Biomass Waste Potential Assessment in the Patiala District of Punjab

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ABSTRACT
Being an agribusiness rich state, Punjab has colossal capability of biomass asset accessibility as harvest buildups. Around 63.514 Mt/yr of the aggregate yield deposit is produced from different major and minor harvests, of which around 71% is devoured in different structures, bringing about 29% as an issue surplus accessible for power generation. Fundamental surplus and net surplus yield buildups for power generations potential were assessed in each one region. Jalandhar, Patiala Sangrur, Ferozpur, Amritsar, and Ludhiana are the real surplus biomass potential locale, while Rupnagar, Nawashahar, Hoshiarpur, Fatehgarh Sahib, Faridkot and Kapurthalla are minimum surplus biomass potential locale inside the state. In this paper the regular accessibility, present utilization of essential yield deposits are assessed in each one region of the Patiala district. It has been assessed that around 113.45 MW and 109.58 MW of power in the state can be created through fundamental surplus and net surplus biomass individually in the Patiala district

Keywords
agribusiness, aggregate, surplus, potential, fundamental, harvest, deposits.

1. INTRODUCTION
Energy plays most important role in our life. Without energy we can't imagine our life. Both conventional and non-conventional energy sources are important for power production. According to world energy forum, the conventional energy sources will be depleted in few decades. In India 63% of power is generated from fossil fuel based power plants. As the fossil fuels are fast depleting, these need to be replaced by non-renewable sources viz; wind, solar, agri waste, tidal, geothermal etc. India is an agricultural based country. Agriwaste available in the country is in abundance. Agriwaste is available even after using it as domestic fuel, fodder, thatching. Environmental pollution resulting from the burning of agriculture waste in the atmosphere is one of the causes of increasing global warming. So it is better to make efforts in the direction of utilizing this waste. The present work makes an effort in the same direction. Availability of surplus biomass is calculated to find out the available power potential in the Patiala District of Punjab state. The results show that Punjab can use biomass for power generation. Thus agri waste which is abundantly available can be turned into high value fuels which are eco friendly and energy efficient both.

1.1 Profile of Punjab State
The state of Punjab is also known as the food granary of the country, located between 29° 33′ to 32° 32′N latitude and 73° 53′ to 76° 56′ E longitude and spread over 50,362 km^2, which is about 1.6% of the total geographical area of the country is one of the smallest states in India.The state shares its boundaries with Jammu and Kashmir in the north, Himachal Pradesh in the northeast and Haryana and Rajasthan to its south. Besides, the state also shares 300 km long international border with Pakistan on the western side. Administratively, the state is divided into 4 divisions, 22 districts, 72 tehsils, 81 developmental blocks, 14 cities and 12,413 villages. The total human population of the state is around 24.29 million (2001 census figures), of which 66% reside in rural areas with population density of 484 person per km^2. Literacy rate among males is higher (66%) as compared to females (50%) in the state. Satluj, Beas, Ravi and Ghaggar are four major perennial rivers of the state. The state has sub tropical climate with hot summers and cold winters. The minimum temperature in winter falls to 0° C and maximum in summer touches 47° C. The average annual rainfall varies from 480 mm in the plains to 960 mm in the hilly regions of the state. Agriculture is the backbone of the state's economy, covering an area of about 4.2 million hectare, contributes 84% of total geographical area of the state. Punjab is also known as the land of five rivers and in fact the very name, Punjab is derived from Persian word, *pun* (river) and *jab* (water). Socio-culturally, the state is classified into three regions (Majha, Doaba and Malwa). Punjab is predominantly rich in agriculture and contributes the major share to the grain basket of India. It has surplus production of major crops. It produces 25% of country's cotton, 22% of wheat and 55% of rice, even though it has only 1.5% of total country cultivable area. Punjab has been meeting its electrical power requirements primarily through conventional thermal and hydro power generation. Hydro power generation has a tendency to fluctuate depending on the availability of water. Thermal power generation has to depend on coal which has to be transported from eastern part of India involving large distances. Cost of generation from coal continuous to escalate and moreover it is polluting.

