Theme 3. ECONOMY: 3.1 Industrial uses of Bamboo

Bamboo as Energy Plantation for Renewable Energy Market

Dr.N.Barathi, Director, Growmore Biotech Ltd., TN, India; e-mail-barathigrowmore@yahoo.com

Abstract

Bamboo is an important source of energy in tropical and sub-tropical countries. Properly managed bamboo plantation can provide biomass on a sustainable basis, at an economical price with plenty of environmental advantages while generating local employment. High density plantation of selective species of bamboo under precision farming involving irrigation and fertigation resulted in high biomass production and lead to the development of "energy plantation" based on bamboo. Bamboo is found to be suitable for short rotation harvest on a sustainable basis if bamboo could be cultivated adopting proper agronomical practices. Improved clones of *Bambusa balcooa* yielded 20 to 40 tons of biomass per acre/year. Industries have started planting bamboo to be used as biomass feed stock in their projects, opening up opportunities for bamboo in the renewable energy sector. At present bamboo biomass is found to be acceptable as raw material for generating electricity, bio-ethanol and bio-CNG. With the development of appropriate cultivation practices for Bamboo, the yield of bamboo has increased to 20 to 40 tons of biomass per acre and lead to the production of 40 MW hours power generation in a year. Bamboo based Energy Plantations have come up in South Africa, Srilanka, Philippines, Ghana and India.

Introduction

Energy demand in the country is expected to grow in line with growth of the industry, but may not be the energy production, leaving a gap which provides opportunity for energy project. In developing countries, with the limited supply being erratic, captive power production shall be the answer for the industries that requires uninterrupted power supply. Use of conventional energy like oil, coal and electricity has increased the carbon di-oxide emission and introduced the problem of Global Warming. Among the several options available for renewable captive power production, "Biomass based power plants" are the most environmentally friendly.

Scope of Bio-power crop: Technically speaking, Energy plantation means growing selected species of trees and shrubs which are harvested in a short cycle and are specifically meant for fuel. The fuel wood may be used either directly in wood burning stoves and boilers or processed into ethanol and producer gas. The energy plantations provide almost inexhaustible renewable sources (with total time constant of 1-5 years only for each cycle) of energy which are essentially local and independent of unreliable and finite sources of fuel.

Figure 1

Biomass is an important source of energy in tropical countries. Properly managed biomass energy plantations can be sustainable, environmentally advantageous, economically sound and generates substantial local employment. Biomass resources are potentially the world's largest renewable sources.

Current trend indicates that biomass will continue to be an important source of energy and Government policies have been modified to support the production of biomass and utilization of biomass for energy.

Bamboo based Energy Plantations – Scope & Potentials of Bamboo as a Bio-power crop:

India has one of the richest Bamboo resources in the World, second only to China in terms of bamboo production. There are 1500 bamboo species in the world and more than 20 Million Hectare of bamboo forests and plantations. Biomass energy includes fuel, wood, charcoal and agriculture residues which are renewable in nature and do not contribute to the problem of Global warming.

Bamboo has been recognized as the fastest growing plant species in the world with very favourable characteristics for gasification and power generation. Its heating value of 4,000 k.cal./kg of average GCV is higher than most agricultural residues, grasses and straw, hence this should be considered as the best amongst other known biomass resources.

The energy potential of "Fast growing grass – Bamboo" remains untapped due to lack of awareness of its potential. Bamboo is highly cultivable and responds very well to agriculture management practices, whereas today, the bamboo is available mostly in the wild or grown with no care.
In India, for example, the national average yield of Bamboo is less than 1ton/acre/year, while cultivated Bamboo in farmland is between 4-7 tons/acre/year. At the same time, many farmers and commercial establishments have cultivated high yielding bamboo under irrigated and fertilized conditions; adopting precision farming methods have resulted in 20 tons to 50 tons of biomass per acre / year. When Bamboo is grown as Energy Plantation, it is harvestable continuously every year, which provides biomass under closed interval as compared to many other tree species.

Due to very low yield of Bamboo in the wild, so far Bamboo is never considered as energy crop though it is the fastest growing plant on earth. Introduction of high yielding clone and best agronomical practices developed specifically for Energy Plantation by GROWMORE BIOTECH LTD in India, has led Bamboo cultivation to the status of Energy Plantation.

Improved Clones of Bamboo for Energy Plantation: Tropical and sub-tropical countries enjoy favourable conditions for growing bamboo faster; however lack of information and implementation of technology in bamboo biomass production by energy plantation has restricted its growth. At present, managed bamboo plantations are not available due to absence of information and technology adoption in the field level. The commonly available bamboo is thin wall, low yielding, some are thorny - making it difficult to cultivate and harvest.

