PROBLEMS AND CHALLENGES IN HARVESTING OF BIOMASS ENERGY FUELS

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Abstract : Biomass **has always been an important energy source for the country considering the benefits it offers. It is renewable, widely available, carbon-neutral and has the potential to provide significant employment in the rural areas. This paper discusses the major sources of biomass fuel, woody fuels and animal waste. These fuels are summarized, along with their respective benefits and barriers with respect to cost. Further this paper summarizes Problems and challenges in harvesting of biomass in India.**

***IndexTerms* - Biomass, Energy Crops, Renewable, Harvesting**

I. INTRODUCTION:

Biomass is an always important energy source for the country considering the benefits it offers. It is renewable source, widely available, carbon indifferent and potential to provide significant employment in the rural areas. About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs. Ministry of New and Renewable Energy has realised the potential and role of biomass energy in the Indian context and hence has initiated a number of programmes for promotion of efficient technologies for its use in various sectors of the economy to ensure derivation of maximum benefits. Biomass power generation in India is an industry that attracts investments of over Rs.600 crores every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days in the rural areas. For efficient utilization of biomass, bagasse based cogeneration in sugar mills and biomass power generation have been taken up under biomass power and cogeneration programme.

The current availability of biomass in India is estimated at about 500 millions metric tones per year. Studies sponsored by the Ministry has estimated surplus biomass availability at about 120 – 150 million metric tones per annum covering agricultural and forestry residues corresponding to a potential of about 18,000 MW. This apart, about 5000 MW additional power could be generated through bagasse based cogeneration in the country's 550 Sugar mills, if these sugar mills were to adopt technically and economically optimal levels of cogeneration for extracting power from the bagasse produced by them

2. SOURCES OF BIOMASS

Wood remains the largest biomass energy source today, examples include forest residues (such as dead trees, branches and tree stumps), yard clippings, wood chips and even municipal solid waste. Based on the source of biomass, biofuels are classified broadly into two major categories. First-generation biofuels are derived from sources such as sugarcane and corn starch. Second-generation biofuels, on the other hand, utilize non-food-based biomass sources such as agriculture and municipal waste.

Plant energy is produced by crops specifically grown for use as fuel that offer high biomass output per hectare with low input energy. Some examples of these plants are wheat, which typically yields 7.5–8 tonnes of grain per hectare, and straw, which typically yields 3.5–5 tonnes per hectare in the UK. The grain can be used for liquid transportation fuels while the straw can be burned to produce heat or electricity. Plant biomass can also be degraded from cellulose to glucose through a series of chemical treatments, and the resulting sugar can then be used as a first-generation biofuel.

2.1 ENERGY CROPS*:*

Energy crops are plants that are grown specifically for use as fuel or for conversion into other biofuels. They include trees that are harvested for combustion as well as trees and plants that provide the raw materials for biofuels, such as ethanol, biodiesel, and biogas.

Woody Crops: These are mainly trees grown in a forest or plantation that are used primarily for burning to generate heat or electricity. The critical aspect of harvesting woody crops from forests is the sustainability of the forest. Hybrid poplars and cottonwood trees can be harvested every 5 to 8 years, and the stumps grow into new trees, so replanting is not required.

Agricultural Crops: These types of crops mainly fall into two categories: (1) crops that are grown to make biofuels (mainly ethanol) for use as a gasoline additive, and (2) crops that are grown for their oily seeds, which can be converted to a diesel substitute known as biodiesel. The most widely used crops for ethanol production are annual crops such as corn and sugar cane that must be planted every year. Use of perennial crops, such as switchgrass and other crops with cellulose in their body mass, is also increasing because they are easier to grow (e.g., they don't need to be replanted after harvesting) and they require less water than corn and sugar cane. Plants grown for their oily seeds include annual crops such as soybeans, sunflowers, rapeseed, and castor beans. Perennial crops include seeds from the oil palm.

