International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-1 Issue-2, June 2012

Power Generation using Bio-Mass Power Plant

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Abstract*: - Technologies to produce electricity from biomass through combustion are state of the art. There are many applications with different power generation principle (steam turbine, steam screw type engines, ORC turbines) in operation. Caused by the logistic frame conditions of biomass production, storage and transportation as well as the possibility to use the thermal energy for community heating, decentralized power plants are the most economically solutions. Similar statuses have the bio-chemical conversion technologies (e.g. biogas technologies) or the physical-chemical conversion technologies like the production of plant oils and the power generation of the liquid/gaseous fuels in internal combustion engines. All these technologies are highly developed and reached readiness for marketing in Europe as well as in Asian countries.

***Index Terms*— Renewable Energy, Biomass, Conversion Technologies, Combined Heat & Power Generation**

I. INTRODUCTION

All organic matter is known as biomass, and the energy released from biomass when it is eaten, burnt or converted into fuels is called biomass energy. Biomass provides a clean, renewable energy source that could dramatically improve our environment, economy and energy security. Biomass energy generates far less air emissions than fossil fuels. Biomass integrated gasified/ combined cycle (BIG/CC) technology has potential to be competitive (Reddy et al, 1997; Johansson et al, 1996) since biomass as a feedstock is more promising than coal for gasification due to its low sulfur content and less reactive character. The biomass fuels are suitable for the highly efficient power generation cycles based on gasification and pyrolysis processes. Steady increase in the size of biomass technologies has contributed to declining fixed unit costs. For electricity generation, two most competitive technologies are direct combustion and gasification. Typical plant sizes at present range from 0.1 to 50 MW.Co-generation applications are very efficient and economical. Fluidized bed combustion (FBC) is efficient and flexible in accepting varied types of fuels. Gasifies first convert solid biomass into gaseous fuels which is then used through a steam cycle or directly through gas turbine/engine. Gas turbines are commercially available in sizes ranging from 20 to 50 MW. Technology development indicates that a 40 MW combined cycle gasification plant with efficiency of 42 percent is feasible at a capital cost of 1.7 million US dollars with electricity generation cots of 4 cents/ KWh (Frisch, 1993).

A. Where Does Biomass Come From

Biomass contributes over a third of primary energy in India. Biomass fuels are predominantly used in rural households for cooking and water heating, as well as by traditional and artisan industries. Biomass delivers most energy for the domestic use (rural - 90% and urban - 40%) in India (NCAER, 1992). Wood fuels contribute 56 percent of total biomass energy (Sinha et. al, 1994). Consumption of wood has grown annually at 2 percent rate over past two decades (FAO, 1981; FAO, 1986; FAO, 1996). Estimates of biomass consumption remain highly variable (Rabindranath and Hall, 1995; Joshi et. al., 1992) since most biomass is not transacted on the market. Supply-side estimates (Rabindranath and Hall, 1995) of biomass energy are reported as: fuel wood for domestic sector- 218.5 million tons (dry), crop residue- 96 million tons (estimate for 1985), and cattle dung cake- 37 million tons. A recent study (Rai and Chakrabarti, 1996) estimates demand in India for fuel wood at 201 million tons (Table 1). Supply of biomass is primarily from fuels that are home grown or collected by households for own needs. The Government sponsored social forestry programmer has added to fuel-wood supply to the tune of 40 million tons annually (Rabindranath and Hall, 1995). Estimates of biomass consumption remain highly variable (Ravindranath and Hall, 1995; Joshi et. al., 1992) since most biomass is not transacted on the market.

Manuscript Received June 03, 2012.

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B. Traditional Biomass Energy

Most biomass energy in India is derived from owned sources like farm trees or cattle, or is collected by households from common property lands. The biomass energy consumption is primarily limited to meet cooking needs of households and traditional industries and services in rural areas. In absence of a developed energy market in rural areas, most biomass fuels are not traded nor do they compete with commercial energy resources. In developing countries, due to excess labor, biomass acquires no resource value so long as it is not scarce. In the absence of an energy market, the traditional biomass fails to acquire exchange value in substitution. Absence of market thus acts as a barrier to the penetration of efficient and clean energy resources and technologies. An additional problem with the traditional biomass use is the social costs associated with excessive pollution. The incomplete combustion of biomass in traditional stoves releases pollutants like carbon monoxide, methane, nitrogen oxides, benzene, formaldehyde, benzo (a) pyrene, aromatics and reparable particulate matter. These pollutants cause considerable damage to health, especially of women and children who are exposed to indoor pollution for long duration (Smith, 1987; Smith, 1993, Patel and Raiyani, 1997). The twin problems of traditional biomass use are the energy inefficiency and excessive pollution.