There are many species of bamboo, varying in their diameter, height and weight, but few are the selected species like, *Bambusa balcooa*, has thick wall, fast growth and high yield, which can be considered as biomass for energy generation. It is imperative that such species is selected as per the local climatic condition of the region and identify superior and elite clones for establishing energy plantation. Among many such clones available, BEEMA bamboo is one of the selections out of *Bambusa balcooa* which yields 20 to 40 tons per acre / year, making it possible to consider Bamboo biomass as a fuel for energy production. This clone has been field tested for over 10 years, getting propagated by Plant Tissue Culture method that ensures genetic uniformity, higher vigour, free from pests and diseases and with better physiological status for the plant.

In general bamboo is used for handicraft, furniture and value added products. However, bamboo has been used in large quantity for paper pulp, which is even now continued in few parts of the world. Similar to this bamboo can be considered as biomass feed stock for power generation bio-ethanol, bio-CNG, Charcoal, Briquettes and Pellets. Bamboo has a capacity to grow faster than any other tree species or plant species on earth. At the same time bamboo keep regenerating without necessity to replant it that makes bamboo as a sustainable biomass feed stock. Since bamboo has never been considered as biomass feed stock, there is an apprehension among many of us that bamboo has not been considered as feed stock.

Among the many reasons why bamboo is not popular as biomass feed stock, the low productivity of bamboo, higher cost of production of bamboo resulted in unviable proposition for bamboo to be considered as biomass feed stock.

Bamboo as Biomass Feed stock: Efforts have been made in India to increase the biomass yield of bamboo and lower the cost of production which resulted in establishment of bamboo plantation as "Energy plantation".

Cultivation of Bamboo as Energy Crop: Unlike most of the applications of bamboo which needs whole bamboo, bamboo for energy application requires chipped, crushed or powdered bamboo. Hence, the stringent physical quality standard followed for most of the applications of bamboo is not required for the application of bamboo as biomass. Application of bamboo for energy would rely on the calorific value, ash content, bulk density, cellulose and hemi-cellulose content. This provides opportunity for bamboo to be cultivated as a short cycle crop for harvest. Planting bamboo closely under high density provides opportunity to harvest in 3 years time as physically immature bamboo which means all the quality standard required for a biomass feed stock. Hence, the cultivation practice for bamboo as energy crop is different from the conventional growing of bamboo and developed high density plantation with drip irrigation and fertigation in India. This has been demonstrated in many parts of India, Srilanka, South Africa, Philippines and Ghana as Energy Plantation on commercial scale. It has been found that the bamboo is ready for first harvest in 2 ½ years when bamboo is planted in rows which are 10 feet apart and the spacing of 10 ft. x 4 ft., provided with adequate water and fertiliser through drip irrigation and fertigation.

Establishment of Bamboo based Energy Plantation: Bamboo based Energy Plantations have started coming up in the past 3 years in various parts of the world for power generation and charcoal production.

M/s.Greengrid Energy Pty Ltd in South Africa has planted over 1,000 acres near Durban in South Africa to produce 3.MW electricity by bamboo gasification.

In Philippines Marinduque State College has started planting bamboo as Energy Plantation since 2014 and extended it to other parts of Philippines for the last 3 years.

In Srilanka Aakash group has put up a 10MW bamboo biomass based power project in northern part of Srilanka and started planting Bamboo in 2,000 acres to generate complete biomass feed stock required for 10MW power plant.

M/s.Vayunanda Power plant in Maharashtra in India has started planting since 2012 and so far completed 60 acres of plantations. They have harvested fin 3 years and annual harvest is practiced for the last 3 years. In the first harvest during 3rd year it has recorded 28 tons per acre, in the 2nd harvest during4th year harvested 40 tons per acre and last year harvested 60 tons per acre. All the harvested biomass consumed by them for their own power production and seeing the success planning to expand bamboo cultivation to several hundred acres.

Over hundred acres of bamboo based energy plantation has got planted in Ghana in the past 3 years.

Bamboo for Electricity: The power is generated out of bamboo by two major parts:


Figure 2

1. Complete Combustion:

The Combustion process involves complete burning of bamboo biomass to generate steam under pressure; it is converted into mechanical energy by steam turbine and ultimately into power by alternator connected to steam turbine. In general, one ton of

dry bamboo biomass generates 1 MW of electricity and ash as a by product.

