CHAPTER **15** Patiala

Executive Summary

Patiala is located in the eastern part of Punjab. The district lies between north latitude 29° 49' to 30° 47' and east longitude 75°58' to 76°54'. It has Fatehgarh Saheb and Roopar districts in the north, Sangrur in the west Jind and Ambala in the south as boundaries. This district has 5 tehsils, 9 towns and 1084 villages as per the 2001 census. District Patiala has a population of 1839056 with a density of population in the district is 507 persons per sq km.

Table 1. District at Glance

S No	District	Patiala
1	Geographical Situation	
	Latitude (North)	29° 49' to 30° 47'
	Longitude (East)	75°58' to 76°54'
2	Number of Sub-Division	5
3	Number of Blocks	8
4	Total Population	1844934
	Rural Population	1200224
	Urban Population	644710
5	No. of Households	327859
6	Literacy (%)	69.96
7	Total Livestock Population	17,88,800
	Cattle & Buffaloes Population	6,46,200
8	Total Geographical Area (ha)	368000
9	Forest Area	15000
	(% of Geographical Area)	4.08
10	Net Area under Cultivation (ha)	303000
	(% of Geographical Area)	82.34
11	No. of Rice Mills	279
12	No. of Saw Mills	260
13	Total Biomass Generation (MT/Year)	3792252
	Crop Residues	3428373
	Forest & Other Lands	249789
	Agro-Industry	114090
14	Total Consumption (MT/Year)	2526663
15	Surplus Biomass (MT/Year)	
	Basic	1338311
	Productive	1278149
	Net	1225311
16	Power Potential (MW)	
	Basic	164.97
	Productive	156.89
	Net	149.49

The total biomass generation and consumption in the district has been categorized as per the definitions provided by the National Focal Point (NFP) - Indian Institute of Science (IISc), Bangalore.

Total generation (TG): This is the biological generation per year from all sources in the district.

Essential class (EC): The biomass consumption for fodder, thatching end-uses in the district has been put under this category. (EC = Fodder Crops + Thatching)

Basic Surplus (QBS): The remaining biomass after reducing the Essential Class and bagasse from Total Generation is called as Basic Surplus. (QBS = TG – EC)

Productive Surplus (QPS): From the Basic Surplus, 50% of the quantum of biomass used for domestic fuel consumption and 50 % for manure & similar usages. This gives the Productive Surplus in the district. (QPS = QBS – [0.50 * Domestic fuel + 0.50 * Manure & similar usages])

Net Surplus (QNS): The Net Surplus is derived after reducing the biomass consumption in industrial sector also from the Productive Surplus. (QNS = QPS – Industrial Consumption)

The total biomass generated in this district from all sources like Agriculture crop residues, Forest & other wastelands and Agro-Industry is 3792252 MT/year. Essential class is 2353501 MT/year and non-essential class is 1438751 MT/year. The basic surplus available from this district is 1338311 MT/year, productive surplus is 1278149 MT/year, and net surplus is 1225311 MT/year.

Total power generation potential has been calculated, assuming that the plant will operate for 7000 hours per annum with a plant load factor (PLF) of 75 %. From the calculations made, basic surplus is 164.97 MW, productive surplus is 156.89 MW, and net surplus is 149.49 MW.

If the sugar mills opt for optimum cogeneration, they can install 15.44 MW and export 11.12 MW of power to grid.

The following table gives, source wise generation, classification and surplus of biomass:

Table 2. Overall surplus biomass in the district

Quantity MT/year

S No	Source	Generation	Classification		Surplus		
			Essential Class	Non Essential Class	Basic (QBS)	Productive (QPS)	Net (QNS)
1	Crop Residues	3428373	2353501	1074872	1074872	1051547	1051547
2	Forest & Other Waste Lands	249789	0	249789	249789	212952	173765
3	Agro Industries	114090	0	114090	13650	13650	0
	Total	3792252	2353501	1438751	1338311	1278149	1225311

The following table gives the total generation and various surpluses from different sources.

Table 3. Crop residue wise surplus biomass in the district

Quantity MT/yr

Crop Name	Residue Type	Generation	Classification		Surplus		
			Essential	Non-Essential	Basic (QBS)	Productive (QPS)	Net (QNS)
Kharif Crops							
Paddy	Straw	1044624	132556	912068	912068	899011	899011
	husk	136255	0	136255	136255	134552	134552
	Bran	45418	45418	0	0	0	0
	Hull	227092	227092	0	0	0	0
Maize	Stalks	22481	22481	0	0	0	0
	Cobs	3441	0	3441	3441	1721	1721
Moong	Stalks	209	209	0	0	0	0
	Husk	20	20	0	0	0	0
Ground nut	Stalks	166	166	0	0	0	0
	Shell	23	0	23	23	12	12
Sugar cane	Tops & Leaves	21147	21147	0	0	0	0
	Trash	14098	0	14098	14098	11759	11759
Rabi Crops							
Wheat	Straw	1572192	1572192	0	0	0	0
	Pod	196524	196524	0	0	0	0
Barley	Stalks	10918	10918	0	0	0	0
Gram	Stalks	189	189	0	0	0	0
Arhar	Stalks	1175	0	1175	1175	588	588
	Husk	144	144	0	0	0	0
Masoor	Stalks	990	990	0	0	0	0
Rape seed & mustard	Stalks	1938	0	1938	1938	969	969
Sun flower	Stalks	2265	0	2265	2265	1132	1132
Sesamum	Stalks	26	0	26	26	13	13
Dry chillies	Stalks	1180	0	1180	1180	590	590
Cotton	Stalks	2403	0	2403	2403	1202	1202
Fodder	Straw	123455	123455	0	0	0	0
Total		**3428373**	**2353501**	**1074872**	**1074872**	**1051547**	**1051547**
Forest & Other Waste lands	Wood	249789	0	249789	249789	212952	173765
Agro Industries							
Saw Mill	Wood chips	11700	0	11700	11700	11700	0

