

Biomass Resource Assessment for Power Generation: A Case Study for Haryana State, India

The information on biomass resource study in the State of Haryana have been taken from one of the research paper titled "Biomass resources assessment for power generation: A case study from Haryana state, India" published in Biomass and Bioenergy, authored by Mr. Suresh Chahuan from The Energy and Resources Institute (TERI).

Introduction

Haryana state is considered as one of the agricultural state of India. The state has a geographical area of about 44,200 km², which is 1.4% of the total geographical area of the country. About 85% of the area in the state is cultivable, of which 96% has already been brought under plough. Out of the total ploughed area, 75% is cultivated area; 50% is irrigated through groundwater, and the rest is from the surface water such as canals, drains and rivers. About 70% of the total population is sustained on agriculture, and thus, agriculture is the main economic activity in the state.

Methodology Adopted for the Study

The methodology adopted for the study consisted of field surveys, interviews and secondary data collection from 67 Talukas of the state, covering both, agriculture and agro-industrial sectors. Field surveys based on household and direct interview methods were carried out during June to November 2003 in the 19 districts¹ of the state. In all, a total of 1,134 respondents, averaging at 60 respondents in each district, were interviewed. These respondents spread across different user categories such as households, saw mills, brick kilns, sugar mills, biomass traders, rice mills and other industries, and geographical extent. At the household level, the sources of biomass production, patterns of consumption, types and efficiency of improved devices, if any were assessed. Within the Taluka, villages selected for the study were located at a minimum of 5 km from the main road.

Besides, primary data was collection through direct interviews, secondary data were also collected from various sources. The information regarding the ratio of area under different crops and the crop wise per unit area productivity were collected from Statistical Abstract of Haryana, 2001-02. The Crop Residue Ratio (CRR) for the major and minor crops are measured and compared with the data of Ministry of Agriculture (MoA), Government of India.

¹In 2003, There Were 19 Districts in Haryana. Today, There Are Total of 21 Districts in the State Including the Newly Formed Districts Mewat (2009) and Palwal (2008).

However, no major difference was found between the field data and MoA data, except for wheat in few districts, where high yielding varieties were grown.

From agro-industrial sector, a sample of about three to five industrial units was drawn from each biomass producing or consuming industries in each district of the state. The sources of information are District Industries Centers (DICs), Department of Industries (DoI) and Department of Food and Civil Supplies (DFCS). In all, a total of about 15 to 20 industrial units covering all types of biomass based industries were drawn as a sample in each district. In addition, in-depth interviews with biomass traders were conducted to assess the quantum, collection timing, source, destination and pricing of the biomass.

Agricultural Residue Production in Haryana

Field Based Residues

Round the year, different varieties of crops are grown in the state. The major crops grown during the rabi season are wheat, barley, gram, mustard, cotton and sugarcane, while during kharif season paddy, jowar, bajra and maize. The residues generated from these crops consists of wheat stalk and pod, barley stalk, gram stalk, mustard stalk and husk, cotton stalk, sugarcane top and trash, paddy husk and straw, jowar stalk, bajra stalk and cobs and maize stalk and cobs. Apart from these major and minor crops, there are various other crops such as chillies, vegetables, pulses, and green manure etc.

The total residue generated from all the major and minor crops was reported to be 24.697 million tonnes (Mt) per annum. Of this, the major agro residues are of Wheat and Paddy in the form of stalk, pod and husk, contributing to about 80% of the total residue. The remaining amount was contributed by the residues of cotton (7.78%) and mustard (3.66%) among other crops. Sirsa, Hissar, Jind and Fatehabad are reported as major crop residue potential districts within the state, which is due to the large agricultural area, higher crop yield, better irrigation facilities, more irrigated area, higher cropping intensity and introduction of high yielding varieties of crop seeds in these districts. Among the least crop residues producing districts are Panchkula, Yamunanagar, Rewari, Rohtak and Mahendragarh. The total crop residue generation in the state is provided in Table 1.