2. LITERATURE SURVEY
Suresh Chauhan (2010) [1] in his paper told that being an agricultural state, Haryana has a huge potential of biomass availability in the form of crop residue and sawdust. In the agricultural sector, a total 24.697Mty^{-1} of residue is generated, of which 71% is consumed in various domestic and commercial activities within the state. While in agro based industrial sector, a total of 646kty^{-1} of saw dust is generated, of which only 6.65% is consumed in the state. Of the total generated biomass in the state, 45.51% is calculated as basic surplus, 37.48% as productive surplus and 34.10% as net surplus. The power generation potential from all these three categories of surplus biomass is 1.499GW, 1.227GW and 1.120GW respectively. Suresh Chauhan (2012) [2], in his paper told that being an agriculture rich state, Punjab has huge potential of biomass resource availability in the form of crop residues. Around 40.142 Mty^{-1} of the total crop residue is generated from various major and minor crops, of which around 71% is consumed in various forms, resulting in 29% as a net surplus available for power generation. Basic surplus

and net surplus crop residues for power generation potential were estimated in each district. Sangrur, Ferozpur, Amritsar, Patiala and Ludhiana are the major surplus biomass potential districts, while Rupnagar, Nawashahar, Hoshiarpur, Fatehgarh Sahib, Faridkot and Kapurthalla are least surplus biomass potential districts within the state. It has been estimated that around 1.510 GW and 1.464 GW of power in the state can be generated through basic surplus and net surplus biomass respectively. Besides, the seasonal availability, present usage pattern and costing of important crop residues are also estimated in each district of the state.Subhrabaran Das, Tushar Jash (2008) [3], described that West Bengal is basically an agricultural-based state in India. Agriculture and forest residues are the two main categories of biomass residues generated in West Bengal. Out of the total biomass residues generated in the state, about 79% comes from agriculture. In this paper, district-wise biomass residues generation and the potential for power generation from surplus biomass, in the state, have been estimated. The study is based on a primary survey carried out in West Bengal. It has been estimated that about 2107 MW of power generation is possible.Pratik N. Sheth, B.V.Babu (2009) [4], described a process of conversion of solid carbonaceous fuel into combustible gas by partial combustion is known as gasification. The resulting gas, known as producer gas, is more versatile in its use than the original solid biomass. In the present study, a downdraft biomass gasifier is used to carry out the gasification experiments with the waste generated while making furniture in the carpentry section of the institute's workshop. Dalbergia sisoo, generally known as sesame wood or rose wood is mainly used in the furniture and wastage of the same is used as a biomass material in the present gasification studies. The effects of air flow rate and moisture content on biomass consumption rate and quality of the producer gas generated are studied by performing experiments. The performance of the biomass gasifier system is evaluated in terms of equivalence ratio, producer gas composition, calorific value of the producer gas, gas production rate, zone temperatures and cold gas efficiency. Material balance is carried out to examine the reliability of the results generated. The experimental results are compared with those reported in the literature.

Weiguo Fu, Yanyou Wu (2011) [5], described that the determination of above ground biomass (AGB) is an important step in planning the protection and sustainable use of mangrove resources. In the present paper, allometric relationships for estimating AGB of different morphology mangrove trees on the basis of canopy diameter (CD) and tree height (H) were studied. By comparing of correlation between AGB and CD^2*H, and of relative error rates between measurement value and simulation value within the three mangrove specie, results show that regression equation, in the form of $AGB=a(CD^2*H)^b$, is very suitable for estimation of AGB of multi-stemmed mangrove trees such as *Aegiceras corniculatum*, and is not suitable for single stemmed mangrove trees such as *Kandelia candel*, but may be applied to those mangrove trees between multi stemmed and single-stemmed in morphology such as *Avicennia marina*.

