. Soil without fertilizer is depleted of nutrients and produce fewer crops.
6. Biomass has less energy than a similar volume of fossil fuels [8].

6. BIOMASS PROJECTS IN THE NORTH AMERICA

6.1 OKEELANTA COGENERATION PLANT, SOUTH BAY, FLORIDA

The Okeelanta Cogeneration Plant is a 74-MW biomass cogeneration project located next to the Flo-Sun Inc. Okeelanta Sugar Mill, in Palm Beach County, Florida. U.S. Generating Co. (USGen) and Flo-Energy Corp. (an affiliate of Flo- Sun Inc.) joined together to construct and operate the facility. It is the largest bagasse/biomass cogeneration plant in the U.S. The plant provides process steam and power to the Okeelanta Sugar Mill and Florida Crystals Refinery, and sells its excess electricity to FPL.

Fuels: Each year, about two-thirds of fuel requirements are met by bagasse, and the remainder by wood waste. The sugarcane harvesting and grinding season lasts about 6 months, from October through late March or early April. Bagasse cannot be stored for a long time without deterioration of its fuel value, so many bagasse-fired cogeneration plants rely on a supplemental fuel such as wood waste or coal during the off-season when bagasse is not produced as a by-product of sugar mill. The fuel at the Okeelanta Cogeneration plant is not dried before combustion. Wood wastes used as fuel at the plant include urban wood wastes, land clearing wood wastes, and construction debris.

One type of wood waste is melaleuca, a pest tree that threatens to overwhelm everglades [9]. Melaleuca trees, which soak up about 50 gal of water a day, were imported decades ago from Australia to dry out land in the Everglades to make it buildable. The gnarly trees have successfully taken root and smothered native vegetation. They have no native predators. When cut down, they grow back. When burned, their seedlings spread, giving birth to yet more trees. They burn well in the Okeelanta boiler, and the plant now receives as many as 10 truckloads a day from land clearing activities in the Everglades. Before the Okeelanta Cogeneration plant started its operation, the district had no options other than to haul melaleuca to the landfill or burn it on site [9].

Operating Experience: From February 1998 to February 1999, the Okeelanta plant has run at a steady rate as required to meet the sugar mill's energy demand. The Okeelanta sugar mill and refinery have no off-season. They run year round except for scheduled maintenance shutdowns, processing extract from cane, and processing sugar.

Environmental Performance: Annual aggregate emission level is about 75% less than previous levels produced by the sugar mill's 50-year-old boilers, even though the new plant produces 74 MW of electricity and meets all steam and power requirements that were previously handled by the mill's boilers. The cogeneration plant's air quality permits would link the two facilities. After the cogeneration plant has operated long enough to establish its reliability, the sugar mill will be required to dismantle the old boilers [9].

Economic Information: The reported total capital cost for the Okeelanta plant was $194.5 million; based on 74 MW, this is equivalent to about $2800/kW in 1998 dollars. The Osceola plant's total capital cost was reported as $162 million; based on 52 MW, this is equivalent to about $3300/kW in 1998 dollars. The Okeelanta Cogeneration Plant provides many environmental benefits and should serve as a reliable energy source for the sugar mill and the electric utility.

6.2 KEATTLE FALLS STATION, KEATTLE FALLS, WASHINGTON

Avista Corporation, previously known as the Washington Water Power Company (WWP), has operated since 1983 a 46-MWe (net) wood-fired steam turbine power plant at Kettle Falls, Washington. Avista is an investor-owned utility company located in Spokane, Washington. The plant site is 86 miles north of Spokane next to the Columbia River. Fuel consists primarily of lumber mill wastes from mills in northeastern Washington, and some in Canada. The facility began commercial service in December 1983. With the plant's opening, WWP became the first utility in the nation to operate a stand-alone power plant of this size fired entirely by wood waste.

