Low-Carbon Clean Technology for Waste Energy Recovery in Power Plants Based on Green Environmental Protection

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Abstract

With the development of biomass power generation technology, biomass waste has a more excellent recycling value. The article establishes a biomass waste inventory model based on the material flow analysis method and predicts raw material waste's energy utilization potential. The results show that the amount of biomass waste generated from 2016 to 2020 is on the rise. In 2020, biomass waste's energy utilization can reach 107,802,300 tons, equivalent to 1,955.28PJ of energy. Through biomass energy analysis and emission analysis, the results show that the biomass waste can generate 182.02 billion kW·h in 2020, which can replace 35.9% of the region's total power consumption, which is compared with the traditional power generation method under the same power generation capacity. Power generation can

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reduce SO_2 emissions by 250,400 tons, NOx emissions by 399,300 tons, and PM10 emissions by 49,700 tons. Reduce direct economic losses by 712 million yuan. Therefore, Chinese promotion of the recycling of biomass waste and the acceleration of the biomass energy industry's development is of great significance for reducing pollutant emissions and alleviating energy pressure.

Keywords: Green environmental protection, power plant, biomass waste, resource potential, waste recycling, environmental benefits.

1 Introduction

The conflict between energy and the environment has become a bottleneck restricting the sustainable development of the economy. The energy conversion of biomass waste is an effective means to resolve conflicts. Biomass waste has the advantages of a wide range of sources, a large amount of theoretically usable, and convenient access. It is the only renewable carbon source known as the "fourth-largest energy source in the world" after coal, oil and natural gas.

The utilization of biomass waste in foreign developed countries has a reasonably mature system. The research covers the impact of biomass energy on food, land, energy, economy, environment, etc., at the regional level of the country through empirical analysis and the improvement of utilization efficiency and other issues. Research on waste management and the biomass energy industry in China is still in its infancy [1]. Some scholars have carried out a quantitative analysis of particular biomass wastes from a macro level regarding biomass resources. Still, the types of biomass wastes involved are not comprehensive and lack a regional level. However, other research aspects are mainly based on qualitative analysis, such as introducing foreign experience, describing the current situation, existing problems, development trends and development prospects and policy directions, and rarely involving quantitative assessment of energy substitution and environmental benefits. Based on the above situation, this article draws on the research methods of solid waste management, builds a biomass waste analysis model based on the basic ideas of the material flow analysis method to analyse the biomass waste inventory quantitatively, and uses the energy analysis method in combination with the characteristics of energy use in China Explore the energy utilization potential and environmental benefits of biomass waste.

2 Usable Amount of Biomass Waste

Biomass waste is solid waste generated by humans in the process of using natural resources. This paper applies the basic idea of material flow analysis to establish a biomass waste inventory model. The model takes agriculture and forestry planting. The harvest as the starting point generates nodes from the interaction between human activities and biomass waste generation sources. It takes the final discharge of material waste into nature as the endpoint as the system boundary. Vertically, it is divided into material flow analysis and possible source utilization analysis of biomass waste. It is horizontally divided into the agricultural unit, urban unit, and forestry unit, as shown in Figure 1.

2.1 Agricultural Unit

The flow direction of the agricultural unit is crop harvesting, crop processing, and livestock breeding. Correspondingly, the generated biomass waste is classified into crop straw, agricultural product processing waste, and livestock manure.

(1) The amount of crop stalks in this paper is calculated by the production waste coefficient method (crop stalk coefficient). Since the straw coefficients of the same varieties of crops in different regions are different, it needs to be obtained from field experiments or observations. This article mainly calculates the amount of possible source utilization: the number of straw

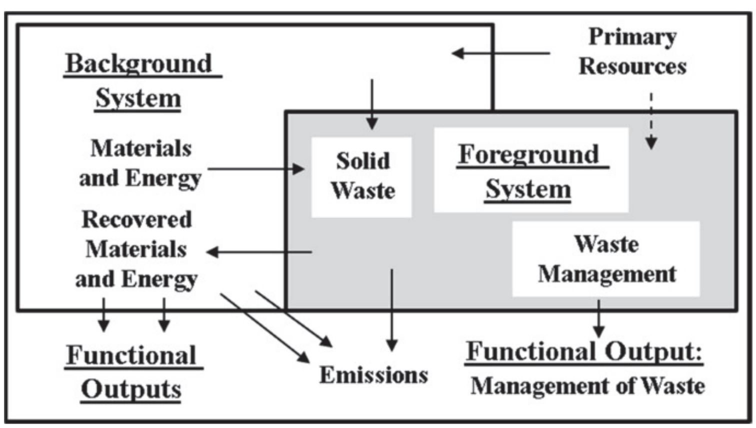

Figure 1 Biomass waste inventory model.