A third kind of agricultural crop, algae, is currently not widely used for biofuel production although it is being studied extensively. Algae are single-cell, photosynthetic organisms found in freshwater and seawater that are known for their rapid growth and high energy content. Some algal strains are capable of doubling their mass several times per day. In some cases, more than half of that mass consists of lipids or triglycerides—the same material found in vegetable oils. These bio-oils can be used to produce biodiesel. Some researchers argue that because of the rapid growth rate and high oil productivity, algae may exceed other biomass crops in meeting growing energy demands.

Wastes Used for Energy Production:

A wide variety of wastes can be used to generate energy in the same way that energy crops can. These include residues from forestry operations, wastes from the construction and furniture making industries, agricultural wastes such as corn stover and animal wastes, municipal solid waste, food waste, and commercial and industrial waste

3. TYPES OF BIOMASS FUELS

Biomass fuels are organic materials produced in a renewable manner. Two categories of biomass fuels, woody fuels and animal wastes, comprise the vast majority of available biomass fuels. Municipal solid waste (MSW) is also a source of biomass fuel. Biomass fuels have low energy densities compared to fossil fuels. In other words, a significantly larger volume of biomass fuel is required to generate the same energy as a smaller volume of fossil fuel.

The low energy density means that the costs of fuel collection and transportation can quickly outweigh the value of the fuel. Biomass fuels are typically consumed on-site or transported short distances only (e.g., less than 50 miles). Biomass fuels tend to have a high moisture content, which adds weight and increases the cost of transportation. The moisture content also decreases combustion performance.

There are two primary factors to be considered in the evaluation of biomass fuels: Fuel supply, including the total quantities available, the stability of the supply or of the industry generating the fuel, and competitive uses or markets for the fuel. Cost of biomass fuel collection, processing, and transportation, and who pays these costs.

3.1 WOODY FUELS

Wood wastes of all types make excellent biomass fuels and can be used in a wide variety of biomass technologies. Combustion of woody fuels to generate steam or electricity is a proven technology and is the most common biomass-to-energy process. Different types of woody fuels can typically be mixed together as a common fuel, although differing moisture content and chemical makeup can affect the overall conversion rate or efficiency of a biomass project. There are at least six subgroups of woody fuels. The differentiators between these subgroups mainly have to do with availability and cost. Forestry residues—in-forest woody debris and slash from logging and forest management activities. Mill residues—byproducts such as sawdust, hog fuel, and wood chips from lumber mills, plywood manufacturing, and other wood processing facilities. Agricultural residues byproducts of agricultural activities including crop wastes, vineyard and orchard prunings or turnings, and rejected agricultural products. Urban wood and yard wastes—residential organics collected by municipal programs or recycling centers and construction wood wastes. Dedicated biomass crops—trees, corn, oilseed rape, and other crops grown as dedicated feedstocks for a biomass project. Chemical recovery fuels (black liquor)—woody residues recovered out of the chemicals used to separate fiber for the pulp and paper industry.

3.2 FORESTRY RESIDUES

Forestry residues have been the focus of many recent biomass studies and feasibility assessments due to increasing forest management and wildfire prevention activities under the National Fire Plan. The USDA Forest Service and the Bureau of Land Management have been tasked with reducing the hazardous fuel loading within the forests and the urban-wildland interface.

Forestry residues are typically disposed of by on-site (in-forest) stacking and burning. This results in substantial air emissions that affect not only the forest lands and nearby populations, but the overall regional air quality as well. Open burning can also cause water quality and erosion concerns. The Forest Service and other public and private land management entities would like to have viable alternatives for disposing of their forestry residues in a more environmentally benign manner. An ideal situation, from the perspective of forest managers, would be the creation of a market for the forestry residues. The market they envision would generate revenues for the forest managers, which in turn would allow much needed expansion of the forest management programs

3.3MILL RESIDUES

Mill residues are a much more economically attractive fuel than forestry residues, since the in-forest collection and chipping are already included as part of the commercial mill operations. Biomass facilities collocated with and integral to the mill operation have the advantage of eliminating transportation altogether and thus truly achieve a no-cost fuel. Mill residues have long been used to generate steam and electricity.