Crop Name	Residue Type	Generation	Classification		Surplus		
			Essential	Non-Essential	Basic (QBS)	Productive (QPS)	Net (QNS)
	Saw dust	1950	0	1950	1950	1950	0
Sugar Mills	Bagasse	100440	0	100440	0	0	0
Total		**114090**	**0**	**114090**	**13650**	**13650**	**0**
Grand Total		**3792252**	**2353501**	**1438751**	**1338311**	**1278149**	**1225311**

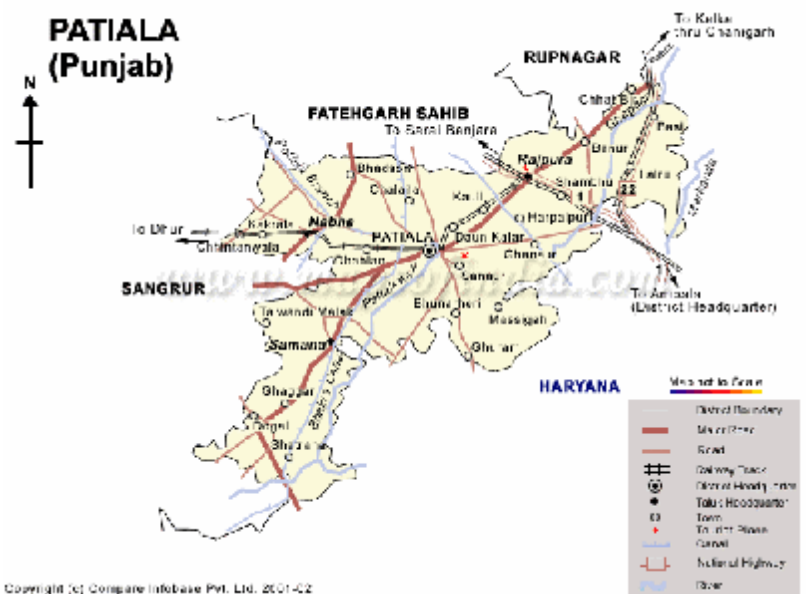
The residues, which have power generation potential, are given below.

Table 4. Crop residue wise power generation potential in the district

Crop Name	Residue	Power Potential (MW)		
		Basic (PBS)	Productive (PPS)	Net (PNS)
Kharif Crops				
Paddy	Stalks	109.45	107.88	107.88
	Husk	14.99	14.80	14.80
Maize	Cobs	0.48	0.24	0.24
Ground nut	Shell	0.0033	0.0016	0.0016
Sugar cane	Trash	1.97	1.65	1.65
Rabi Crops				
Arhar	Stalks	0.153	0.076	0.076
Rape seed & mustard	Stalks	0.25	0.13	0.13
Sun flower	Stalks	0.29	0.15	0.15
Sesamum	Stalks	0.0034	0.0017	0.0017
Dry chillies	Stalks	0.153	0.077	0.077
Cotton	Stalks	0.34	0.17	0.17
Total		**128.09**	**125.17**	**125.17**
Forest &				
Other Waste lands	Wood	34.97	29.81	24.33
Agro Industries				
Saw Mill	Wood chips	1.64	1.64	0.00
	Saw dust	0.27	0.27	0.00
Sugar Mills	Bagasse	0	0	0.00
Total		**1.91**	**1.91**	**0**
Grand Total		**164.97**	**156.89**	**149.49**

Introduction

Patiala is located in the eastern part of Punjab. The district lies between north latitude 29° 49' to 30° 47' and east longitude 75°58' to 76°54'. It has Fatehgarh Saheb and Roopar districts in the north, Sangrur in the west Jind and Ambala in the south as boundaries. This district has 5 tehsils, 9 towns and 1084 villages as per the 2001 census. District Patiala has a population of 1839056 with a density of population in the district is 507 persons per sq km.



The district has two major crops, wheat and paddy with a combined cropping area of more than 86%. Residue from wheat, maize stalk, sugarcane tops & leaves and a part of paddy straw are used as fodder for the cattle and, stalks from mustard, cotton, are being used as domestic fuels. The other major biomass-generating source in the district is forest, wastelands and farm-bund forestry, where kikar and jhandi are the main tree species.

Among the industries, there are two sugar mills, 260 saw mills and 279 rice mills in the district. The Sawmills generates wood chips (11700 MT/year) and saw dust (1950 MT/year) that is being consumed as fuel for near by industries. Sugar mills generate as well as consume bagasse within the plant itself; sugar mills are having the crushing capacity ranging from 1250 to 2500 TCD. In sugar crushing season of 2001 –02, Sugar mills crushed 334800 tons of cane. Rice is milled in hullers where, husk and bran is in the mixed form, where as modern rice mills separate husk and bran. Residue from hullers is used as fodder, bran from the modern rice mills is also used as fodder, and husk is used as domestic fuel and available as surplus.