Fuel: The Kettle Falls plant is designed to burn approximately 500,000 t/yr of 50% moisture wood waste. Fuel consists of bark, sawdust, shavings, and slabs—milling by-products from about 15 log processing plants in northeast Washington, southeast British Columbia, and northern Idaho, approximately a 100-mi radius. The economic haul distance is longer in cases where backhauls are possible. The average fuel higher heating value (HHV) is about 4,700 Btu/lb as received. The average one-way haul from suppliers under contract is about 46 mi. Average transportation costs were estimated in 1983 at 10.8¢/t-mi. Average delivered fuel costs were estimated in 1983 to be about $12/green t (approximately $1.40/MBtu). The supply of hog fuel generated by the lumber mills in the Kettle Falls area continues to be more than adequate. The plant has had to curtail fuel deliveries from major suppliers at times. The mills in Canada are generating more biomass fuel than ever, as environmental restrictions on wigwam burning are tightened [9].

Operating Experience: From the start of commercial operation in 1983 through the early 1990s, the station's capacity Factor (CF) averaged 88.9%, which includes the 6 month period when the plant was off line for precipitator replacement shortly after opening. The CF has been lower in recent years, not because of problems at the plant, but because of the very low market prices for hydroelectric energy in the Pacific Northwest. Originally rated at 42.5 MW (net), the Kettle Falls plant can operate continuously at 46 MW (net). On average, the plant generates 1000 kWh of electricity for every 1.5 t of sawmill waste burned. This is equivalent to a net plant heat rate of about 14,100 Btu/kWh (24.2% thermal efficiency, HHV basis).

Economic Information: In 1983 dollars, the estimated capital cost at completion of the project was $82.5 million. This is about $1940/kW in 1983 dollars, or about $3100/kW in 1998 dollars using the GDP deflator index. This figure includes all capitalized items including electrical transmission required to integrate the output into the system. Using wood waste as a renewable resource for power generation has proven to be a successful operation for Avista Corporation and a sound environmental solution for the wood products industry. Long-term residents in the Kettle Falls area reported major reductions in haze after the plant went into operation. The plant improved air quality by eliminating numerous wigwam burners in Stevens County.

6.3 RIDGE GENERATING STATION, AUBURNDALE, FLORIDA

Because of its low-lying geography and high water table, Florida has a stronger incentive than most states to find alternatives to land filling solid wastes. Landfills that begin at ground level and rise as high as 200 ft are commonly the highest elevations in Florida coastal counties. State legislation and incentive programs since the 1970s have caused Florida to have the largest capacity of waste-to-energy (WTE) facilities of any state.

The Ridge Generating Station Limited Partnership owns an independent power-producing unit between Auburndale and Lakeland, Florida, that burns waste wood, waste tires, and landfill gas. The unit has a gross capacity of 45 MW and nets about 40 MW in sales to Florida Power Corporation. The plant came into operation in August 1994. Not counting Ridge Generating Station, there are 12 WTE plants in Florida with a combined capacity of 486 MW. (Four are operated by Wheelabrator.) Because of its climate, Florida also has a relatively high per-capita generation rate of urban wood wastes.

Fuels: The facility receives waste wood and tires from local haulers and communities within about a 50-mi radius. The rest of the wood wastes are obtained at very low cost. The waste wood includes a great deal of vegetative waste, which has a high moisture content. Varying moisture content is one of the major control problems, but using tires and landfill gas helps control the combustion process. Most urban wood waste fuel is tree wastes, brought to the plant by tree service companies and land clearing companies. About 10%-15% of the total wood wastes are wood debris; industrial wood wastes such as pallets and scraps account for a smaller percentage.

Operating Experience: The plant has operated well, although it has experienced some of the typical problems with boiler tube fouling, etc., caused by the use of waste fuels containing alkali, chlorine, sulfur, and other contaminants [9].

Environmental Performance: No difficulties were reported in meeting the air quality permit requirements. A very slight haze was visible in the plume leaving the plant's stack, which is typical of plants that use NH3 injection for NOx control. In July 1996 the plant obtained approval to reuse its ash in asphalt or concrete mixtures; treatment methods to allow the ash to be marketed in this way are being evaluated. Presently, ash is disposed of in the landfill.

6.4 WILLIAMS LAKE GENERATING STATION, BRITISH COLUMBIA, CANADA

The Williams Lake Generating Station in British Columbia is located about 225 miles North/northeast of Vancouver and is the largest single-unit biomass-fired power plant in North America. The plant's rated capacity is 60 MW net, of which 55 MW is purchased by B.C. Hydro. The plant can produce 67-69 MW net and frequently operates at that production level.