In Washington State alone, there are approximately 38 facilities that combust about 3 million BDT of mill residues per year to generate steam and electricity. All but two of these mill-residue-fired biomass projects are owned and operated by the mills or wood products companies that supply their fuel. The in-plant facilities primarily generate steam for lumber drying and processing. Any electricity produced is used to offset plant use, although a few facilities do sell excess electrical power to the local utility.

One example of a mill residue biomass-to-energy facility not owned by a mill is Avista Utility's Kettle Falls Station in northeastern Washington. The facility is strategically located within an average distance of 46 miles from 15 different mills, and purchases approximately 350,000 BDT per year of residues to generate 46 MW of electrical power. The facility was conceived in the late 1970s when mills were facing stricter pollution regulations that required them to replace their wigwam burners. Rather than invest in new equipment, the mills were willing to enter into long-term contracts with the private electric utility to supply a biomass facility with mill residues. The facility continues to operate successfully, due in large part to its unique location in one of the most heavily forested areas in the Pacific Northwest

3.4 AGRICULTURAL RESIDUES

Agricultural residues can provide a substantial amount of biomass fuel. Similar to the way mill residues provide a significant portion of the overall biomass consumption in the Pacific Northwest, agricultural residues from sugar cane harvesting and processing provide a significant portion of the total biomass consumption in other parts ofthe world. One significant issue with agricultural residues is the seasonal variation of the supply.

Large residue volumes follow harvests, but residues throughout the rest of the year are minimal. Biomass facilities that depend significantly on agricultural residues must either be able to adjust output to follow the seasonal variation, or have the capacity to stockpile a significant amount of fuel.

3.5 URBAN WOOD AND YARD WASTES

Urban wood and yard wastes are similar in nature to agricultural residues in many regards. A biomass facility will rarely need to purchase urban wood and yard wastes, and most likely can charge a tipping fee to accept the fuel. Many landfills are already sorting waste material by isolating wood waste. This waste could be diverted to a biomass project, and although the volume currently accepted at the landfills would not be enough on its own to fuel a biomass project, it could be an important supplemental fuel and could provide more value to the community in which the landfill resides through a biomass project than it currently does as daily landfill cover.

3.6 DEDICATED BIOMASS CROPS

Dedicated biomass crops are grown specifically to fuel a biomass project. The most prevalent example of dedicated biomass crops are corn varieties grown for ethanol production. Fast-growing poplar trees have also been farm-raised for a biomass fuel, but this has not proven to be economically sustainable. Another dedicated crop example is soybean oils used in the production of biodiesel.

3.7 CHEMICAL RECOVERY FUELS

Chemical recovery fuels are responsible for over 60 percent of the total biomass energy consumption of the United States, and therefore must be mentioned in any analysis of biomass. By and large, the chemical recovery facilities are owned by pulp and paper facilities and are an integral part of the facility operation.

3.8 ANIMAL WASTES

Animal wastes include manures, renderings, and other wastes from livestock finishing operations. Although animal wastes contain energy, the primary motivation for biomass processing of animal wastes is mitigation of a disposal issue rather than generation of energy. This is especially true for animal manures. Animal manures are typically disposed of through land application to farmlands. Tightening regulations on nutrient management, surface and groundwater contamination, and odor control are beginning to force new manure management and disposal practices. Biomass technologies present attractive options for mitigating many of the environmental challenges of manure wastes. The most common biomass technologies for animal manures are combustion, anaerobic digestion, and composting. Moisture content of the manure and the amount of contaminants, such as bedding, determine which technology is most appropriate.

The dairy industry in particular is well suited to biomass-to-energy opportunities because of the large volume of manure that a milking cow produces, and because dairy operations have automated and frequent manure collection processes. Yakima County is the largest producer of dairy products of any county in the State, and the dairy populations within the County include approximately 75,000 to 85,000 active milking cows on about 80 separate dairies.

3.9 DRY ANIMAL MANURE

Dry animal manure is produced by feedlots and livestock corrals, where the manure is collected and removed only once or twice a year. Manure that is scraped or flushed on a more frequent schedule can also be separated, stacked, and allowed to dry. Dry manure is typically defined as having a moisture content less than 30 percent. Dry manure can be composted or can fuel a biomass-to-energy combustion project.