Table 1: Agricultural Residue Production in the Haryana State

District	Crop Residues (in kilo tonnes per year)													
	Paddy Straw	Paddy Husk	Maize Stalk	Maize Cob	Wheat Stalk	Wheat Pod	Sugar cane Top	Sugar cane Trash	Bajra Stalk	Bajra Cob	Cotton Stalk	Gram Stalk	Mustard Stalk	
Ambala	325.50	43.40	18.30	3.50	294.00	140.30	14.60	14.60	0.00	0.00	0.00	0.00	0.00	

District	Crop Residues (in kilo tonnes per year)													
	Paddy Straw	Paddy Husk	Maize Stalk	Maize Cob	Wheat Stalk	Wheat Pod	Sugar cane Top	Sugar cane Trash	Bajra Stalk	Bajra Cob	Cotton Stalk	Gram Stalk	Mustard Stalk	
Bhiwani	30.00	4.00	0.00	0.00	568.80	232.30	0.00	0.00	312.00	25.00	166.30	54.60	158.40	
Faridabad	116.00	16.00	0.00	0.00	646.80	242.60	4.70	4.70	34.60	3.00	0.00	0.00	0.00	
Fatehabad	318.40	39.80	0.00	0.00	797.00	386.10	0.00	0.00	26.60	2.20	377.00	0.00	23.40	
Gurgaon	28.70	4.00	0.00	0.00	596.40	216.50	0.00	0.00	148.60	12.50	0.00	0.00	74.40	
Hisar	88.20	12.60	0.00	0.00	1,020.10	416.90	0.00	0.00	139.90	11.80	496.70	0.00	87.40	
Jhajjar	38.10	5.00	0.00	0.00	482.40	188.90	0.00	0.00	64.70	5.00	0.00	0.00	49.80	
Jind	288.60	44.40	0.00	0.00	1,113.60	401.00	0.00	0.00	134.20	10.20	136.20	0.00	0.00	
Kaithal	488.80	78.20	0.00	0.00	791.20	337.10	0.00	0.00	9.00	0.80	0.00	0.00	0.00	
Karnal	599.40	88.80	0.00	0.00	884.20	346.10	6.20	6.20	0.00	0.00	0.00	0.00	0.00	
Kurukshetra	520.20	71.40	0.00	0.00	607.20	227.70	9.40	9.40	0.00	0.00	0.00	0.00	0.00	
Mahendergarh	0.00	0.00	0.00	0.00	241.70	76.40	0.00	0.00	228.10	17.60	0.00	10.90	118.40	
Panchkula	24.30	3.60	28.80	5.60	55.40	19.80	0.50	0.50	0.00	0.00	0.00	1.20	1.40	
Panipat	259.90	37.40	0.00	0.00	410.60	191.60	2.90	2.90	0.00	0.00	0.00	0.00	0.00	
Rewari	0.00	0.00	0.00	0.00	262.20	102.60	0.00	0.00	118.00	9.40	0.00	0.00	131.00	
Rohtak	50.40	7.20	0.00	0.00	383.70	172.50	6.80	6.80	56.70	4.30	44.80	0.00	18.90	
Sirsa	155.40	22.20	0.00	0.00	1,053.80	456.70	0.00	0.00	0.00	0.00	699.70	0.00	68.90	
Sonepat	190.40	27.60	0.00	0.00	613.80	251.10	3.80	3.80	21.60	1.90	0.00	0.00	5.40	
Yamunanagar	223.60	32.80	0.00	0.00	276.00	103.50	27.00	27.0	0.00	0.00	0.00	0.00	0.00	
Total	3745.90	538.40	47.10	9.10	1,1098.90	4,509.70	75.90	75.90	1,294.00	103.70	1,920.70	66.70	737.40	
Percentage of Total	(15.17)	(2.18)	(0.19)	(0.04)	(44.94)	(18.26)	(0.31)	(0.31)	(5.24)	(0.42)	(7.78)	(0.27)	(2.99)	

Values in parenthesis refer to the percentage of total biomass production.

Field survey June to November, 2003

Agro-Industrial Residues

The major agro based industries in the state are sugar mills, rice mills and saw mills. During the study, 15 sugar mills were found that were operative and few of them having cogeneration plant. The state also has some saw mills, which were small and process firewood only. This sawmills process timber, procured either from farmers or purchase

auctioned wood from the Forest Department. These sawmills operate for about 15 to 20 days a month with an average of six to eight hours per day for the whole year except during the monsoon period. The average wood processed in one mill is about 1,500 tonnes per year. It is important to mention here that paddy husk has been considered as agriculture by a product, rather than a by product of agro-industrial sector in the state.