Exploitation of abundant biomass resources from common lands sustained the traditional biomass consumption since millennia. Increasing pressure from growing population, growing energy needs from rural industry and commerce and penetration of logistics infrastructure into remote biomass rich areas have now led to an unsustainable exploitation of biomass. Three main problems associated with the traditional biomass are - inefficient combustion technologies, environmental hazards from indoor pollution and unsustainable harvesting practices. The aims of modern biomass programmed are to overcome these problems.

II. BACKGROUND

A. Literature Review

India has a long history of energy planning and programme interventions. Programmed for promoting biogas and improved cook-stoves began as early as in 1940’s. Afforestation and rural electrification programmed are pursued since 1950’s. A decade before the oil crisis of 1973, India appointed the Energy Survey Committee. The national biomass policy originated later, in the decade of 1970’s, as a component of rural and renewable energy policies as a Response to rural energy crisis and oil imports. Rural energy crisis in the mid-1970s arose from four factors - i) increased oil price, ii) rising rural household energy demand (following the population growth), iii) trading of wood in rural areas and urban peripheries to meet demand of growing industries like brick making and services like highway restaurants in the wake of sustained shortages of commercial energy, and iv) over exploitation of common property biomass resources. The crisis called for a national policy response to find economically viable and sustainable energy resources to meet growing rural energy needs. A short term response resorted to was of importing kerosene and LPG to meet cooking needs and diesel for irrigation pumping. India's oil imports rose rapidly during 1970’s with kerosene and diesel contributing most to the rising oil imports bill. Share of oil in imports, which was 8 Percent in 1970, increased to 24 percent in 1975 and 46 percent in 1980 (Shukla, 1997). In following decade, oil imports became the major cause of growing trade deficit and balance of payment crisis. The oil import was neither a viable solution at micro economy level. A vast section of poor households had little disposable income to buy commercial fuels. To ameliorate increasing oil import burden and to diffuse the deepening rural energy crisis, programs for promoting renewable energy technologies (RETs) were initiated in late 1970s. Biomass, being a local, widely accessible and renewable resource, was potentially the most suitable to alleviate macro and micro concerns raised by the rural energy crisis. Biomass policies followed a multi-pronged strategy: i) improving efficiency of the traditional biomass use (e.g. improved cook-stove programme), ii) improving the supply of biomass (e.g. social forestry, wasteland development), iii) technologies for improving the quality of biomass use (e.g. biogas, improved cook-stoves), iv) introduction of biomass based technologies (wood gasifiers for irrigation, biomass electricity generation) to deliver services provided by conventional energy sources, and v) establishing institutional support for programme formulation and implementation. The institutional response resulted in establishment of DNES (Department of Non-Conventional Energy Sources) in 1982 and state level nodal energy agencies during the early 1980s decade.

The RETs programme received enhanced support with the establishment of DNES which emphasized decentralized and direct use renewable technologies. The renewable energy sources were viewed primarily as the solution to rural and remote area energy needs, in locations and applications where the conventional technology was unavailable or as stop gap supply options where commercial energy could not be supplied. In other words, RETs were never viewed as viable competitive options. Direct subsidy to the user and supply orientation were the major element of the Renewable Energy Programme. The energy projects were thus pushed by the government. Some of the programmed achievements include introduction of efficient and clean technologies for household energy use like improved cook-stoves (22.5 million), family sized biogas plants of 2 to 4 cubic meter per day capacity (2.4 million) and community biogas plants (1623) have been added (till March 1996) to the technology stock (CMIE, 1996). Although, the biogas and improved cook-stove programed have been moderately successful, their overall impact on rural energy remains marginal (Ramana et al, 1997). Two deficiencies in policy perspectives contributed to the slow progress in the penetration of biomass technology. Firstly, the biomass was viewed solely as a traditional fuel establishing institutional support for programme formulation.

III.TECHNOLOGY FOR PRODUCTION OF BIOMASS

A.Convert your waste in green energy

Uniconfort boilers are compatible with various types of biomass Forest and woodworking industry waste (sawdust, bark, chips and woody materials in pieces of various sizes and varying moisture content)Agricultural waste (Olive yard waste, Vineyard waste, Straw and Husk, Horse litter, Peel and Stones, etc.)Food processing industry waste (tomato peels, suspend distillation residues, apple processing residues, fruit juice processing residues, brewery distillation residues, seed oil production waste, bran processing waste, etc.)Dedicated tree and grass crops (short-medium rotation)Cleaning urban landscaping and embankments (Green waste)