2. Partial combustion/Pyrolysis:

In this method Bamboo biomass is made to generate Combustible gas known as "Producer gas / Syn gas" by a thermal chemical conversion carried out through the process of oxidation and reduction with limited air supply. The residue of pyrolysis process is activated bamboo charcoal. Usually one to 1.2 tons of bamboo biomass is required to produce 1 MW of deliverable power along with 70 to 100 kg. of charcoal as bye product. The biomass feed stock required by 1 M Power Project is approximately 8,000 tons of biomass per acre to generate power for 24 hours a day and for 330 days. The above 8,000 tons of biomass can effectively be produced from 200 acres of bamboo based energy plantation, provided best bamboo clones are planted and followed the farming practice appropriately by providing the required quantity of water, fertiliser and adhering to inter cultural operation. The same quantity of biomass can possibly made available through other trees that needs cultivation in over 1,000 acres as against 200 acres of cultivated bamboo.

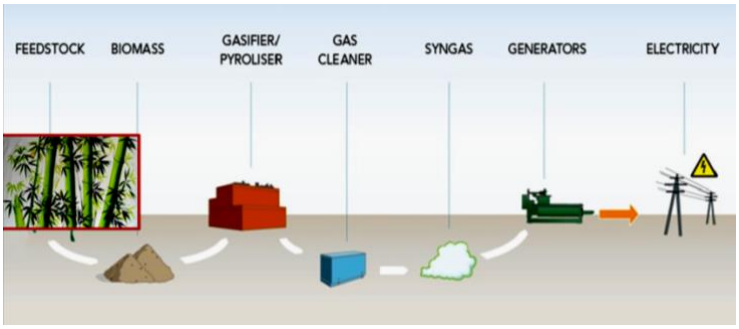

Figure 3

Bamboo for Ethanol: Ethanol is renewable and used as fuel by blending along with petrol to an extent of 5 to 80%. Conventionally, Ethanol is produced from Sugars of sugarcane, sugarbeat or from starches of maize, cereals. Bamboo is lingo cellulosic product that has 60 to 70% digestible cellulose making it one of the best resources for bio-ethanol production. In the recent year cellulosic material of plants and trees are also being enzymatic ally digested for commercially producing ethanol. Several years of research has lead to the successful development of bamboo cellulose into ethanol in Japan, China, Taiwan, UK, and now in India.

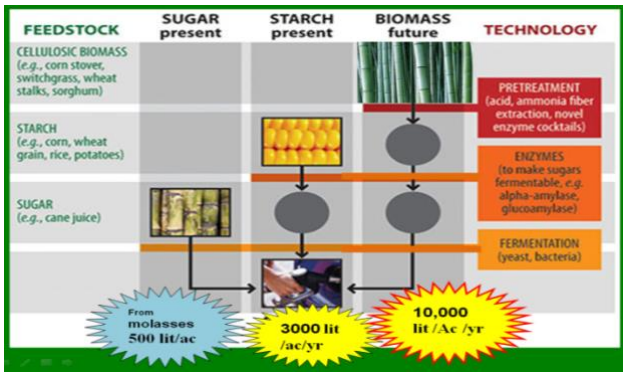

Figure 4

Numaligarh Refineries in Assam, India is putting up a Ethanol plant based on bamboo as a raw material and the technology is provided by Finland based company. Cultivated bamboo has the potential to generate 30 to 40 tons of biomass annually which can be effectively digested to convert into 8000 to 10,000 ltrs. of Ethanol annually. This is the highest among commonly available plant species since sugarcane is able to generate 2,500 litres of ethanol and maize is able to generate 3,000 litres of Ethanol per acre / year. Bamboo being non-food feed stock, capable of regenerating on a sustainable basis with no impact on the environment. Bamboo will be the future energy plantation crop for bio-ethanol.

Bamboo for Bio-CNG: CNG is less polluting the environment than other popular fuel such as Petroleum and Diesel. Bamboo is convertible into biogas that can be processed into bio-CNG. Bio-CNG is a renewable fuel that is identical in composition and better impurity than fossil CNG. In India, Agro-Gas, Pune has tested bamboo and established a commercial model of Bio-CNG in Pune. All parts of Bamboo are collected, processed into small pieces and fermented with right combination of micro organism and bio-digested for 24 to 36 hours. With the present method of processing 8 kg. of Bamboo generates 1 kg. of CNG and 4 kg. of undigested biomass having lignin as major component. The bio-gas generated is scrubbed and cleaned from carbon dioxide, carbon monoxide and sulphur components and compressed into bio-CNG.