The residue production from sawmills in the form of sawdust has been considered as a major biomass production from agro based industries, calculated at 646 kilo tonnes (kt) per annum. Of this, major contribution is from Kurukshtra, Panchkula, Panipat and Ambala districts, owing to the existence of large number of sawmills in these districts, estimated at around 150 to 200.

The residues from sugarcane in these districts (trash/tops and leaves) have been treated as any other biomass residue. But for bagasse, it is assumed that it would be used for cogeneration after sun drying in the sugar mills itself. At the time of study, these sugar industries do not dry the bagasse and use it with up to 50% moisture. As per the government industrial policy, the study considered that all the bagasse generated from the sugar mills are consumed in the cogeneration plant. Thus, the total bagasse generated is considered as “Zero” while accounting net surplus.

Agricultural Residue Consumption in Haryana

Field Based Residues

The agricultural residue consumption has been categorized into five categories such as domestic fuel, fodder, thatching, manuring, and industrial usage in the state. The total residue consumption in the state is 17.716 Mt per annum. Of this, domestic fuel and fodder together consume more than 88%, while rest is used in thatching, manuring and industrial usage form. Corresponding to the higher production potential, agricultural residues consumption is also reported high in districts Sirsa, Hissar, Jind, Fatehabad, Bhiwani and Karnal with 11.31%, 8.45%, 8.38%, 7.97%, 7.95%, and 7.37% respectively. This is because of the large number of rural human and domestic cattle population and small scale agro residue consuming industries such as brick kilns and rice mills etc. Districts Sirsa, Jind and Fatehabad together have about 0.314 million rural households, as against a total of 0.193 million in Panchkula, Ambala and Yamuna Nagar districts. Most of the residue generated from wheat, barley and bajra is used for fodder, while paddy husk being used as fodder, is also consumed in making dung cakes (dung cakes are used mainly in open cook stoves called ‘hara’, which are used for cooking feed for cattle and also for slow boiling of milk in the rural areas) and sold within the neighbouring areas. While cotton and gram 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 the farmers. The least biomass consuming districts are Panchkula, Ambala, Yamunanagar and Rewari as shown in Table 2.

Together, it was calculated that 88.8% of the total crop residue is consumed within the state as fodder and fuel. Besides, about 564 kt per year of crop residue is imported from the neighboring areas. Of this, maximum was reported from Sirsa and Kaithal districts. This was perhaps due to the higher fodder demand in these districts for paddy husk and mustard husk in view of large number of livestock population.

Table 2: Agricultural Residue Generation in the Haryana State

District	Uses of Biomass (in Percentage)					
	Domestic Fuel	Fodder	Thatching	Manuring	Industrial	Total Consumption
Ambala	0.00	38.98	0.48	4.57	1.39	45.42
Bhiwani	19.07	59.73	0.50	3.37	2.36	85.03
Faridabad	0.00	41.59	0.43	0.99	17.14	60.15
Fatehabad	13.28	52.64	0.00	3.39	1.75	71.07
Gurgaon	6.64	71.77	0.26	4.13	5.84	88.64
Hisar	15.76	47.38	0.48	0.02	2.24	65.88
Jhajjar	7.53	62.69	0.86	1.05	1.24	73.37
Jind	5.12	59.98	0.00	4.08	0.59	69.77
Kaithal	0.00	54.36	0.00	0.00	11.42	65.78
Karnal	0.00	59.37	0.00	0.32	7.94	67.63
Kurukshetra	0.00	49.00	0.90	0.94	6.30	57.15
Mahendergarh	16.75	58.75	0.00	1.61	4.38	81.49
Panchkula	1.83	63.50	0.00	5.98	0.00	71.32
Panipat	0.00	57.86	0.00	0.40	8.06	66.33
Rewari	18.11	55.37	0.00	0.97	0.11	74.56
Rohtak	6.93	62.17	1.32	2.20	5.07	77.69
Sirsa	19.47	55.70	0.18	1.59	2.53	79.47
Sonepat	0.49	66.18	0.48	0.34	26.28	93.77
Yamunanagar	0.00	48.84	0.00	15.39	3.16	67.39

Field Survey June - November 2003

Agro-Industrial Residues

The sawdust is mixed with cow dung to make dung cake as a source of domestic fuel and is also consumed in brick kilns. The total sawdust consumption in the state is estimated at about 42.93 kt per annum. Major sawdust consuming districts are Sonipat, Hissar, Rohtak and Yamunanagar.