Table 1 Straw coefficient and collection coefficient of significant crops

Crop	Straw Coefficient W	Dry Weight Ratio S	Utilization Factor α	Low Calorific Value/kJ
Paddy	0.95	0.94	0.45	16200
Wheat	1.17	0.87	0.45	15974
Corn	1.05	0.85	0.45	15831
Beans	1.36	0.9	0.45	12645
Tubers	0.69	0.88	0.45	13142
Peanut	0.8	0.85	0.45	13543
Cotton	2.62	0.85	0.45	17111
Millet	1.12	0.85	0.45	18298
Beet	1.6	0.25	0.45	19083
Other	1.6	0.75	0.45	15494

resources used as energy in a particular area. Therefore, we should eliminate the used straw returning to the field and feed processing [2]. After research, we get that the utilization coefficient of crop straw for energy use is 45% (Table 1).

$$P_1 = \sum_{r}^{n} R_\gamma \times W_\gamma \times S_\gamma \times \alpha \tag{1}$$

In formula (1) P_1 represents the possible source utilization of agricultural resource waste (ten thousand tons); n is the type of crop, γ is the number of each straw crop, R_γ represents theγ annual output of the first crop (t); W_γ is the first crop The straw coefficient of the γ crop straw; S_γ is the dry weight ratio of the γ crop straw. α is the utilization factor of crop straw used as energy.

Crop yield has a direct impact on straw resources. As shown in Table 2, the main crops showed a steady upward trend from 2016 to 2020, and they have quite a wealth of straw resources with stable yields. From 2016 to 2019, the usable straw resources rose from 17.6473 million tons to 19.5465 million tons, only in 2020. The slight decrease in available straw resources reached 19.38 million tons, but the decrease was minimal. It is speculated that some crops may be reduced in production due to climatic reasons. It can be seen from Figure 2 that the primary sources of possible straw utilization are field crops such as wheat and corn. Taking 2020 as an example, the possible source of straw in the whole year is 310.31PJ, and the annual output of wheat and corn stalks are 7,901,300 tons and 8,609,600 tons, accounting for 85% of the

Table 2 The possible sourced straw yields of significant crops from 2016 to 2020

Crop	2016	2017	2018	2019	2020
Corn	796.46	862.01	862.57	888.89	860.96
Cheat	690.88	715.36	748.13	770.39	790.13
Peanut	47.24	47.07	46.31	47.33	46.89
Tubers	31.02	33.04	35.14	35.23	31.58
Beet	35.27	33.49	42.79	53.45	54.45
Paddy	28.05	30.37	26.13	30.7	28.39
Millet	19.96	22.09	20.69	22.93	24.29
Cotton	74.59	85.62	73.36	59.59	55.33
Beans	22.41	23.65	21.36	20.01	22.33
Other	18.85	21.51	32.41	26.13	23.64
Total	1764.7	1874.2	1908.9	1954.6	1938

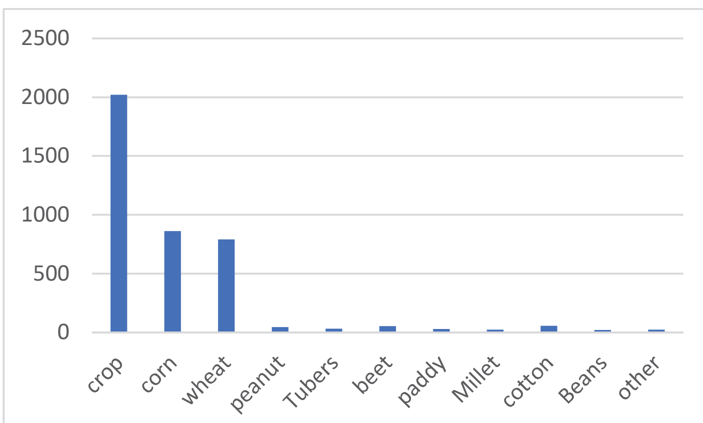

Figure 2 The possible source utilization of various crop straws in 2020.

total straw, which is equivalent to 265.69PJ. The yields of other major crops are as follows: cotton, sugar beet, peanut, etc.