A snapshot of the district Patiala features is given in the table below:

Table 5. Demographical Features

S No	Particulars	Description
1	Geographical Area (Sq. Km)	3627
2	Total Population	1844934
3	Rural Population	1200224
4	Urban Population	644710
5	No. Households	327859
6	Population Density (Per Sq. Km)	507
7	Literacy Rate (%)	69.96
8	Sex Ratio	864

SOURCE Statistical Abstract of Punjab, 2002

Administratively, the divisions of Patiala district are given in the table below:

Table 6. Administrative divisions

Tehsils	Sub-tehsils	Blocks
Patiala	Dudhan Sadhan	Patiala
		Bhuner Heri
Rajpura	Ghanaur	Rajpura
		Ghanaur
Samana	Patran	Samana
		Patran
Nabha	Bhadson	Nabha
Dera Bassi		Dera Bassi

SOURCE Statistical Abstract of Punjab, 2002

The topography and geo-physical conditions of Patiala can be described as central plain area. The annual rainfall in the district in the year 2001 is given in the table below:

Table 7. Annual Rainfall in mm

Month	2000	2001	2002
January	8.22	95.9	9.2
February	116.8	12.8	132.54
March	21.9	67.8	76.5
April	15.4	138.61	0
May	216.3	184.1	0
June	576.0	508.2	44.9
July	1395.1	550.9	357.1
August	350.4	787.5	623.5
September	144.1	0	696.4
October	0	0	208.2
November	0	0	137.6
December	20	13	0
Total	**2864.22**	**2358.81**	**2285.94**

SOURCE Dept. of Agriculture, Patiala

Net-cropped area is 303 thousand ha. Net sown area is 82.34 % of the geographical area. The major crops in this district are paddy, wheat and fodder.

Irrigated as well as rain fed farming is practiced in the district, about 9500 ha of area are being irrigated by govt. canals and 281200 ha. by tube well and wells.

Table 8. Irrigation sources

S No	Source	Area in ha
1	Government canals	9500
2	Tube wells and wells	281200
	Total	**290700**

SOURCE Statistical Abstract of Punjab, 2002

Land use pattern in Patiala

Following table gives the land use pattern in the district.

Table 9. Land use pattern in the district

Particulars	Area in ha	Percentage Contribution
Geographical Area	368000	100.00
Forest	15000	4.08
Barren &uncultivable land	4000	1.09
Land put to non agriculture use	45000	12.23
Cultivable waste	0	0.00
Permanent pastures and other grazing land	450	0.12
Land under misc.trees	3000	0.82
Current fallow	1000	0.27
Fallow land	0	0.00
Net area sown	303000	82.34

SOURCE Statistical Abstract of Punjab, 2002 and Department of Agriculture, Patiala

It can be observed from the table above, a relatively small area (45,000 ha – only about 12.23 %) is not available for agriculture, while 4.08% area (15000 ha) is designated as forest in the district. Only about 4,450 ha land is classified as barren and unculturable land, permanent pastures. As such the biomass availability from non-agricultural lands (barrens, permanent pastures and current fallows) is not significant in the district and in fact availability of greens for fodder is a problem in the district. Forest department, categorised the forest into State forest and Private forest. The private forestland belongs to farmers; the biomass generation from State forest is not considered. Only 30% of the biomass generated from private forestlands is available for various utilities in the district rest 70% is exported as raw material to paper and pulp industries in Haryana.

Total forest area is 15372.33. The segregation of the different forests is given below.

Table 10. Segregation of different Forests

S No	Particular	Area ha
1	State Forest	15232.23
	a. Block Forest	8106.02
	b. Road Strips	2491.49
	c. Railway Strips	445.13
	d. Canal drain strips	4189.59
2	Private forest	140.00
	Total forest	15372.23

Power scenario in the district

The number of connections and consumptions under various categories of consumers in Patiala district is given in the table below:

Table 11. Consumer categories of power

S No	Connection type	Number of connections	Consumption in MU
1	Domestic	297067	350.71
2	Commercial	50871	83.40
3	Industrial	6368	882.51
4	Public Lighting & Bulk	218	42.95
5	Agricultural	65734	592.91
	Total	**420258**	**1952.48**

SOURCE Statistical Abstract of Punjab, 2002

Livestock Population

The total live stock population in this district is 17,88,800 out of which 6,46,200 are cattle and buffaloes.

Table 12. Livestock population

Category	Number in thousands
Cattle	175
Buffaloes	471.2
Sheep	30.1
Goats	17.8
Pigs	11.6
Poultry	1083.1
Total	**1788.8**

SOURCE Statistical Abstract of Punjab, 2002

Primary survey

The survey in Patiala district was carried out in the second week of July 2003. The number of respondents for each category interviews carried out is given in the table below.

Table 13. Number of interviews in Patiala

S No	Category of respondent	Number of interviews
1	Households	100
2	Agro-forestry	25
3	Saw mill owners	45
4	Brick kiln owners	35

Biomass generation

Agricultural sector

There are two major agricultural seasons in Patiala – Kharif and Rabi. The main crops, yields and production for last three years are given in below table.