S.C. Bhattacharya (2009) [6],described that promoting renewable energy in India has assumed great importance in recent years in view of high growth rate of energy consumption, high share of coal in domestic energy demand, heavy dependence on imports for meeting demands for petroleum fuels and volatility of world oil market. A number of renewable energy technologies (RETs) are now well established in the country. The technology that has achieved the most dramatic growth rate and success is wind energy; India ranks fourth in the world in terms of total installed capacity. India hosts the world's largest small gasifier programme and second largest biogas programme. After many years of slow growth, demand for solar water heaters appears to be gaining momentum. Small hydro has been growing in India at a slow but steady pace. Installation of some of the technologies appears to have slowed down in recent years; these include improved cooking stoves (ICSs) and solar photovoltaic (PV) systems. In spite of many successes, the overall growth of renewable energy in India has remained rather slow. A number of factors are likely to boost the future prospects of renewable energy in the country; these include global pressure and voluntary targets for greenhouse gas emission reduction, a possible future oil crisis, intensification of rural electrification program, and import of hydropower from neighbouring countries. Zuberi, M.J.S et al. (2013) [7], described that Pakistan is facing severe economic crises due to continuous increasing gap between energy demand and supply. Demand is increasing exponentially and expected to increase more than 66000 MW by 2030 while the supply is observed to remain constant over the last few years due to frozen capacity in spite of having significant renewable/alternate energy resources. Current electricity shortfall has reached up to 6000 MW. This paper investigates the potential of two major biomass energy resources available in Pakistan: Livestock and Bagasse. These resources, if utilized to their full extent for power generation, can contribute up to 42% in the current scenario. The biomass resource quantification is done along with its environmental impact assessment in terms of methane emissions pre and post production of biogas. Economic appeal of biomass energy is demonstrated by a comparative cost analysis among heavy fuel oil, natural gas and biomass (i.e. dung). The ongoing policies and incentives on biomass energy usage, and bottlenecks in making the biomass a component of energy portfolio of Pakistan are also reviewed. Tripathy, P. et al. (2015) [8], explained that due to facing with the innumerable number of crises centered on depletable energy sources, mankind is trying its best to wriggle itself out of the situation through greater reliance with sources of energy which are not depletable, in particular, the renewable ones like the solar energy and its immediate manifestation, viz.biomass, wind energy and hydro power. Thus bringing in sustainability and the national needs as our prime focus, it can be well addressed that the renewable energies should be given more priority and be supplemented with more emerging technologies. Considering that the energy consumption is increasing with populations and economic developments, there is a high need that the oil dominated world economy should be prioritized to be changed. The requirement for the replacement fuels will distinctly increase based on the fact that the third decade of 21st century is approaching at a fast pace, nevertheless, it cannot be denied that the alternative energies will take around five to fifteen years to get developed. Taking these factors into our consideration, it is at this point when we think of an efficient energy source, as there is an urgent need to control the harmful effects on the environment, so as to have a better environment. Relating this to energy, we find biomass energy to be best applicable at this scenario. The cause for this choice has been gradually brought to the limelight, with the passage of this piece of research work. The potential of biomass in the state of Odisha has also been highlighted.