(2) Crop processing waste refers to the residues produced during the rough processing of crops, such as rice husks, corn cobs, etc., but excluding wheat bran, bran and other acceptable processing by-products. Compared with field straw, processing by-products have their characteristics. Because they are the products after the leading products' primary processing, the by-products' seasonal performance is relatively weak, and the collection process before

Table 3 Processing waste coefficient of each major crop

Crop	Processing factor J	Utilization factor S	Low calorific value/kJ
Corn	0.17	0.95	17 725
Wheat	0.12	0.95	14 224
Peanut	0.25	0.95	17 717
Tubers	0.17	0.95	16 513
Beet	0.27	0.95	16 600
Millet	0.27	0.95	14 224
Paddy	0.38	0.95	14 224
Cotton	0.27	0.95	17 492
Beans	0.17	0.95	14 224
Other	0.15	0.95	14 224

large-scale use is relatively simple [3]. Presently, the primary use of processing waste is direct combustion, so this article sets the availability coefficient of processing waste to 0.95. The weight ratio of cotton clothing divided into lint to seed cotton is 0.38, and the sugar beet moisture content is recorded as 75%.

$$P_2 = \sum_{r}^{n} R_\gamma \times J_\gamma \times S_\gamma \tag{2}$$

In formula (2) P_2 represents the possible source utilization of agricultural processing waste (wt); J_γ is the γ crop processing waste coefficient, that is, the relative mass density of processing waste in its economic output; S_γ is the γ crop The availability factor of processing waste. The processing waste coefficient of each major crop is shown in Table 3.

It can be seen from Table 4 that agricultural processing waste and straw yield are closely related to grain output. From 2016 to 2020, the possible source utilization of processed waste will increase from 5.6144 million tons to 611.63 million tons. Available energy in 2020 The amount of processing waste is 97.68PJ. The processing waste mainly includes rice husks, peanut husks, and corn cobs, which account for more than 80% of the total (Figure 3). It can be seen that processing wastes that have not received attention have objective resources.

(3) The economy develops rapidly. To meet people's demand for meat, eggs, milk and other poultry products, the animal husbandry industry develops in a blowout manner. Taking 2020 as an example, the leading livestock, beef

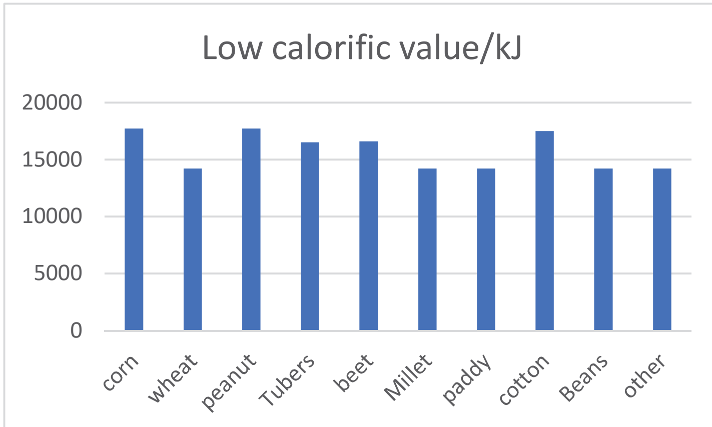

Figure 3 The possible source utilization of crop processing waste in 2020.

Table 4 The output of processing waste that may be sourced from major crops in 2016–2020

Crop	2016	2017	2018	2019	2020
Corn	202.28	218.92	219.06	225.75	218.66
Wheat	223.08	230.98	241.56	248.75	255.12
Peanut	35.43	35.31	34.73	35.5	35.16
Tubers	26.98	28.73	30.56	30.63	27.46
Beet	12.25	11.63	14.86	18.56	18.91
Paddy	11.16	12.08	10.39	12.21	11.29
Millet	6.73	7.45	6.98	7.74	8.19
Cotton	29.74	34.13	29.25	23.76	22.06
Beans	9.88	10.43	9.43	8.83	9.85
Other	3.93	4.48	6.75	5.44	4.92
Total	561.4	594.1	603.5	617.1	611.6

cattle, broilers, pigs, and sheep, will be slaughtered [4]. They were 3.64 million heads, 624.3 million heads, 41.32 million heads and 22.3 million heads. It can be seen that there is a considerable amount of livestock manure. Besides, the proportion of large and medium-sized farms has increased year by year. Compared with traditional natural stocking methods, large and medium-sized farms generally adopt a centralized feeding method. The manure is concentrated and easy to collect, which also provides a reliable guarantee for use.