Table 14. Three years Cropping Pattern of Major Crops

A – Area ha Y – Yield kg/ha

S No	Crop	2001-02		2000-01		1999-00	
		A	Y	A	Y	A	Y
1	Paddy	251000	3.62	255000	3.35	250000	3.25
2	Maize	5000	2.29	5000	2.82	5000	3.05
3	Wheat	265000	4.94	261000	4.56	264000	4.80
4	Barley	2000	4.37	2000	3.67	2000	2.55
5	Oil seeds (g.nut + sesamum)	145	0.63	0	0	0	0
6	Rape & mustard	2000	0.88	2000	1.11	2000	1.07
7	Sunflower	400	1.29	400	1.20	2000	1.17
8	Sugarcane	4000	70.49	3000	72.48	3000	59.84
9	Cotton (Total)	1000	0.27	1000	0.40	1000	0.13

SOURCE Statistical Abstract of Punjab, 2002, 2001, 2000

From the above table, it is revealed that there is little variation in cropped area, yield and production. The following tables describe the Cropped area, yield and residue ratios of all crops along with biomass generation.

Table 15. Cropping pattern of 2001-02

Crop	Area in Ha	Percentage Contribution
Kharif Crops		
Paddy	251000	96.02
Maize	5000	1.91
Moong	300	0.11
Ground nut	100	0.04
Sugar cane	5000	1.91
Total	261400	100
Rabi Crops		
Wheat	265000	79.25
Barley	2000	0.60
Gram	200	0.06

Crop	Area in Ha	Percentage Contribution
Arhar	600	0.18
Masoor	1000	0.30
Rape seed & mustard	1400	0.42
Sun flower	700	0.21
Sesamum	45	0.01
Dry chillies	800	0.24
Cotton	900	0.27
Fodder	61727	18.46
Total	**334372**	**100**
Grand Total	**595772**	

In the following table the Crop residue ratio (CRR) of the crops in Patiala district collected during the primary survey and biomass generated from different crop residues are shown. The total biomass generated in this district is 3428373 MT/Year

Table 16. CRR and Residue Generation

Crops Name	Type	CRR	Residue Generation (MT/Year)	Percentage Contribution
Kharif Crops				
Paddy	Straw	1.15	1044624	68.95
	Husk	0.15	136255	8.99
	Bran	0.05	45418	3.00
	Hull	0.25	227092	14.99
Maize	Stalks	1.96	22481	1.48
	Cobs	0.30	3441	0.23
Moong	Stalks	1.05	209	0.0138
	Husk	0.10	20	0.0013
Ground nut	Stalks	1.84	166	0.0109
	Shell	0.26	23	0.0015
Sugar cane	Tops & Leaves	0.06	21147	1.40
	Trash	0.04	14098	0.93
Total			1514976	100
Rabi Crops				
Wheat	Straw	1.20	1572192	82.17
	Pod	0.15	196524	10.27
Barley	Stalks	1.25	10918	0.57
Gram	Stalks	1.08	189	0.01
Arhar	Stalks	2.28	1175	0.06
	Husk	0.28	144	0.01
Masoor	Stalks	1.65	990	0.05
Rape seed & mustard	Stalks	1.58	1938	0.10
Sun flower	Stalks	2.50	2265	0.12
Sesamum	Stalks	1.65	26	0.00
Dry chillies	Stalks	1.90	1180	0.06
Cotton	Stalks	1.00	2403	0.13
Fodder	Straw	1.00	123455	6.45
Total			**1913397**	**100**
Grand Total			**3428373**	

SOURCE Primary Survey for CRR

Total biomass generation from agriculture activities is 3428373 MT /year.

Table 17. Crop wise biomass generation

Crop Name	Type	Season	Year	Area of Cultivation (ha)	Total Production (MT/year)	Total Crop Yield (T/ha)	Total Grain Yield (T/ha)	Grain to Residue Ratio	Residue Yield T/ha	Crop Residue Ratio
Paddy	Stalks	Kharif	2001-02	251000	908369	7.78	3.619	0.87	4.162	1.15
Paddy	Husk	Kharif	2001-02	251000	908369	4.16	3.619	6.67	0.543	0.15
Paddy	Bran	Kharif	2001-02	251000	908369	3.80	3.619	20.00	0.181	0.05
Paddy	Hull	Kharif	2001-02	251000	908369	4.52	3.619	4.00	0.905	0.25
Maize	Stalks	Kharif	2001-02	5000	11470	6.79	2.294	0.51	4.496	1.96
Maize	Cobs	Kharif	2001-02	5000	11470	2.98	2.294	3.33	0.688	0.30
Moong	Stalks	Kharif	2001-02	300	200	1.36	0.665	0.95	0.698	1.05
Moong	Husk	Kharif	2001-02	300	200	0.73	0.665	10.00	0.067	0.10
Ground nut	Stalks	Kharif	2001-02	100	90	2.56	0.9	0.54	1.660	1.84
Ground nut	Shell	Kharif	2001-02	100	90	1.13	0.9	3.85	0.230	0.26
Sugar cane	Tops & Leaves	Kharif	2001-02	5000	352450	74.72	70.49	16.67	4.229	0.06
Sugar cane	Trash	Kharif	2001-02	5000	352450	73.31	70.49	25.00	2.820	0.04
Wheat	Straw	Rabi	2001-02	265000	1310160	10.88	4.944	0.83	5.933	1.20
Wheat	Pod	Rabi	2001-02	265000	1310160	5.69	4.944	6.67	0.742	0.15
Barley	Stalks	Rabi	2001-02	2000	8734	9.83	4.367	0.80	5.459	1.25
Gram	Stalks	Rabi	2001-02	200	175	1.82	0.873	0.93	0.943	1.08
Arhar	Stalks	Rabi	2001-02	600	515	2.82	0.859	0.44	1.959	2.28
Arhar	Husk	Rabi	2001-02	600	515	1.10	0.859	3.57	0.241	0.28
Masoor	Stalks	Rabi	2001-02	1000	600	1.59	0.6	0.61	0.990	1.65
Rape seed & mustard	Stalks	Rabi	2001-02	1400	1226	2.26	0.876	0.63	1.384	1.58
Sun flower	Stalks	Rabi	2001-02	700	906	4.53	1.294	0.40	3.235	2.50
Sesamum	Stalks	Rabi	2001-02	45	16	0.93	0.35	0.61	0.578	1.65
Dry chillies	Stalks	Rabi	2001-02	800	621	2.25	0.776	0.53	1.474	1.90
Cotton	Stalks	Rabi	2001-02	900	2403	5.34	2.67	1.00	2.670	1.00
Fodder	Straw	Rabi	2001-02	61727	123455	4.00	2	1.00	2.000	1.00