Animal manure does have value to farmers as fertilizer, and a biomass-to-energy project would need to compete for the manure. However, the total volume of manure produced in many livestock operations exceeds the amount of fertilizer required for the farmlands, and Nutrient Management Plans are beginning to limit the over-fertilization of farmlands. Therefore, although there are competitive uses for the manure and low-cost disposal options at this time, manure disposal is going to become more costly over time, and the demand for alternative disposal options, including biomass-to-energy, will only increase.

3.10 WET ANIMAL MANURE (DAIRY MANURE SLURRY)

Wet animal manure is typically associated with larger and more modern dairy operations that house their milking cows in free-stall barns and use a flush system for manure collection. The combination of free-stall barns and manure flushing collects all of the milking cow manure with every milking cycle, two or three times a day. The manure is significantly diluted through the addition of the flush water, but after separation of some of the flush water, the slurry is an excellent fuel.

4. IMPORTANCE OF BIOMASS ENERGY

Biomass energy has rapidly become a vital part of the global renewable energy mix and account for an ever-growing share of electric capacity added worldwide. As per a recent UNEP report, total renewable power capacity worldwide exceeded 1,470 GW in 2012, up 8.5% from 2011. Renewable energy supplies around one-fifth of the final energy consumption worldwide, counting traditional biomass, large hydropower, and “new” renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels).

Traditional biomass, primarily for cooking and heating, represents about 13 percent and is growing slowly or even declining in some regions as biomass is used more efficiently or replaced by more modern energy forms. Some of the recent predictions suggest that biomass energy is likely to make up one third of the total world energy mix by 2050. Infact, biofuel provides around 3% of the world’s fuel for transport.

Biomass energy resources are readily available in rural and urban areas of all countries. Biomass-based industries can provide appreciable employment opportunities and promote biomass re-growth through sustainable land management practices. The negative aspects of traditional biomass utilization in developing countries can be mitigated by promotion of modern waste-to-energy technologies which provide solid, liquid and gaseous fuels as well as electricity. Biomass wastes encompass a wide array of materials derived from agricultural, agro-industrial, and timber residues, as well as municipal and industrial wastes.

The most common technique for producing both heat and electrical energy from biomass wastes is direct combustion. Thermal efficiencies as high as 80 – 90% can be achieved by advanced gasification technology with greatly reduced atmospheric emissions. Combined heat and power (CHP) systems, ranging from small-scale technology to large grid-connected facilities, provide significantly higher efficiencies than systems that only generate electricity. Biochemical processes, like anaerobic digestion and sanitary landfills, can also produce clean energy in the form of biogas and producer gas which can be converted to power and heat using a gas engine.

5. ADVANTAGES OF BIOMASS ENERGY

Bioenergy systems offer significant possibilities for reducing greenhouse gas emissions due to their immense potential to replace fossil fuels in energy production. Biomass reduces emissions and enhances carbon sequestration since short-rotation crops or forests established on abandoned agricultural land accumulate carbon in the soil.

Bioenergy usually provides an irreversible mitigation effect by reducing carbon dioxide at source, but it may emit more carbon per unit of energy than fossil fuels unless biomass fuels are produced unsustainably. Biomass can play a major role in reducing the reliance on fossil fuels by making use of thermo-chemical conversion technologies. In addition, the increased utilization of biomass-based fuels will be instrumental in safeguarding the environment, generation of new job opportunities, sustainable development and health improvements in rural areas.

The development of efficient biomass handling technology, improvement of agro-forestry systems and establishment of small and large-scale biomass-based power plants can play a major role in rural development. Biomass energy could also aid in modernizing the agricultural economy.

When compared with wind and solar energy, biomass plants are able to provide crucial, reliable baseload generation. Biomass plants provide fuel diversity, which protects communities from volatile fossil fuels. Since biomass energy uses domestically-produced fuels, biomass power greatly reduces our dependence on foreign energy sources and increases national energy security.