Surplus Crop Residue Available in Haryana

Field Based Residues

Of the total 24.697 Mt per annum of generated crop residue, the basic, productive and net surplus residue was calculated as 44%, 36% and 33% respectively. The major biomass potential districts in the state are Hissar (10.76%), Kaithal (8.70%), Karnal (8.57%), Jind (8.34%) and Sirsa (8.01%), which contribute maximum to net surplus biomass in the state. On the other hand, Panchkula (0.51%), Gurgaon (2.06%), Mahendragarh (2.18%), Rohtak (2.62%), Rewari (2.69%) and Yamunanagar (2.80%) are reported as the least surplus biomass producing districts in the state. Table 3 illustrates the district wise surplus biomass availability in Haryana.

Table 3: Surplus Agricultural Residue Available in the Haryana State

District	Total Generation (kt/yr)	Basic Surplus (kt/yr)	Productive Surplus (kt/yr)	Net Surplus (kt/yr)
Ambala	854.22	517.11	478.10	466.24 (5.8)
Bhiwani	1,656.87	658.82	366.04	326.99 (4.06)
Faridabad	1,068.33	619.34	608.77	448.26 (5.57)
Fatehabad	1,986.77	940.88	675.71	644.39 (8.01)
Gurgaon	1,123.39	314.26	211.93	165.77 (2.06)
Hissar	2,273.49	1,185.28	916.25	865.38 (10.76)
Jhajjhar	884.87	322.55	263.33	252.29 (3.14)
Jind	2,128.27	851.72	683.14	670.66 (8.34)
Kaithal	1,705.07	778.23	778.23	700.03(8.70)
Karnal	1,931.00	784.64	778.44	689.64 (8.57)
Kurukshatra	1,445.23	723.98	710.40	639.00 (7.94)
Mahendragarh	772.03	318.42	209.04	175.20 (2.18)
Panchkula	142.04	51.82	41.36	41.36 (0.51)
Panipat	905.23	381.43	377.88	326.31 (4.06)
Rewari	723.29	322.83	217.59	216.78 (2.69)
Rohtak	763.28	278.73	222.26	211.06 (2.62)
Sirsa	2,521.69	1,112.43	704.17	644.69 (8.01)
Sonipat	1,122.57	374.26	366.34	335.62 (4.17)
Yamunanagar	689.84	352.89	246.72	224.93 (2.80)
Total	24,697.48	10,889.62	8,855.70	8,044.60

Agro-Industrial Residues

The total surplus residue in the industrial sector is estimated as 603 kt per annum in the state. Of this, Panchkula (12.25%), Kurukshetra (12.05%), Panipat (9.37%) and Ambala (8.67%) contribute maximum to the surplus biomass. On the other hand, districts such as Bhiwani (1.5%), Fatehabad (2.12%), and Rohtak (2.38%) contribute minimal to the agro-

industrial sector. Table 4 provides the surplus agro-industrial residue available in the state.

Table 4: Surplus Agro-Industrial Residue Available in the Haryana State

District	Total Biomass Generation (kt/year)	Total Biomass Consumption (kt/year)	Surplus Biomass (kt/year)
Ambala	52.33 (8.10)	-	52.33(8.67)
Bhiwani	11.86 (1.84)	2.80 (6.50)	9.06 (1.50)
Faridabad	24.09 (3.73)	1.60 (3.70)	22.49 (3.73)
Fatehabad	13.71 (2.12)	0.90 (2.10)	12.81 (2.12)
Gurgaon	28.00 (4.33)	-	28.00 (4.64)
Hisar	27.90 (4.32)	6.20 (14.40)	21.70 (3.60)
Jhajjar	27.84 (4.31)	-	27.84 (4.61)
Jind	42.93 (6.64)	-	42.93 (7.12)
Kaithal	27.40 (4.24)	-	27.40 (4.54)
Karnal	20.43 (3.16)	0.80 (1.90)	19.63 (3.25)
Kurukshetra	75.00 (11.61)	2.40 (5.60)	72.60 (12.03)
Mahendergarh	20.59 (3.19)	2.63 (6.10)	17.96 (2.98)
Panchkula	75.90 (11.75)	2.00 (4.70)	73.90 (12.25)
Panipat	58.40 (9.04)	1.90 (4.40)	56.50 (9.37)
Rewari	22.62 (11.75)	-	22.62 (3.75)
Rohtak	19.64 (3.04)	5.30 (12.30)	14.34 (2.38)
Sirsa	44.00 (6.81)	-	44.00 (7.29)
Sonepat	30.24 (4.68)	12.10 (28.20)	18.14 (3.01)
Yamunanagar	23.33 (3.61)	4.30 (10.00)	19.03 (3.15)
Total	646.21	42.93	603.28