Forest & Other lands

Total state forest area in this district is15, 232.23 ha. Biomass from this land is not calculated in the present study, since there is complete banned on the tree felling under this category of land. The forest area under private holding is 140.0 ha out of which 98.0 ha is under Eucalyptus which generates soft wood used for paper manufacturing at an average yield of 10 MT/ha. Of the total soft wood material generated from private forest, 70% is of soft wood

utilised for paper manufacturing and the remaining 30% consists of roots, tops and branches which is below 2 inch can be utilised as fuel wood.

Besides the State forest and private forest there are other areas, which include farm bunds and waste lands in the district. Interaction with the farmers, during the survey revealed that the annual sustainable productivity of the farm bundhs in the district is 0.80 MT/year and wastelands, which includes barren uncultivatable, permanent pasture and grazing land are 1.5 MT/year.

Biomass from the farm bundhs are calculated through multiplying the net cropped area by the average sustainable annual productivity from farm bundhs, while biomass from wastelands is calculate through multiplying the total area under barren uncultivable, permanent pasture and grazing land by the average annual sustainable productivity of wastelands. The following table indicates the area and biomass generated from forest and other lands in the district.

Table 18. Biomass from forest & other lands

Particular	Area in ha	Yields (MT/year)	Biomass generated (MT/year)
Private Forest	140	10.00	1400
Waste lands	4450	1.50	6675
Form bunds	303000	0.78	241714
Total	**307590**		**250475**

SOURCE Primary Survey

Industrial Activity

In this district the main industries related to biomass generation or consuming are Sugar mills, Rice mills and saw mills.

Sugar Mills

There are two sugar mills in this district crushing about 334800 tonnes of cane every year generating 100440 tonnes of bagasse. The detailed are given in the following table.

Table19. Sugar Mills Data

(Quantity in MT)

S No	Name of the Mill	TCD	Cane crushed	Bagasse generated
1	Patiala Co-operative Sugar Mills Ltd., Rakhra	1250	150300	45090
2	Piccadly Sugar and Allied Ind. Ltd., Patran	2500	184500	55350
	Total	**3750**	**334800**	**100440**

The sugar mills in this district are having boilers of 21 bar and 45 bar boilers. These sugar plants operate for 100 to 110 days. They also consume around 90% of bagasse generated during season. These co-operative sugar mills may not be in a position to set up cogeneration plants.

Installed capacity of optimum cogeneration can be 15.44 MW. 4.32 MW will be consumed in the sugar plant for manufacturing of sugar and operating the power plant. 11.12 MW will be available for export to the grid.

Cogeneration Potential

If these Sugar Plant goes for Cogeneration then the optimum cogeneration potential will be as shown in the table

Table 20. Cogeneration Potential

Name of the Mill	Location	Crushing capacity TCD	No. of operating days	Cane crushed in Tons/Year	Cane crushed in Tons/Day	Power Generation MW	Power Consumption MW	Power Surplus MW
Patiala Co-operative Sugar Mills Ltd., Rakhra	Rakhra	1250	130	150300	1156	6.02	1.69	4.34
Piccadly Sugar and Allied Ind. Ltd., Patran	Patran	2500	102	184500	1809	9.42	2.64	6.78
Total						**15.44**	**4.32**	**11.12**

Saw Mills

About 39,000MT of wood is being processed every year in this district, which in tern generates 11,700MT of wood chips and 1,950 MT of sawdust. These two residues are serving the purpose of fuel in the nearby industries.

Table 21. Saw Mills Data

Particulars	Unit	Quantity
No. of mills	Number	260
Wood processed	MT/year	39000
Wood chips generated	MT/year	11700
Saw dust generated	MT/year	1950

The total biomass generated from industrial activity is 153278 MT/year. The break is given in the following table.

Table 22. Biomass Generation from Industrial Activity

District Name	Name of Industry	Capacity	Type of Residue	Generation MT/year	Consumption MT/year	Surplus MT/year
Patiala	Saw Mill	150-250 MT/year	Wood chips	11700	11700	0
			Saw dust	1950	1950	0
Patiala	Sugar Mill	1250-2500 TCD	Bagasse	100440	100440	0

Total	**114090**	**114090**	**0**

Total biomass generation

Total biomass generated in this district is 37,92,252 MT. Crop residues contribute 90.40%, Agro industry contributes 3.00% and 6.60% from forest, waste lands, and farm bunds.