Glavas, H et al.(2014) [9], provided an overview of the biomass potential as Croatian significant renewable energy source especially in the region of Slavonia and Baranja. Starting from the national energy framework authors points to the decline of primary energy supply in Republic Croatia and decrease in energy efficiency. Quantity and energy potential of biomass from crop residues, fruit and grape production in Slavonia and Baranja has been estimated. In conclusion, authors provide suggestions for specific evaluation of agricultural solid biomass potential in Slavonia and Baranja region. Al-Soud et al. (2015) [10], in this paper they addressed the current status and the future potentials of renewable energy applications in Jordan, the data analysis shows that Solar is by far the renewable source with largest the oreticalpotential, with 1,642 GW, followed by wind, which potential is in the range of 182-319 GW potential of other renewable energies is comparative small like Biomass/Biogas potential is estimated at 30-50 MW. According to the analysis carried out, the maximum renewable energies grid can handle in 2020 is 1650 MW wind and 800 MW solar, within a confidence interval of 95%. Following economic criteria wind capacity is allocated first as is the most economic advantageous, followed by Photovoltaic and concentrated Solar Panel. Biomass will enter as plants are constructed. The Jordanian Government strategy targets the implementation of 1,800 MW of Renewable generation capacities by 2020. These will be split in 1,200 MW wind power plants, and 600 MW solar plants. The indicative prices of different renewable energy sources are presented. The Economic profitability indicators: Economic Net present Value (ENPV) and Economic Internal Rate of Return was presented in this paper. Shuma, R.M et al. (2015) [11], described that solid biomass continues to be the primary energy source for a significant proportion of Sub-Saharan African society. It is estimated that 80% of energy for heating and cooking in this subcontinent is derived from round wood biomass resulting in estimated annual rate of deforestation of 0.7%. This is unsustainable. This is despite the existence of a substantial resource of loose biomass (forest and agricultural residues) that is produced and disposed of annually. However, one major challenge in harnessing loose biomass as a source of energy is low energy density and poor combustion behaviour. Biomass briquetting technologies can be deployed to improve energy density and combustion behaviour of loose biomass. This requires understanding of the energy content in locally available loosebiomass sources. This paper investigates the calorific values (energy content) and combustion behaviour of loose biomass collected from a region in the Limpopo Province of South Africa. The aim of the investigation is to understand the energy value and hence viability of using such loose biomass with the overall goal of developing recipes for biomass briquetting in the region. Calorific values were measured for 12 samples of loose biomass and their combustion behaviour analysed. Certain loose biomass sources are then identified as potential briquetting candidates.

3. PROBLEM FORMULATION

Keeping in mind the threat of fast depletion of finite resources of energy, green house gas effects in the environment, increase prices of oil and natural gases, ozone layer depletion. It is decided to do mathematical analysis to find out assessment of biomass energy production potential in the different districts of Punjab. Punjab being an agricultural state has no coal, oil, gas reserves. So it has to depend on others for the supply of fossil fuels. The results indicate that Punjab has abundant biomass resources and biomass is found to be one of the promising areas.

3.1 Objectives

Considering the literature review observations the present work has been formulated with the following objectives:

- Calculation of availability of different biomass resources.
- Area wise data collection of different biomass resources.
- Land efficiency for biomass assessment.

Suggestion for utilization of available biomass

3.2 Methodology of study

To achieve the stated objectives, following methodology will be adopted:

- Data (area under crops, grain production , Agri-residue output) pertaining to different local growing crops will be collected from local patwaris.
- The rich experience of Farmers will also be collected regarding crop production and crop-residue.
- For this project data will be collected from PEDA Chandigarh India. This agency collect data from field survey and direct inrerview method.

4. PROFILE OF PATIALA DISTRICT

Patiala district is one of the famous states of Punjab. Forming the south-eastern part of the state, it lies between 29°49' and 30°47' north latitude, 75°58' and 76°54' east longitude.It is surrounded by the districts of Fatehgarh Sahib & Rupnagar and the Union Territory of Chandigarh in the north, Sangrur district in the west, Ambala and Kurukshetra districts of neighbouring state of Haryana in the east and Kaithal district of Haryana in the south. It is the 6th most populated district of the Punjab after Amritsar, Ludhiana, Gurdaspur, Sangrur and Jalandhar. Patiala district is a predominantly rural district. As per the 2011 census, 59.74% lived in rural areas and only 40.26% lived in urban areas.The Climate here is typical of Punjab plain i.e. very hot in summer and very cold in winter. The district is generally dry and hot, with monsoon lasting three months. Both summer and winter are severe. The annual average rainfall is 688 mm. On an average there are 61 rainy days. The variation in rainfall is appreciable. The month of May is the hottest with the mean monthly maximum temperature of 43.1°Celsius. January is the coldest month with mean monthly minimum temperature of 2.1°Celsius.Patiala District consists of 5 tehsils/subdivisions viz.Pattran, Nabha, Patiala, Rajpura Samana. Besides, there are 3 sub-tehsils, viz. Bhadson,Dudhan Sadhan Ghanaur. The district is divided into 8 development blocks. According to 2011 figures of District Statistical Office, the district has 924 inhabited villages.