The Williams Lake region was often beset with layers of smoke and a generous sprinkling of ash particles from wood waste burners at the five local sawmills. Beginning around 1988, concerted action by the provincial government, the local utility, the sawmill owners, and the public resulted in construction of Williams Lake station. Commercial operation started on April 2, 1993. By year's end, all performance goals were met or exceeded. In each of the five following years the plant has generated more than 500 GWh/yr and consumed more than 550,000 tons/yr of mill residues.

The Williams Lake Generating Station not only has the largest wood-fired boiler in North America and generates more electricity each year than any other wood-fired power plant; it is also the most efficient stand-alone wood-fired power plant in North America, with a net plant heat rate of about 11,700 Btu/kWh. With nearly free fuel, efficiency is not a major priority at Williams Lake. However, the steam conditions, auxiliary power consumption, and turbine efficiency are considerably better than those at smaller plants [9].

Fuels: The plant consumes more than 550,000 green t/yr of wood waste from sawmills in the Cariboo region. Five sawmills, located within 5 km, supply the fuel at no cost, and receive value from alleviating an environmental liability of waste disposal. Because the mills are so close to the plant, conveyor belts were considered, but short haul trucking is used to transport the fuel. The fuel mix is approximately 40%-50% bark; the rest is an assortment of sawdust, chips, and slabs.

Environmental Performance: Diverting wood residue from the local sawmills resulted in closure of their beehive burners. This reduced particulate emissions by more than 95%, solving a severe and longstanding local air pollution problem. The power from this regionally sustainable, environmentally beneficial project enables B.C. Hydro to defer construction of other power projects.

7. BIOMASS POWER PRODUCTION WORLD WIDE

Biomass already contributes 5% of the European Union's (EU) energy supply, and 65% of the total renewable energy production; predominately for heat and power applications. In the long term, the contribution of biomass in the EU energy supply may increase to 20%, depending on the policies adopted by the EU in relation to agriculture, sustainability, a secure energy supply and Kyoto obligations Renewable Energy Systems (RES) mainly produce electricity. However, only 20% of current EU energy supply is in the form of electricity - the remaining 80% is in the form of fuels for heating and transport. Biomass is the only RES which produces solid or liquid fuels, which could be used as, or transformed into, fuels for heating (in buildings and industry) and transport. In addition, biofuels are one of the few options for a net CO2-free system for transport applications. Some of the biomass facilities in the world are described below.

7.1 LAHTI GASIFICATION COFIRING PROJECT, LAHTI, FINLAND

The goal of the Lahden Lampovoima Oy's Kymijarvi power plant gasification project is to demonstrate the direct gasification of wet biofuel and the use of hot, raw and very low-Btu gas directly its coal boiler. Lahden Lampovoima Oy (LLO) operates the Kymijarvi power plant near the city of Lahti in southern Finland.

In Europe, typically about 30-150 MW of biofuel energy is available within 50 km from the power plant. This amount can be gasified and used directly in mid- or large- sized coal fired boilers. Thus, a power plant concept consisting of a gasifier connected to a large conventional boiler with a high efficiency steam cycle offers an attractive and efficient way to use local biomass sources in energy production.

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The amount of biofuels and refuse fuels available each year is enough to substitute for about 15% of the fuels burned in the Lahti plant's boiler, or to substitute for 30% of the coal burned. Assuming 7000 h/yr of plant operation, 300 GWh/yr is equivalent to about 43 MW of thermal energy available from local bio fuels. In addition to the REF fuel components, peat, demolition wood waste, and shredded tires are used as fuels in the gasification plant.

7.2 BIOMASS IN ASIA

In Southeast Asia, biomass is an important source of energy since fuel wood is still the dominant source of energy in almost 50 percent of the region. By country, the share of biomass in the primary energy supply in 1999 was: Myanmar - 86%; Lao PDR - 86%; Cambodia - 83%; Vietnam - 48%; Indonesia - 29%; Philippines - 21%; Thailand - 17%; and Malaysia - 8%. Biomass energy is largely used in the household sector and in small-scale industries. Recently, its use in combined heat and power generation is increasing. The role of biomass is presently limited in power development, but opportunities exist for increasing its share [10].