Table 23. Total biomass generation

Source	Quantity in MT
Crop residues	3428373
Forest and other lands	249789
Agro industry	114090
Total	**3792252**

Biomass consumption

Domestic sector

Fodder

Wheat straw (known as Tudi), Maize stalks and a part of Paddy straw especially of basmati category, is used as fodder. Sorgar, Gowar, Napier Bajra, Bajra Makshari, Barseem, Lusoon, Jevi are the fodder crops grown in this district. Cattles and buffaloes are considered for fodder consumption. The total livestock population considered for fodder consumption is 6,46,200. These animals consume crop residue and rice bran. The per capita consumption of fodder is 6.0 kg/day excluding bran. The total fodder required per year is 22,97,589 MT.

Wheat Straw – 1532887, Fodder crops –120368, Maize stalks – 21919, Paddy straw – 125355, Sugarcane Tops & Leaves – 20618, and balance is from other crops.

Domestic Fuel

Rural population is considered for domestic fuel consumption. In Punjab State the farmers are progressive use LPG, Kerosene, cow dung, wood and crop residues as domestic fuel. Hence the per capita consumption of wood and residues are less. The Per capita consumption of crop residue as domestic fuel is 9.70 kg/year where as that of wood is 61.383 kg/year. Total crop residue utilised for this purpose is 16465 MT/year mainly of stalks of sunflower, mustard, Arhar, linseed, gram and maize cobs etc. Wood is sourced from farm bunds & waste lands. Wood consumption for domestic fuel is 73,673 MT/year. Total biomass consumed for domestic fuel is 90138 MT/year.

Thatching

Most of the houses in the Punjab state are pucca. About 2% of the households are using biomass for covering their households. Stalks

are used for supporting the straw material. In the district 7,201MT/year of biomass is being utilised for thatching.

Consumption in domestic sector

Biomass consumed for domestic fuel is 90,138 MT, fodder is 22,97,589 MT and for thatching 7,201 MT/year. Total consumption in domestic sector is 23,94,929 MT/year.

Industrial sector

Sugar mill

This district is having two sugar mills. Sugar mills required some amount of wood at the start of season. Sugar plant utilises bagasse as a fuel under boilers for steam generation. The total biomass consumed by the sugar mills is 188 MT/year of wood, 1,00,440 MT of bagasse.

Saw mills

This district is having 260 Saw mills. These saw mills are processing 39,000 MT/year of wood that is being supplied from forest, farm bunds & waste lands. The wood chips and sawdust generated from these saw mills is also being utilised as fuel in the nearby industries include brick kilns etc.
Total biomass consumed in industries is 25,26,663MT/year.

The following table gives a clear picture of percentage wise crop residue usage pattern in this district. More than 95 % of the residue from Bajra, maize barley, wheat and fodder crops are utilised as fodder. Similarly stalks of, arhar, mung, masur, dry chillies, mustard and maize cobs have about 97% usage as domestic fuel.

The following table shows the percentage use of the generated biomass for different purposes.

Table 24. Residue Usage Pattern in % wise

Crop	Type	Fodder	Domestic Fuel	Thatching	Manure	Industrial	Total
Kharif Crops							
Paddy	Stalks	12.00	0.00	0.69	2.50	0.00	16.89
	husk	0.00	0.00	0.00	2.50	0.00	2.50
	Bran	100.00	0.00	0.00	0.00	0.00	100.00
	Hull	100.00	0.00	0.00	0.00	0.00	100.00
Maize	Stalks	97.50	0.00	0.00	2.50	0.00	100.00
	Cobs	0.00	97.50	0.00	2.50	0.00	100.00
Moong	Stalks	97.50	0.00	0.00	2.50	0.00	100.00
	Husk	97.50	0.00	0.00	2.50	0.00	100.00
Ground nut	Stalks	97.50	0.00	0.00	2.50	0.00	100.00
	Shell	0.00	97.50	0.00	2.50	0.00	100.00
Sugar cane	Tops & Leaves	97.50	0.00	0.00	2.50	0.00	100.00
	Trash	0.00	30.69	0.00	2.50	0.00	33.19

Crop	Type	Fodder	Domestic Fuel	Thatching	Manure	Industrial	Total
Rabi Crops							
Wheat	Straw	97.50	0.00	0.00	2.50	0.00	100.00
	Pod	97.50	0.00	0.00	2.50	0.00	100.00
Barley	Stalks	97.50	0.00	0.00	2.50	0.00	100.00
Gram	Stalks	97.50	0.00	0.00	2.50	0.00	100.00
Arhar	Stalks	0.00	97.50	0.00	2.50	0.00	100.00
	Husk	97.50	0.00	0.00	2.50	0.00	100.00
Masoor	Stalks	97.50	0.00	0.00	2.50	0.00	100.00
Rape seed & mustard	Stalks	0.00	97.50	0.00	2.50	0.00	100.00
Sunflower	Stalks	0.00	97.50	0.00	2.50	0.00	100.00
Sesamum	Stalks	0.00	97.50	0.00	2.50	0.00	100.00
Dry chillies	Stalks	0.00	97.50	0.00	2.50	0.00	100.00
Cotton	Stalks	0.00	97.50	0.00	2.50	0.00	100.00
Fodder	Straw	97.50	0.00	0.00	2.50	0.00	100.00

Biomass Generation and Consumption

The total biomass generated in this district is analysed for its consumption in various sectors like domestic and industrial. The following table gives the clear picture of the biomass generation, and consumption in MT/year in Patiala district.