A large amount of energy is expended in the cultivation and processing of crops like sugarcane, coconut, and rice which can met by utilizing energy-rich residues for electricity production. The integration of biomass-fueled gasifiers in coal-fired power stations would be advantageous in terms of improved flexibility in response to fluctuations in biomass availability and lower investment costs. The growth of the bioenergy industry can also be achieved by laying more stress on green power marketing

6. BIOMASS HARVESTING

Biomass harvesting and collection is an important step involving gathering and removal of the biomass from field which is dependent on the state of biomass, i.e. grass, woody, or crop residue. The moisture content and the end use of biomass also affect the way biomass is collected. For crop residues, the operations should be organized in sync with the grain harvest as it occupies the centrestage in farming process.

All of other operations such as residue management and collection take place after so-called grain is in the bin. On the other hand, the harvest and collection dedicated crops (grass and woody) can be staged for recovery of the biomass only. In agricultural processing, straw is the stems and leaves of small cereals while chaff is husks and glumes of seed removed during threshing.

Modern combine-harvesters generally deliver straw and chaff together; other threshing equipment separates them. Stover is the field residues of large cereals, such as maize and sorghum. Stubble is the stumps of the reaped crop, left in the field after harvest. Agro-industrial wastes are by-products of the primary processing of crops, including bran, milling offal, press-cakes and molasses. Bran from on-farm husking of cereals and pulses are fed to livestock or foraged directly by backyard fowls.

The proportion of straw, or stover, to grain varies from crop to crop and according to yield level (very low grain yields have a higher proportion of straw) but is usually slightly over half the harvestable biomass. The height of cutting will also affect how much stubble is left in the field: many combine-harvested crops are cut high; crops on small-scale farms where straw is scarce may be cut at ground level by sickle or uprooted by hand.

Collection involves operations pertaining to gathering, packaging, and transporting biomass to a nearby site for temporary storage. The amount of a biomass resource that can be collected at a given time depends on a variety of factors. In case of agricultural residues, these considerations include the type and sequence of collection operations, the efficiency of collection equipment, tillage and crop management practices, and environmental restrictions, such as the need to control erosion, maintain soil productivity, and maintain soil carbon levels.

7. PROBLEM AND CHALLENGES IN HARVESTING OF BIOMASS

Unlike solar and wind, biomass is relatively a much reliable source of renewable energy free of fluctuation and does not need storage as is the case with solar. But it is not the preferred renewable energy source till now, mainly due to the challenges involved in ensuring reliable biomass supply chain. This is because of the wide range in its physical properties and fluctuation in availability round the year depending on cropping patterns. Biomass from agriculture is available only for a short period after its harvesting, which can stretch only for 2-3 months in a year. So there is a need to have robust institutional and market mechanism for efficient procurement of the required quantity of biomass, within this stipulated short time, and safe storage till it is finally used.

Some of the major barriers faced in faster realization of available biomass power potential for a variety of end use applications are (i) inadequate information on biomass availability, (ii) absence of organized formal biomass markets, (iii) problems associated with management of biomass collection, transportation, processing and storage; problems associated with setting up large size biomass plants, (iv) non-availability of cost effective sub megawatt systems for conversion of biomass to energy in a decentralized manner, and (v) lack of capability to generate bankable projects on account of financial and liquidity problems, etc.

The major challenge in ensuring sustained biomass supply at reasonable prices are: Increasing competing usage of biomass resources, leading to higher opportunity costs; unorganized nature of biomass market, which is characterized by lack of mechanization in agriculture sector, defragmented land holdings, and vast number of small or marginal farmers. Another major challenge is the cost of biomass storage and transportation to power plants, which is consistently rising rapidly with time.

8. BIOMASS SECTOR IN INDIA – PROBLEMS AND CHALLENGES

Biomass power plants in India are based mostly on agricultural wastes. Gasifier-based power plants are providing a great solution for off-grid decentralized power and are lighting homes in several Indian states. While for providing grid-based power 8-15 MW thermal biomass power plants are suitable for Indian conditions, they stand nowhere when compared to power plants being set up in Europe which are at least 20 times larger.