Table 1 Patiala District at a glance

Geographical location: Latitude(North)	30^0 34'
Longitude(East)	76^0 38'
Administration Setup (in nos.)	
Sub Tehsil	3
Tehsils/ Sub Division	5
Blocks	8
Cities	9
Towns	11
Villages	924
Population Distribution	
Total Population	1,895,686
Rural Population	1,132,406
Urban Population	763,280
Population Density (persons per Sq.km)	570
Literacy Rate	
Rural	
Male	76.32
Female	63.25
Urban	
Male	88.90
Female	81.02
Land use Pattern (in 000 ha)	
Geographical area	322
Forests	12
Barren and Unculturable land	4
Land put to Non agricultural Use	36
Culturable Waste	7
Permanent Pastures and other grazing land	0.01
Net Sown Area (in hectares)	263
Gross Sown Area (in hectares)	535.5
Land under Misc. tree crops and groves Not included in net sown area	---

Source : Statistical Abstract of Punjab

5. INTRODUCTION TO BIOMASS

All organic matter is called biomass and the energy released from the biomass when it is burnt is called biomass energy. In India, biomass is always very important energy source for generation due to its properties like renewable, widely available and carbon neutral. All other sources like hydro power generation is feasible only if area has plenty of water resources, wind energy is usually near coastal areas and solar energy has high capital investment. But the biomass is the major source of energy available all over the India for renewable power generation. Biomass has always been an important energy source for the country in view of the benefits it offers. It is renewable, broadly available, carbon-neutral and has the potential to provide large employment in

Source :District Administration Patiala,Punjab

Figure 1 Geographical map of Patiala District

the rural areas. Biomass is also capable of providing continuous energy. About 32% of the total primary energy use in the country is still generated from biomass and more than 70% of the country's population depends upon it for its energy desires. Ministry of New and Renewable Energy has realized the potential and role of biomass energy in the Indian environment and hence has started a number of programs for support of efficient technologies for its use in various sectors of the economy to make sure derivation of maximum benefits. Biomass power generation in India is an industry that attracts investments of over Rs.600 crore every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man days in the rural areas. Since, Punjab is agricultural state, so biomass is in abundant in Punjab. There are two major agricultural seasons in the state "Rabi"(winter crop) and "Kharif" (summer crop). The major crops grown during the Rabi season are wheat, arhar (Cajanus Cajan), barley (Hordeum vulgare), gram, mustard (Brassica juncea), sunflower (Helianthus annuus), cotton, dry chillies, sesamum and fodder, while during Kharif season paddy, bajra (Pennisetum glaucum), jowar (Sorghum bicolor), maize (Zea mays), moong (Vigna radiata), ground nut (Arachis hypogaea) and sugarcane (Saccharum arundinaceum) are important crops. Apart from these crops, there are various other crops such as vegetables, potatoes, tomatoes, green manure, etc., which are categorized as 'Insignificant Crops'. Here, it is important to mention that in the present study we took only major and minor crops. A crop was considered major if its crop area fraction was 10% orabove of the total cultivated area or one or more of its residues had the residue fraction of 10% or above of the total residue production of the district. A crop was considered minor if it was not covered under the major crop and had either crop area fraction of 2.5% or above or one or more of its residues had the residue fraction of 2.5% or above. Crops that do not qualify either as major or minor was considered 'Insignificant crop'. Data for the insignificant crops were not calculated in the present resource assessment study due to miniscule contribution by such crops in the total biomass production. The total biological residue generation was expressed in kt perseason at 10% moisture content and CRR (Crop to Residue Generation Ratio) measured in terms of their weight and averaged. The residues generated from the major crops consists of wheat straw and husk, barley stalk, gram stalk, mustard stalk, sunflower stalk, cotton stalk, fodder grass stalk, paddy straw and husk, bajra stalk, husk and sugarcane leaves and trash as shown in Table 2.