In Asia, the potential of biomass for power generation is promising: about 50,000 MW for all biomass resources in Indonesia approximately 3,000 MW in Thailand about 1,117 MW in palm oil industry of Malaysia about 60-90 MW from bagasse and 352 MW from ricehulls in the Philippines and 250 MW from bagasse in Vietnam. About 920 MW in installed capacity could be expected from over 19 million tons of residues in ASEAN wood industry.

Many of this potential could be developed through cogeneration. However, in order to tap the estimated potential, the following key challenges have to be addressed: 1) Establishment of a level playing field for biomass power in competition with the often subsidised centralized power generation; 2) establishment of mechanisms to compensate for the avoided external costs of biomass power generation, for example through a so-called environmental “adder” on top of the normal buy-back rate; 3) access to power grid under clear and fair terms and conditions; and 4) development of a market for biomass waste resources. Thailand is facing these challenges by initially launching a competitive bidding for 300 MW of renewable energy generation, mainly biomass. The Thai government has also established a fund to provide developers assistance to cover the differential between production and market price of biomass power. In Malaysia, grid access regulations and buy-back power rates are being developed, and the first grid-based biomass power plant is being constructed [10].

In India, more than 2000 gasifiers have been established with a capacity in excess of 22 MW and a number of villages have been electrified with biomass gasifier based generators. Being an agrarian country there is easy availability of agricultural based mass, which can be used to generate energy, burning this biomass is the easiest and oldest method of generating energy and also the least efficient. Over 70% of the population of India is in villages but it is these villages, which receive neither electricity nor a steady supply of water-crucial to survival and economic and social development and growth. Biomass exists in these villages and needs to be tapped intelligently to provide not only electricity but also water to irrigate and cultivate fields to further increase production of biomass (either as a main product or as a by-product), ensuring steady generation of electricity. Biomass gasification in India offers immense scope and potential for: Water pumping, Electricity generation: 3 to 1 MW power plants, Heat generation: for cooking gas – smokeless environment, Rural electrification means better healthcare, better education and improved quality of life.

9. CONCLUSIONS

Biomass-based power systems are unique among non-hydro renewable power sources because of their wide range of applicability to a diverse set of needs. Biomass systems can be used for village-power applications in the 10-250 kW scale, for larger scale municipal electricity and heating applications, for industrial application such as hog-fuel boilers and black-liquor recovery boilers, in agricultural applications such as electricity and steam generation in the sugar cane industry, and for utility-scale electricity generation in the 100 MW scale [8]. Biomass-based systems are the only non-hydro renewable source of electricity that can be used for base-load electricity generation.

Tripling US use of biomass for energy could provide as much as $20 billion in new income for farmers and rural communities and reduce global warming emissions by the same amount as taking 70 million cars off the road [8].
Biomass energy has the potential to supply a significant portion of America's energy needs, while revitalizing rural economies, increasing energy independence and reducing pollution. Farmers would gain a valuable new outlet for their products. Rural communities could become entirely self-sufficient when it comes to energy, using locally grown crops and residues to fuel cars and tractors and to heat and power homes and buildings.

Opportunities for biomass energy are growing. In June 2000, the federal government in the United States passed a law that will provide $49 million per year for five years to develop advanced technologies and crops to produce energy, chemicals, and other products from biomass. A number of states also provide incentives for biomass energy [6].

In 1998, biomass provided about 2% of America's electricity, 1% of the fuel used in cars and trucks, and some of the heat and steam used by homes and businesses. With more energy crops and better conversion technology, it could gain a much larger portion of the market. Energy crops and crop residues could provide 14% of US electricity use by 2008 or 13% of the nation's motor fuel [8]. Thus it is seen that the emerging technologies of biomass as a renewable source of energy is highly advantageous to promote a greener planet and also cut down on the need for fossil fuels which not only cause pollution in the atmosphere but also are fast depleting.

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BIOGRAPHIES

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