Biomass Generation: 37,92,252
Biomass Consumption: 25,26,663

Table 25. Detailed Statement of Biomass Generation, Consumption and Surplus

(Quantity in MT/year)

Crop Name	Residue Type	Biomass Generation	Consumption MT/yr								Total Cons.	Surplus		
			Fodder	Domestic Fuel	Thatching	Manure	Commercial	Industrial	Exp. Perennial [Rs/Ton]	Imp. Perennial [Rs/Ton]		Basic (QBS)	Productive (QPS)	Net (QNS)
Kharif Crops														
Paddy	Straws	1044624	125355	0	7201	26116	0	0			158672	912068	899011	899011
	husk	136255	0	0	0	3406	0	0			3406	136255	134552	134552
	Bran	45418	45418	0	0	0	0	0			45418	0	0	0
	Hull	227092	227092	0	0	0	0	0			227092	0	0	0
Maize	Stalks	22481	21919	0	0	562	0	0			22481	0	0	0
	Cobs	3441	0	3355	0	86	0	0			3441	3441	1721	1721
Moong	Stalks	209	204	0	0	5	0	0			209	0	0	0
	Husk	20	19	0	0	0	0	0			20	0	0	0
Ground nut	Stalks	166	161	0	0	4	0	0			166	0	0	0
	Shell	23	0	23	0	1	0	0			23	23	12	12
Sugar cane	Tops & Leaves	21147	20618	0	0	529	0	0			21147	0	0	0
	Trash	14098	0	4326	0	352	0	0			4678	14098	11759	11759
Rabi Crops														
Wheat	Straw	1572192	1532887	0	0	39305	0	0			1572192	0	0	0
	Pod	196524	191611	0	0	4913	0	0			196524	0	0	0
Barley	Stalks	10918	10645	0	0	273	0	0			10918	0	0	0
Gram	Stalks	189	184	0	0	5	0	0			189	0	0	0
Arhar	Stalks	1175	0	1146	0	29	0	0			1175	1175	588	588
	Husk	144	141	0	0	4	0	0			144	0	0	0
Masoor	Stalks	990	965	0	0	25	0	0			990	0	0	0
Rape seed & mustard	Stalks	1938	0	1889	0	48	0	0			1938	1938	969	969
Sun flower	Stalks	2265	0	2208	0	57	0	0			2265	2265	1132	1132
Sesamum	Stalks	26	0	25	0	1	0	0			26	26	13	13

Crop Name	Residue Type	Biomass Generation	Consumption MT/yr								Total Cons.	Surplus		
			Fodder	Domestic Fuel	Thatching	Manure	Commercial	Industrial	Exp. Perennial [Rs/Ton]	Imp. Perennial [Rs/Ton]		Basic (QBS)	Productive (QPS)	Net (QNS)
Dry chillies	Stalks	1180	0	1150	0	29	0	0			1180	1180	590	590
Cotton	Stalks	2403	0	2343	0	60	0	0			2403	2403	1202	1202
Fodder	Straw	123455	120368	0	0	3086	0	0			123455	0	0	0
Total		3428373	2297589	16465	7201	78897	0	0			2400152	1074872	1051547	1051547
Forest & Other Waste lands		249789	0	73673	0	0	0	39188			112861	249789	212952	173765
Agro Industries														
Saw Mill	Wood chips	11700	0	0	0	0	0	11700			11700	11700	11700	0
	Saw dust	1950	0	0	0	0	0	1950			1950	1950	1950	0
Sugar Mills	Bagasse	100440	0	0	0	0	0	100440			0	100440	100440	0
Total		114090	0	0	0	0	0	114090			13650	114090	114090	0
Grand Total		3792252	2297589	90138	7201	78897	0	153278			2526663	1438751	1378589	1225311

Power generation potential in the district

The total biomass generated in this district is anlysed depending on its utilisation, as essential class and non-essential class. The quantity of fodder from these crops is taken as essential and rest is taken as non-essential class.

The total biomass generated in this district from all sources like Agriculture crop residues, Forest & other wastelands and Agro-Industry is 3792252 MT/year. Essential class is 2353501 MT/year and non-essential class is 1438751 MT/year. The basic surplus available from this district is 1338311 MT/year, productive surplus is 1278149 MT/year, and net surplus is 1225311 MT/year.

Table 26. Classification of available biomass

Crop Name	Residue Type	Generation	Classification		Surplus		
			Essential	Non-Essential	Basic (QBS)	Productive (QPS)	Net (QNS)
Kharif Crops							
Paddy	Straw	1044624	132556	912068	912068	899011	899011
	husk	136255	0	136255	136255	134552	134552
	Bran	45418	45418	0	0	0	0
	Hull	227092	227092	0	0	0	0
Maize	Stalks	22481	22481	0	0	0	0
	Cobs	3441	0	3441	3441	1721	1721
Moong	Stalks	209	209	0	0	0	0
	Husk	20	20	0	0	0	0
Ground nut	Stalks	166	166	0	0	0	0
	Shell	23	0	23	23	12	12
Sugar cane	Tops & Leaves	21147	21147	0	0	0	0
	Trash	14098	0	14098	14098	11759	11759
Rabi Crops							
Wheat	Straw	1572192	1572192	0	0	0	0
	Pod	196524	196524	0	0	0	0
Barley	Stalks	10918	10918	0	0	0	0
Gram	Stalks	189	189	0	0	0	0
Arhar	Stalks	1175	0	1175	1175	588	588
	Husk	144	144	0	0	0	0
Masoor	Stalks	990	990	0	0	0	0
Rape seed & mustard	Stalks	1938	0	1938	1938	969	969
Sun flower	Stalks	2265	0	2265	2265	1132	1132
Sesamum	Stalks	26	0	26	26	13	13
Dry chillies	Stalks	1180	0	1180	1180	590	590
Cotton	Stalks	2403	0	2403	2403	1202	1202
Fodder	Straw	123455	123455	0	0	0	0
Total		3428373	2353501	1074872	1074872	1051547	1051547
Forest & Other Waste lands	Wood	249789	0	249789	249789	212952	173765
Agro Industries							
Saw Mill	Wood	11700	0	11700	11700	11700	0