Energy from biomass is reliable as it is free of fluctuation unlike wind power and does not need storage to be used in times of non-availability as is the case with solar. Still it is not the preferred renewable energy source till now, the primary reason that may be cited is the biomass supply chain. Biomass availability is not certain for whole year. Biomass from agriculture is available only after harvesting period which can stretch only for 2-3 months in a year. So there is a need to procure and then store required quantity of biomass within this stipulated time.

Some of the Indian states leading the pack in establishing biomass-based power supply are Karnataka, Andhra Pradesh, and Maharashtra. Ironically, states having agricultural-based economy have not properly been able to utilize the opportunity and figure low on biomass energy utilization. Only Uttar Pradesh has utilized large part of the biomass potential in north Indian States and that is mainly due to the sugarcane industry and the co-generation power plants. Interestingly Punjab and Haryana don't have much installed capacity in comparison to potential even though tariff rates are more than Rs. 5 per unit, which are better than most of the states. This can be attributed to the fact that these tariffs were implemented very recently and it will take time to reflect the capacity utilization.

Table1: Biomass Potential and Installed Capacity in Key Indian States

State	Power Potential (MWe)	Installed Capacity (by 2011)	Tariff
Punjab	2413.2	74.5	@ Rs 5.25 per unit, (2010-11)
Uttar Pradesh	1594.3	592.5	@ Rs 4.70
Haryana	1120.8	35.8	@Rs 5.24 per unit
Rajasthan	1093.5	73.3	@ Rs 4.72/unit water cooled (2010-11)
Maharashtra	1014.2	403	@ Rs 4.98 (2010-11)
Madhya Pradesh	841.7	1.0	@ Rs 3.33 to 5.14/unit paise for 20 years with escalation of 3-8 paise
Karnataka	631.9	365.18	@ Rs 3.66 per unit (PPA signing date) Rs 4.13 (10th year)
Andhra Pradesh	625	363.25	@ Rs 4.28 per unit (2010-11)
Gujarat	457.7	0.5	@ Rs 4.40 per unit (with accelerated depreciation)
Chhattisgarh	248.5	231.9	@Rs 3.93 per unit (2010-11)
Kerala	195.9	–	@ Rs 2.80 per unit escalated at 5% for five years (2000-01

Source: Biomass Atlas by IISc, Bangalore and MNRE website

The electricity generation could be cheaper than coal if biomass could be sourced economically but ssome established biomass power plants tend to misuse the limit of coal use provided to them (generally 10-15% of biomass use) to keep it operational in lean period of biomass supply. They are not able to run power plants solely on biomass economically which can be attributed to :

- Biomass price increases very fast after commissioning of power project and therefore government tariff policy needs an annual revision
- Lack of mechanization in Indian Agriculture Sector
- Defragmented land holdings
- Most of the farmers are small or marginal

Government policy is the biggest factor behind lack of investment in biopower sector in states with high biomass potential. Defragmented nature of agricultural lands do not allow high mechanization which results in reduction of efficiency and increase in procurement cost.

Transportation cost constitutes a significant portion of the costs associated with the establishment and running of biomass power plants. There is need of processing in form of shredding the biomass onsite before transportation to increase its density when procurement is done from more than a particular distance. While transportation in any kind or form from more than 50 Km becomes unviable for a power plant of size 10-15MW. European power plants are importing their biomass in form of pellets from other countries to meet the requirement of the huge biopower plants.

Not all the biomass which is regarded as agri-waste is usually a waste; part of it is used as fuel for cooking while some part is necessary to go back to soil to retain the soil nutrients. According to conservative estimates, only two-third of agricultural residues could be procured for power production.

And as human mentality goes waste is nothing but a heap of ash for the farmer till someone finds a way to make profit out of it, and from there on the demand of waste increases and so its price. Though there is nothing wrong in transferring benefits to the farmers and providing them a competitive cost of the agri-waste but operations becomes increasingly unviable with time. A robust business model is necessary to motivate local entrepreneurs to take up the responsibility of supplying biomass to processing facilities. Collection centres covering 2-3 villages can be set up to facilitate decentralization of biomass supply mechanism. Biomass power plant operators may explore the possibility of using energy crops as a substitute for crop wastes, in case of crop failure. Bamboo and napier grass can be grown on marginal and degraded lands

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