It was increasingly realized that a limiting factor to the success of programmes was the restrictive perception of biomass as a traditional fuel for meeting rural energy needs and focus on the supply-side push. Since energy markets were non-existent or weak in rural areas, the traditional approach did not consider any role for market in promoting biomass supply or efficient use. Since early 1990s, the policy shift towards market oriented economic reforms by the Government of India has shifted the perspective towards allowing a greater role by market forces. The policy shift is characterized by: i) higher emphasis on market based instruments compared to regulatory controls, ii) reorientation from technology push to market pull, and iii) enhanced role of private sector. Besides, the alleviation of DNES in 1992 to a full-fledged ministry, MNES (Ministry of Non-Conventional Energy Sources), led to the enhanced statusOf RET programmes. Under the old perspective, biomass was viewed as a non-commercial rural resource (a poorMan's fuel), the use of which had to be improved through a push by government programmes. The new perspective views biomass as a competitive energy resource which can be pulled through energy markets. Under this view, government's role is not to push programmes but to enact policies which internalize social benefits and costs of competing fuels. The timing of the change in the perspective coincided with the development of several advanced biomass technologies. As a result, the MNES's policy shift towards market based incentives and institutional support has led to introduction of modern biomass technologies such as bagasse based co-generation and large scale gasification and combustion technologies for electricity generation using a variety of biomass.

B. Early Policy Perspective - The Technology Push Strategy

Enhanced scale has improved economics as well as the technology of biomass power generation. Technology improvement is also derived from joint ventures of Indian firms with leading international manufacturers of turbines and electronic governors. R&D and Pilot Project Experiences Four gasifier Action Research Centers (ARCs) located within different national institutions and supported by the MNES have developed twelve gasifier models, ranging from 3.5 to 100 KW. Two co-generation projects (3 MW surplus power capacity) in sugar mills and one rice paddy straw based power project (10 MW) were commissioned. While the co-generation projects are successfully operated, the 10 MW rice straw based power project completed in 1992 ran into technological problems and is closed since last two years due to want of suitable raw material. A rice husk based co-generation plant of 10.5 MW capacity installed by a private rice processing firm in Punjab and commissioned in 1991 faced problems such as unavailability of critical spares of an imported turbine and uneconomical tariffs from the state utility despite power shortage in the state (Ravindranath and Hall, 1995). The rapid escalation in the price of rice husk and low capacity utilization added to the cost making the operation uneconomical. The experiences with R&D and pilot project suggests the need for considerable technological and institutional improvements to make biomass energy competitive. Large Scale Electricity Generation Programmes The future of modern biomass power programme rests on its competitive ability vis-à-vis other centralized electricity generation technologies. Policies for realizing biomass electric power potential through modern technologies under competitive dynamics has a recent origin in India. The biomass electricity programme took shape after MNES appointed the task force in 1993 and recommended the thrust on bagasse based co-generation. The focus of modern biomass programme is on the cogeneration, especially in sugar industry.Modern biomass supply has to be driven by the dynamics of energy market. Supply of biomass at a competitive cost can be ensured only with a highly efficient biomass production system. Productivity of crops and trees depend critically on agro climatic factors. To enhance biomass productivity, the MNES is supporting nine Biomass Research Centers (BRCs) in nine(of the fourteen) different agro climatic zones in India with an aim to develop packages of practices of fast growing, high yielding and short rotation (5-6 years) fuel wood tree species for the degraded waste lands in these zones. Some centers have existed for over a decade. Packages of practices for 36 promising species are prepared. Biomass yield of up to 36.8 tons per hectare per year is reported (Chaturvedi, 1993) from some promising fuel-wood species. Since the knowledge of these package of practices has remained limited within the research circles, their benefits remains to be realized. The mean productivity of farm forestry nationally is very low at 4.2 tons per hectare per year (Ravindranath and Hall, 1995). Exploitation of bioenergy potential is vitally linked to the adequate land supply. While the use of cultivable crop land for fuel remains controversial under the "food versus fuel" debate, there exists a vast supply of degraded land which is available cheaply for fuel-wood plantations. The estimates of degraded land vary from 66 million hectares (Ministry of Agriculture, 1992) to 130 million hectares (SPDW, 1984). With improved biomass productivity and efficient energy conversion, it is feasible to sustain a significant share of biomass in total energy use in

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

India by utilizing a fraction of this degraded land for biomass plantation.

