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AN EXPERIMENTAL OVERVIEW OF POWER GENERATION POTENTIAL OF PLANT (GULMOHAR, YELLOW KANER AND RATANJOT LEAF)

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Abstract

The present project work is a positive step towards energy and environmental problems facing the world. The presently selected forestry biomass species has no any commercial use and are underutilized. Presently, co-firing (coal + biomass) has been proved to be more attractive and economically viable technique for power generation. In the present work, briquettes were prepared by mixing non-coking coal from Gevra mines and the related biomass species in different ratio (coal: biomass = 95:05, 90:10, 85:15, 80:20). The objectives have been to examine their energy values and power generation potential.

Keywords: proximate analysis, ash fusion temperature, electricity generation, energy content, non-woody biomass species.

Introduction

Biomass resources are potentially the world's largest and most sustainable energy sources for power generation in the 21st century (*Hall & Rao, 1999*). The current availability of biomass in India is estimated at about 500 million metric tonnes per year. Studies sponsored by the Ministry has estimated surplus biomass availability at about 120 – 150 million metric tonnes per annum covering agricultural and forestry residues corresponding to a potential of about 17,000 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 (Ministry of New and Renewable Energy). The details of the estimated renewable energy potential and cumulative power generation in the country have been outlined in Table 1 (*MNRE, 2011*), indicating that the available biomass has a potential to generate around 17,000 MW of electricity.

The Ministry has been implementing biomass power/co-generation programme since mid-nineties. A total of 288 biomass power and cogeneration projects aggregating to 2665 MW capacity have been installed in the country for feeding power to the grid consisting of 130 biomass power projects aggregating to 999.0 MW and 158 bagasse cogeneration projects in sugar mills with surplus capacity aggregating to 1666.0 MW. In addition, around 30 biomass power projects aggregating to about 350 MW are under various stages of implementation. Around 70 Cogeneration projects are under implementation with surplus capacity aggregating to 800 MW.

Literature Review

The key technical issues in woody biomass pre-treatment (***Zhu and Pan, 2010***): barriers to efficient cellulose scarification, pre-treatment energy consumption, in particular energy consumed for wood-size reduction and criteria to evaluate the performance of a pre-treatment. A post-chemical pre-treatment size-reduction approach is proposed to significantly reduce mechanical energy consumption. Because the ultimate goal of biofuel production is net energy output, a concept of pre-treatment energy efficiency (kg/MJ) based on the total sugar recovery (kg/kg wood) divided by the energy consumption in pre-treatment (MJ/kg wood) is defined. It is then used to evaluate the performances of three of the most promising pre-treatment technologies: steam explosion, organosolv and sulphite pre-treatment to overcome lignocelluloses recalcitrance (SPORL) for softwood pre-treatment. The present study found that SPORL is the most efficient process and produced highest sugar yield. Other important issues, such as the effects of lignin on substrate scarification and the effects of pre-treatment on high-value lignin utilization in woody biomass pre-treatment, are also discussed.

In India, fuel wood, crop residues and animal manure are the dominant biomass fuels **(*Ravindranath et al, 2005*),** which are mostly used in the rural areas, at very low efficiencies. Industrial and municipal (urban) residues such as wastewater, municipal solid wastes (MSW) and crop residues such as rice husk and bagasse can also be used for energy generation. In this paper, the potential of energy from crop residues, animal manure, MSW, industrial wastewater and biomass fuels that can be conserved for other applications through efficiency improvement is discussed. The total potential of energy from these sources in 1997 is estimated to be equivalent to 5.14 EJ, which amounts to a little more than a-third of the total fossil fuel use in India. The energy potential in 2010 is estimated to be about 8.26 EJ.

The potential for the use of renewable sources of energy in China and India and their cost effectiveness in air pollution abatement in Asia is studied **(*Boudri et al, 2002*)** This is done through an integrated assessment of the costs and the environmental impacts of several types of renewables, in comparison with fossil fuels. Results for different scenarios for fuel use in China and India for the period 1990–2020 are presented. The acidification model RAINS-ASIA is used to analyse environmental impacts (exceedance of critical loads for acidification) and to perform an optimization analysis, aiming at minimizing abatement costs. The costs of sulphur dioxide (SO_2) emission-control through the switch to renewable energy sources are analysed and compared with the costs of controlling the emissions from fossil fuels (e.g. through flue gas desulfurization). For the environmental targets analysed in this study an increased use of renewable energy could cut SO_2 emission control costs in China by 17–35% and in India by more than two thirds. In view of high energy potentials in non-woody biomass species and an increasing interest in their utilization for power generation **(*Kumar and Patel, 2008*),** an attempt has been made in this study to assess the proximate analysis and energy content of different components of *Ocimumcanum* and *Tridaxprocumbens* biomass species (both non-woody) and their impact on power generation and land requirement for energy plantations. The net energy content in *Ocimumcanum* was found to be slightly higher than that in *Tridaxrocumbens*. In spite of having higher ash contents, the barks from both the plant species exhibited higher calorific values. The results have shown that approximately 650 and 1,270 hectares of land are required to generate 20,000 kWh/day electricity from *Ocimumcanum* and *Tridaxprocumbens* biomass species. Coal samples, obtained from six different local mines, were also examined for their qualities and the results were compared with those of studied biomass materials. This comparison reveals much higher power output with negligible emission of suspended particulate matters (SPM) from biomass materials.