Table 2. Categorization and Production of main agri-residue

Sr.	Type of agrireside crop	R.P.R.	Crop Yield(Q)	Agri-residue prod.(Q/acre)
1	Paddy Straw**	1.7	28	47.6
2	Paddy Husk**	0.2	40	8
3	Wheat Straw **	1.15	22	25.3
4	Sugarcane (Tops and Leaves)**	0.3	400	120
5	Maize (Stalk and Cobs)*	2.5	32	80
6	Cotton (Stalks)*	3.5	3	10.5
7	Rapesed and Mustard (Straw)*	2.1	4.72	9.912
8	Bajra (Stalk andCob)^x	1.85	3.622	6.7
9	Gram (Stalk)^x	1.08	5.72	6.176
10	Barley (Stalk)*	1.2	14.74	17.69
11	Jowar (Stalk)^x	1.65	3.52	5.809
12	Sunflower (Stalk)*	2.4	7.6	18.24

Source: Agricultural Office

5.1 Biomass Classification

Primary and secondary data was compiled and analyzed to calculate the surplus biomass and power generation potential from all the Villages of the Patiala District. In estimating the surplus biomass, the following classification of biomass by utilization was used:

- Basic Biomass Generation[kt/yr] = Kharif or Rabi residue generation can estimated using the CRR(Crop to Residue Ratio) for all the seasons of the year.
- Total Biomass Generation [kt/yr] = Sum of the Biomass Residue generated from all the seasons in the year.
- Basic Surplus Biomass [kt/yr]) = Basic Biomass Generation -- (Fodder + Thatching and Other non fuel domestic usages).
- Net Surplus Biomass [kt/yr] =Basic Surplus Biomass -- (Domestic fuel use*K + Manure and similar usage).

As per the present technologies, the judgmental factor K is expected to be around 25%, which indicates the potential for having the biomass consumption for domestic fuels, by efficiency improvement [12].

6. RESULTS

6.1 Crop Residue Generation From Agriculture Sector

The total residue generation from all the major and minor crops in the district was reported to be 10095.27Kt/yr. Of this, Wheat and Paddy in the form of straw and husk alone contributed more than 86%, while remaining was contributed by residues of cotton, fodder , sugarcane etc. Nabha and Samana reported as major crop residue potential villages within the district, which is due to the large agricultural land, maximum net sown area, higher crop yield, better irrigation facilities, more irrigated area, higher cropping intensity and introduction of high yielding varieties of crop seeds in these villages. Among least crop residues generation villages are Ghanour and Rajpura. These villages have less of agriculture area and more of forest area (Table 3).

Table 3. Biomass Generation in the Patiala district of Punjab

Villages	Area (Hec)	Total Biomass (Kt/yr)	Total cons. (Kt/yr)	Basic Surplus Biomass (Kt/yr)	Net Surplus Biomass (Kt/yr)
Bhunerheri	37025	560.90	284.11	288.10	278.25
Ghanour	33135	454.33	230.13	233.34	225.38
Nabha	61829	957.51	485.00	491.77	475.00
Patiala	36281	555.08	281.16	285.09	275.36
Patran	39550	597.62	302.71	306.94	296.47
Rajpura	28065	417.90	211.67	214.63	207.31
Samana	39802	661.21	334.92	339.59	328.02
Sanour	34122	512.13	259.40	263.03	254.06
Total	**309809**	**4716.68**	**2389.1**	**2422.49**	**2339.85**