Crop Name	Residue Type	Generation	Classification		Surplus		
			Essential	Non-Essential	Basic (QBS)	Productive (QPS)	Net (QNS)
	chips						
	Saw dust	1950	0	1950	1950	1950	0
Sugar Mills	Bagasse	100440	0	100440	0	0	0
Total		**114090**	**0**	**114090**	**13650**	**13650**	**0**
Grand Total		**3792252**	**2353501**	**1438751**	**1338311**	**1278149**	**1225311**

It is assumed that the power plant will operate for 7000 hours per annum. Based on the calorific values and the operation of plant for 7000 hours, National Focal Point, Indian Institute of Science (IISc) Bangalore has provided the following data of crop residue required for 1 MW Generation per annum.

Table 27. Crop Residue Requirement per MW

Crop Name	Type	MW Year / KT
Paddy	Stalks	0.12
Paddy	husk	0.11
Paddy	Bran	0.11
Paddy	Hull	0.11
Jowar	Stalks	0.13
Bajra	Stalks	0.13
Bajra	Cobs	0.13
Bajra	Husk	0.12
Maize	Stalks	0.13
Maize	Cobs	0.14
Moong	Stalks	0.13
Moong	Husk	0.12
Ground nut	Stalks	0.13
Ground nut	Shell	0.14
Sugar cane	Tops & Leaves	0.14
Sugar cane	Trash	0.14
Wheat	Straw	0.13
Wheat	Pod	0.14
Barley	Stalks	0.13
Gram	Stalks	0.13
Arhar	Stalks	0.13
Arhar	Husk	0.12
Masoor	Stalks	0.13
Rape seed & mustard	Stalks	0.13
Sun flower	Stalks	0.13
Sesamum	Stalks	0.13
Linseed	Stalks	0.13
Dry chillies	Stalks	0.13
Cotton	Stalks	0.14
Fodder	Straw	0.13
Agro Industrial Residue	Wood Chips	0.14
Agro Industrial Residue	Saw Dust	0.14
Agro Industrial Residue	Bagasse	0.07

Total power generation potential has been calculated, assuming that the plant will operate for 7000 hours per annum with a plant load factor (PLF) of 75 %. From the calculations made, basic surplus is 164.97 MW, productive surplus is 156.89 MW, and net surplus is 149.49 MW.

Table 28. Power generation potential based on various surpluses

Crop Name	Residue Type	Power Potential (MW)		
		Basic (PBS)	Productive (PPS)	Net (PNS)
Kharif Crops				
Paddy	Stalks	109.45	107.88	107.88
	husk	14.99	14.80	14.80
Maize	Cobs	0.48	0.24	0.24
Ground nut	Shell	0.0033	0.0016	0.0016
Sugar cane	Trash	1.97	1.65	1.65
Rabi Crops				
Arhar	Stalks	0.153	0.076	0.076
Rape seed & mustard	Stalks	0.25	0.13	0.13
Sun flower	Stalks	0.29	0.15	0.15
Sesamum	Stalks	0.0034	0.0017	0.0017
Dry chillies	Stalks	0.153	0.077	0.077
Cotton	Stalks	0.34	0.17	0.17
Total		128.09	125.17	125.17
Forest & Other Waste lands	Wood	34.97	29.81	24.33
Agro Industries				
Saw Mill	Wood chips	1.64	1.64	0.00
	Saw dust	0.27	0.27	0.00
Sugar Mills	Bagasse	0	0	0.00
Total		**1.91**	**1.91**	**0**
Grand Total		**164.97**	**156.89**	**149.49**

Biomass Collection Mechanism

The surplus crop residues can be collected from the farmers at the time of harvest. A mechanism is required to be designed to collect the seasonally available crop residues and store for off seasonal usage. The following table gives the availability season and price per MT of surplus biomass in this district.

Table 29. Price range and seasonal availability of biomass

S No	Biomass	Availability season	Current price range at which traded per MT
1	Paddy straw	Oct – Dec	Rs.500 - 550
2	Wheat straw	Mar – May	Rs.1000 -1050
3	Sugarcane trash	Oct - Feb	Rs. 450 - 500
4	Sugarcane T & L	Oct - Dec	Rs.500 -550
5	Sesamum stalk	Mar - Apr	Rs.450 - 500
6	Firewood	All year	Rs 1100 -1200
7	Tree Biomass	All Year	Rs. 950 - 1250

The transportation of biomass in the district is generally done on tractor trolleys. The cost of transportation depends upon the number of rounds that the trolley has to make rather than the weight of the biomass but generally each trolley can carries 4 - 5 MT depending upon the type of biomass. In general, a sum of Rs 200-250 is charged for each trip of biomass carriage.