Renewable energy sources and technologies have potential to provide solutions to the long-standing energy problems being faced by the developing countries **(*Kumar et al, 2010*).** The renewable energy sources like wind energy, solar energy, geothermal energy, ocean energy, biomass energy and fuel cell technology can be used to overcome energy shortage in India. To meet the energy requirement for such a fast growing economy, India will require an assured supply of 3–4 times more energy than the total energy consumed today. The renewable energy is one of the options to meet this requirement. Today, renewable account for about 33% of India's primary energy consumptions. India is increasingly adopting responsible renewable energy techniques and taking positive steps towards carbon emissions, cleaning the air and ensuring a more sustainable future. In India, from the last two and half decades there has been a vigorous pursuit of activities relating to research, development, demonstration, production and application of a variety of renewable energy technologies for use in different sectors. In this paper, efforts have been made to summarize the availability, current status, major achievements and future potentials of renewable energy options in India. This paper also assesses specific policy interventions for overcoming the barriers and enhancing deployment of renewable for the future.

Result and Discussion

Total Energy Contents and Power Generation Structure from 11 Months old

(approx.), **Gulmohar Plants**

Component	Calorific Value (kcal/t, dry basis)	*Biomass Production	Energy Value (kcal/ha)
Main wood	4132×10^3	21.40	88425×10^3
Leaf	3850×10^3	6.7	25795×10^3
Nascent branch	3810×10^3	10.20	38862×10^3

* Data from IGKV, Raipur

Energy Calculation:

On even dried basis, total energy from one hectare of land = $(88425+25795+38862) \times 10^3$

$= 153082 \times 10^3$ kcal/ha

It is assumed that conversion efficiency of wood fuelled thermal generators = 30 % and mechanical efficiency of the power plant = 85 %.

Energy value of the total functional biomass obtained from one hectare of land at

30 % Conversion efficiency of thermal power plant = $153082 \times 10^3 \times 0.30$

$= 45924.6 \times 10^3$ kcal/ha

$= 45924.6 \times 10^3 \times 4.186$ kJ/ha

$= 192240.4 \times 10^3$ kJ/ha

$= (192240.4 \times 10^3)/3600$ kW-hr/ha

$= 53400.10$ kW-hr/ha

Power generation at 85 % mechanical efficiencyn = $53400.10 \times 0.85 = 45390.08$ kW-hr/ha

Land required to supply electricity for entire year $= 73 \times 10^5 / 45390.08 = 160.82$ hectares

Table 4.9: Total Energy Contents and Power Generation Structure from 11 Months old (approx.), **Ratanjot Plants**

Component	**Calorific Value (kcal/t, dry basis)**	***Biomass Production (t/ha, dry basis)**	**Energy Value (kcal/ha)**
Main wood	4704×10^3	23.00	108190×10^3
Leaf	4287×10^3	7.20	30866.4×10^3
Nascent branch	4348×10^3	11.30	49132.4×10^3

* Data from IGKV, Raipur

Energy Calculation:

On even dried basis, total energy from one hectare of land = $(108190+30866.4+49132.4) \times10^3 = 188190.8\times10^3$ kcal/ha

It is assumed that conversion efficiency of wood fuelled thermal generators = 30 % and mechanical efficiency of the power plant = 85 %.

Energy value of the total functional biomass obtained from one hectare of land at 30 % conversion efficiency of thermal power plant = $188190.8\times10^3 \times 0.30$

= 56457.24×10^3 kcal/ha

$=56457.24\times10^3\times4.186$ kJ/ha

$=236330.01\times10^3$ kJ/ha

$= (236330.01\times10^3) / 3600$ kW-hr/ha

= 65647.22 kW-hr/ha

Power generation at 85 % mechanical efficiency = 65647.22×0.85 = 55800.14 kW-hr/ha

Land required supplying electricity for entire year $=73\times10^5 / 55800.14$ = 130.82 hectares

Table 4.10: Total Energy Contents and Power Generation Structure from 11 Months old (approx.), **Yellow Kaner Plants**

Component	Calorific Value (kcal/t, dry basis)	*Biomass Production (t/ha, dry basis)	Energy Value (kcal/ha)
Main wood	4343×10^3	18.60	80779.8×10^3
Leaf	4114×10^3	6.30	25918.2×10^3
Nascent branch	3696×10^3	9.20	34003.2×10^3

* Data from IGKV, Raipur

Energy Calculation:

On even dried basis, total energy from one hectare of land = $(80779.8+25918.2+34003.2) \times 10^3 = 140701.2\times 10^3$ kcal/ha

It is assumed that conversion efficiency of wood fuelled thermal generators = 30 % and mechanical efficiency of the power plant = 85 %.

Energy value of the total functional biomass obtained from one hectare of land at 30 % conversion efficiency of thermal power plant = $140701.2\times 10^3 \times 0.30$

$= 42210.36\times 10^3$ kcal/ha

$= 42210.36\times 10^3 \times 4.186$ kJ/ha

$=176692.56\times 10^3$ kJ/ha

$=(176692.56\times 10^3)/3600$ kW-hr/ha

$= 49081.26$ kW-hr/ha

Power generation at 85 % mechanical efficiency = $49081.26\times 0.85 = 41719.1$ kW-hr/ha

Land required to supply electricity for entire year $=73\times 10^5/ 41719.1 = 174.97$ hectares

Conclusion

The following conclusion are observed

1. All three plant species (Gulmohar , Yellow Kaner and Ratanjot) showed almost the similar proximate analysis results for their components, the ash contents being more in their leaves and volatile matter content less in wood and leaf.
2. Amongst the three biomass species Ratanjot has the highest energy value compared to Gulmohar and Yellow Kaner.
3. Energy values of coal mixed Ratanjot biomass component were found to be little bit higher than that of coal mixed Gulmohar and Yellow Kaner biomass component.

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