6.2 Crop Residue Consumption from Agriculture Sector

The agricultural residue consumption has been categorized into four categories such as domestic fuel, fodder, thatching and manuring in the district. The total residue consumption from the agriculture sector in the state is 2389.1 Kt/yr, which is about 50.65% of the total generation. Of this, domestic fuel and fodder together consume more than 90%, while rest is used in thatching and manure form. Corresponding to the higher production potential, agricultural residue consumption is also reported high in Villages Nabha and Samana. This is because of the large number of rural human and domestic cattle population. Most of the residue generated from wheat, is used for fodder, while Paddy husk besides being used as fodder, is also consumed in making dung cakes and sold within the neighboring areas. While cotton stalks are used as firewood at domestic level, major portion of mustard husk is traded or sold as fuel to the brick kiln owners by farmers. The least biomass consuming districts are Ghanour and Rajpura (Table 4).

Table 4. Biomass Consumption in the Patiala district of Punjab

Villages	Fodder	Fuel wood	Thatc -hing	Manuri -ng	Total cons.
Bhunerheri	271.97	1.95	0.85	9.33	284.11
Ghanour	220.29	1.58	0.69	7.56	230.13
Nabha	464.27	3.33	1.45	15.94	485.00
Patiala	269.15	1.93	0.84	9.24	281.16
Patran	289.77	2.07	0.91	9.95	302.71
Rajpura	202.63	1.45	0.63	6.96	211.67
Samana	320.61	2.29	1.00	11.00	334.92
Sanour	248.32	1.78	0.78	8.53	259.40
District Total	**2287.01**	**16.38**	**7.15**	**78.51**	**2389.1**

7. CONCLUSIONS

The potential for generating power from the agriculture biomass in Patiala district is significant.

The surplus biomass is concentrated mainly in Nabha and Samana villages of the district. Cotton stalks, paddy stalks, maize cobs, sunflower stalks, sugarcane trash, and mustard stalks are major crops, which can contribute substantially to the power generation potential in the District. Therefore, prices for these residues are showing rising trend day by day. The duration between paddy harvesting and wheat cultivation is of 10 to 15 days, within this short duration farmers prefer burning the paddy stalk in the agriculture field instead of harvesting it for the fodder. About 25 to 30% of the domestic fuel can be saved through introducing improved cooking devices.Thishas been verified through the field surveys.Energy plantations should be encouraged wherever possible in each villages to support the availability of biomass for independent biomass power plant.

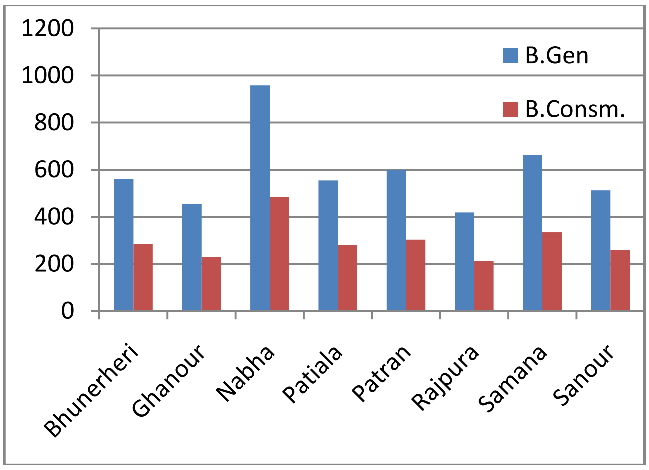

Figure 2. Comparison of Biomass Generation and Biomass consumption in various villages of Patiala District.

8. ACKNOWLEDGMENTS

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