Values in parenthesis refer to the percentage of total biomass generation, consumption and surplus

Total Surplus Biomass Availability

Of the total surplus biomass generation of 25.343 Mt per annum, basic, productive and net surplus biomass is estimated at 45.52%, 37.49% and 34.12% respectively in the state. Hissar and Sirsa districts alone contribute more than 20% to the total basic surplus biomass generation in the state. In productive surplus category, districts such as Hissar (9.94%), Kaithal (8.48 %), Karnal (8.41%) and Kurukshetra (8.27 %) contributed maximum. Finally, in the net surplus category which is considered as the actual surplus available for power generation Hissar (10.26%), Kaithal (8.41%), Jind (8.25%), Kurukshetra (8.23%), Karnal (8.20%) and Sirsa (7.86%) are the districts that contributed maximum net surplus biomass.

Power Generation Potential From the Surplus Biomass

To convert the various biomass residues into power generation potential, Indian Institute of Science (IISc), Bangalore, has analyzed the calorific values and calculated the conversion factor of all the crop residues. The same conversion factor for all the crop residues is applied in the present article.

Power generation from basic, productive and net surplus was calculated as 1.49 gigawatt (GW), 1.22 GW and 1.12 GW per year respectively. Districts such as Hissar (10.62%), Jind (8.30%), Sirsa (8.28%) and Kaithal (8.23%) contributed maximum percent of power generation from net surplus biomass in the state. However, Panchkula (1.39%), Mahendragarh (2.21%), Gurgaon (2.29%), Rohtak (2.67%), Rewari (2.69%), and Yamunanagar (2.74%) are the districts that contributed least percentage of power from the net surplus biomass in the state as shown in Table 5.

Table 5: Total Surplus Available Biomass in the Haryana State

District	Total Generation (kt/yr)	Basic Surplus (kt/yr)	Productive Surplus (kt/yr)	Net Surplus (kt/yr)
Ambala	906.60	569.50 (71.50)	530.50 (66.50)	518.60 (65.20)
Bhiwani	1,668.80	670.70 (87.20)	377.90 (48.30)	336.10 (43.50)
Faridabad	1,092.50	643.50 (84.50)	632.90 (83.10)	470.70 (62.30)
Fatehabad	2,000.50	954.60 (125.60)	689.50 (89.70)	657.20 (86.20)
Gurgaon	1,151.40	342.30 (44.10)	239.90 (30.80)	193.80 (25.80)
Hissar	2,301.30	1,213.10 (164.10)	944.20 (126.50)	887.10 (119.10)
Jhajjar	912.70	350.40 (45.50)	291.20 (37.90)	280.20 (36.80)
Jind	2,171.20	894.60 (116.30)	726.00 (94.30)	713.60 (93.10)
Kaithal	1,732.40	805.60 (100.90)	805.60 (100.90)	727.50 (92.30)
Karnal	1,951.40	805.10 (99.50)	798.80 (98.60)	709.30 (88.70)
Kurukshetra	1,520.20	798.90 (99.70)	785.40 (97.80)	711.60 (89.60)
Mahendragarh	792.60	339.10 (42.90)	229.60 (28.90)	193.10 (24.90)
Panchkula	217.90	127.70 (17.20)	117.20 (15.90)	115.30 (15.70)
Panipat	963.60	439.80 (55.70)	436.20 (55.20)	382.80 (48.90)
Rewari	745.90	345.40 (43.90)	240.20 (30.20)	239.40 (30.10)
Rohtak	782.90	298.30 (39.70)	241.90 (31.90)	225.40 (29.90)
Sirsa	2,565.70	1,156.40 (155.80)	748.20 (99.40)	688.70 (92.90)
Sonipat	1,152.80	404.50 (51.90)	396.60 (50.80)	353.80 (45.70)
Yamunanagar	713.20	376.20 (54.50)	270.10 (40.90)	243.90 (30.70)
Total	25,343.70	11,535.90 (1,500.50)	9,501.90 (1,227.30)	8,648.10 (1,121.40)

Values in the parenthesis refer to the power generation potential in MW per year.