Figure 5

Cultivated bamboo of 300 acres can sustainably provide raw material on a continuous basis for a gas bunk to generate 500 kg. of gas every day. Energy Plantation of bamboo be established to operate CNG Gas Bunks locally instead of distributing the gas through pipes and other means for long distance.

Discussion

When the search is on for effective and sustainable supplies of renewable energy, it is surprising that Bamboo noted for its fast growth and high production, have not been considered as a potential source of renewable energy. This is mainly because of the wild nature of bamboo, low yield, not being cultivated and demonstrated as energy plantation. Identification of superior fast growing clones and intervention of plant propagation by tissue culture lead to the availability of superior planting material.

Yields are the key to the success of energy farming and they are inseparably related to management. The potential of bamboo to out perform other plant species as energy plantation has not been proven due to lack of appropriate agronomy. The development of precision farming in bamboo cultivation involving high density plantation, application of timely manure, and provision of required quantity of water through drip irrigation and attending to intercultural operation such as weeding, earthing up and pruning has resulted in higher yield as compared to other energy plantation crops. The main reasons for using bamboo for energy farming are due to its superior growth rates, the shortness of the harvesting rotation and the higher biomass yields and regeneration on a sustainable basis.

World over biomass has been considered as one of the renewable energy source. Biomass from bamboo is easily able to replace biomass from other tree species because of its equal energy value along with low ash content and annual harvest ability. Bamboo biomass is highly suitable for gasification to generate electricity. Unlike other wood, charcoal from bamboo has higher surface area and hence very much suitable for environmental cleaning requirement as activated charcoal.

Many innovative research in different parts of the world lead to the conversion of bamboo into bio-ethanol and very recently, Bamboo into bio-CNG in India. Years of research work and standardisation with ligno cellulosic biomass of bamboo into ethanol and CNG, which is in high demand in many of the developing countries.

Conclusion:

Bamboo is one of the major non-food biomass resources that can be produced on demand by adopting best cultivation practice. The fast growth of bamboo can commercially be exploited by

planting best clone of the right species of bamboo as per the local condition and adopting proper agronomy, providing irrigation and feeding with required quantity of fertiliser as energy crop. The essential key factor of the success of Bamboo as energy crop scientific cultivation of bamboo, adopting precision farming know-how combined with planting of high quality, disease free, high yielding clones of bamboo.

References

An Ha Truong, Thi My Anh Le, 2015, Overview of bamboo biomass for energy production. HAL- publications 19-22.

Assam Refinery to process Biofuel from Arunachal Bamboo 2017, Energy World, The Economic Times 03.06.2017

Atul Akolkar (2016) India's First Bio-CNG Plant, Fueling the future with Renewable Energy - Akshay Urja P.31 to 33

Barathi, N, Bioenergy India, 2011, Low cost Biomass from Captive Energy Plantation, Issue 8

Dasappa .S and Bharti.N, 2016, Well To Wheel - A Case Study of Usage of Beema Bamboo as a Sustainable Energy Source, 24th European Biomass Conference and Exhibition, Amsterdam, The Netherlands

INBAR Global News, Vol.15 No.1, July 2009 - Bamboo can Play a deep role in Saving the Earth

Jade Littlewood et.al, 2013 Techno Economic Potential of Bio-Ethanol from Bamboo in China, Biotechnology for Biofuels 2013 6:173

Kleinhenz V Midmore DJ:Aspects of Bamboo agronomy. Adv Agron.2001, 74:99-145.

M.A.Siraj - 2014 Bamboo Power, The Hindu 11.04.2014

Poppens, R., Van Dam, J., Elbersen,W., 2013, Bamboo: Analyzing the potential of bamboo feedstock for the bio based economy, NL Agency.

The Beema Bamboo to Energy Project (2014) South African Bio-Energy Workshop - Technology platform

Ya-Nang Wang et.al, 2011 Evaluation of Bamboo as a Feed Stock for Bio-ethanols in Taiwan, World Renewable Energy Congress 2011 - Sweden 8-13 May 2011 Linkoping, Sweden

Figure 1: 3 years old Bamboo Energy Plantation
Figure 2: Bamboo combustion and releasing of Heat Energy in the steam boiler
Figure 3: Schematic diagram for Bamboo gasification to generate Electricity
Figure 4: Comparison of Ethanol production from sugarcane, maize and Bamboo
Figure 5: Bio-CNG plant utilising bamboo as feed stock