IV. PROJECT RESEARCH METHODOLOGY

Modernization in biomass energy use in Asia has happened in the last two decades along three routes - i) improvement of technologies in traditional biomass applications such as for cooking and rural industries, ii) process development for conversion of raw biomass to superior fuels (such as liquid fuels, gas and briquettes), and iii) penetration of biomass based electricity generation technologies. These developments have opened new avenues for biomass energy in several Asian nations, besides India. ***China***, in early 1980's, initiated a nationwide programmes to disseminate improved cook stove and biogas technologies. The programme led to raising energy efficiency of cook stoves to 20 percent, saving nearly a ton of wood fuel per household (Shuhua et al, 1997). In 1995, nearly 6 million biogas digesters produced 1.5 billion m3 gases annually (Baofen and Xiangjun, 1997). Another 24,000 biogas purification digesters, with a capacity of 1 million m3, were in use for treating waste water for 2 million urban populations (Keyun, 1995). Two hundred small biogas based power plants, adding to a capacity of 3.5 MW, produced 3 GWh of electricity annually (Ravindranath and Hall, 1995).**{**PRIVATE **}** Research and development (R&D) in China has focused on a process for converting a high quality Chinese sorghum breed into liquid fuel, pyrolysis technology and gasification of agriculture residue and wood. Biomass based electricity generation technologies have penetrated the Chinese market lately, with a penetration of 483 MW and 323 MW respectively in sugar industry in two major sugar cane producing provinces Guandong and Guangxi (Baofen and Xiangjun, 1997). The policy support points to a promising future for modern biomass in China. ***Philippines*** is a major biomass using nation, where 44% of energy is contributed by biomass. Philippines was among the first nations to initiate the modern biomass programme. In 1970's, a three quarters of electricity in Philippines was generated from oil and diesel fired power plants

V. DESIGN IMPLEMENTATION

A.Specific Areas of Analysis

Biomass based electric power generation technologies succeeded in niche applications such as supplying electricity in decentralized location and industries generating biomass waste. The large scale penetration of biomass power technologies depends on their delivered cost and reliability in direct competition with conventional electricity sources in centralized electricity supply. In India, the principal competing source for electricity supply is the coal based power. Biomass energy cost is highly variable, depending upon the source, location etc. Delivered cost of coal also varies depending upon the extraction costs and logistic costs which vary with the distance from the mine.

B.Station Transient Analysis

Coal power plants are built with large scale technology, with a standard size of 500 MW. Scale of grid based biomass plants vary from a 1 MW to 50 MW. Assuming the base price of coal in India as Rs. 48 per giga joule (GJ) and biomass as Rs. 72 per GJ, the composition of delivered cost of electricity from different plants is as shown in Evidently, the delivered cost of electricity from a 50 MW biomass based power plants is higher compared to coal power plant by 15 percent. In future this gap can be expected to reduce due to three reasons - the scale difference between coal and biomass plants shall narrow,

C ***Status Of Biomass Energy***

Associated with conventional electric power plants are some negative social and environmental externalities. Throughout the coal and nuclear fuel cycles, there are significant environmental and social damages. Contrarily, biomass energy offers positive environmental and social benefits. Biomass plantation is often a best way to reclaim degraded lands and to generate sizable employment (Miller et al., 1986). Fossil fuel plant operations pose local, regional as well as global hazards. Biomass combustion also emits pollutants;

D. Fuel Behaviour under Accident Conditions

A primary policy lacuna hampering the growth of modern biomass energy is the implicit environmental subsidy allowed to fossil fuels. Increasing realization among policy makers about positive externalities of biomass has now created conditions for biomass to make inroads into the energy market. Modern biomass has potential to penetrate in four segments. process heat applications in industries generating biomass waste, ii) cooking energy in domestic and commercial sectors (through charcoal and briquettes), electricity generation and transportation sector with liquid fuels. Economic reforms have opened the doors for competition .

E. Containment Analysis

Most economical option is utilization of waste materials. Potential availability of agro residues and wood processing waste in India can sustain 10,000 MW power. Biomass waste however shall be inadequate to support the growing demands for biomass resources. Sustained supply of biomass shall require production of energy crops (e.g. wood fuel plantations, sugar cane as feedstock for ethanol) and wood plantations for meeting growing non-energy needs. Land supply, enhanced biomass productivity, economic operations of plantations and logistics infrastructure are critical areas which shall determine future of biomass in India. Policy support for a transition towards a biomass based civilization in India

VI. CONCLUSION AND FUTURE WORK

Biomass use is growing globally. Despite advancements in biomass energy technologies, most bioenergy consumption in India still remains confined to traditional uses. The modern technologies offer possibilities to convert biomass into synthetic gaseous or liquid fuels (like ethanol and methanol) and electricity (Johansson et al, 1993). Lack of biomass energy market has been the primary barrier to the penetration of modern biomass technologies. Growing experience with modern biomass technologies in India suggests that technology push policiesneed to be substituted or augmented by market pull policies. A primary policy lacuna hampering the growth of modern biomass energy is the implicit environmental subsidy allowed to fossil fuels.

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