Table 5 Pollution and discharge coefficients of various types of livestock and poultry manure and urine

Livestock and Poultry	Feeding Cycle/d	Excretion Coefficient (/kg·d^{-1})	Collection Factor	Gas Production Rate (/m^3·kg^{-1})
Beef cattle	365	34.99	0.5	0.5
Cows	365	41.1	0.5	0.5
Broiler	55	0.1	0.4	0.8
Laying hen	365	0.15	0.4	0.8
Number of pigs	199	9.25	0.6	0.6
Sheep	365	3.6	0.7	0.6
Duck and goose	210	0.12	0.7	0.6
Horse donkey mule	365	13.9	0.8	0.6

We made appropriate corrections to the production and discharge coefficients based on the number of days in each stage of livestock breeding and the evaluation results of the "Handbook of Poultry and Poultry Breeding Sources and Pollution Coefficients in the North China Region" issued by China in 2015 (Table 5). According to the 2016 "China Environmental Statistics Yearbook," Chinese livestock and poultry manure removal volume were 19.505 million tons, accounting for only 0.90% of the livestock and poultry manure production, and the amount of harmless treatment was even less at 6.908 million tons. Therefore, the utilization rate of poultry manure can be regarded as 100% in this paper.

$$P_3 = \sum_{r}^{n} S_\gamma \times T_\gamma \times X_\gamma \times J_\gamma \times C_\gamma \tag{3}$$

In formula (3), P_3 is the annual manure production, n is the number of livestock and poultry species, γ is the number of each poultry species, is the slaughter volume, T_γ is the feeding period, X_γ is the excretion coefficient, J_γ is the collection coefficient, and C_γ is Gas production coefficient.

Table 6 shows the availability of livestock manure from 2016 to 2020. The results show that due to the stable structure of livestock and poultry breeding in recent years, the overall output has not changed much. In 2020, the amount of manure that may be used as a source will reach 106,392,800 tons, and the theoretical production of biogas is equivalent to 1,299.01PJ. As the output of pigs, sheep, and poultry increases year by year, the manure output of large and medium-sized livestock is relatively high. Taking 2020 as an example,

Table 6 2016–2020 various types of livestock manure can be used as energy

Livestock and poultry	2016	2017	2018	2019	2020
Beef cattle	2493.03	2352.35	2370.55	2270.75	2387.92
Cows	394.97	386.84	397.33	403.42	409.35
Broiler	121.22	124.81	138.17	136.51	138.31
Laying hen	357.1	367.7	407.13	402.23	407.3
Pig	4299.5	4308.1	4502.8	4581.37	4640.1
Sheep	2112.5	2019.2	2031.2	2061.09	2070.1
Duck and goose	204.7	210.8	233.3	230.57	233.8
Horse, donkey and mule	343.1	343.1	340	345.99	352.4
Total	10326.2	10113	10420.6	10431.9	10639.3

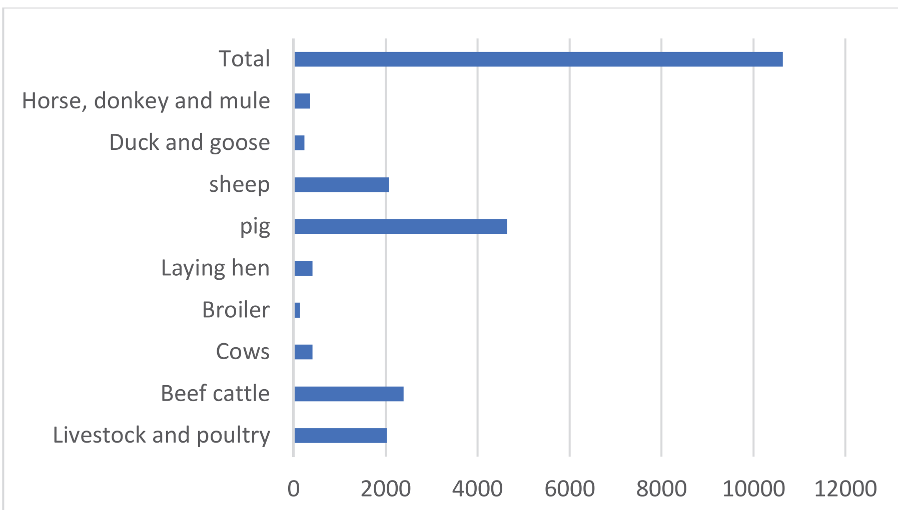

Figure 4 Biogas produced by various types of livestock manure converted into energy in 2020.

pig manure output will reach 46.402 million tons, equivalent to 582.08PJ of energy (Figure 4). Followed by beef cattle and sheep, small poultry, although the amount of slaughter is higher, the amount of manure produced is small. The collection is more complex, the scale of geese and duck breeding is small, the number of horses, donkeys and mules is small, and the amount of livestock manure is the least.

2.2 Forestry Unit

The forestry unit's material flow direction starts from the growth of forestry resources to the end of wood processing. Corresponding to the biomass waste, the used firewood forest is removed. The usable energy biomass waste includes two major categories: forestry resource growth residues and wood processing Use leftovers.

(1) The growth surplus of forestry resources means that the forest does not form forest harvesting products and unused branches, stubs, shrubs, stumps, and withered trees during the logging operations such as primary cutting, young forest tending, low-yield forest transformation, and mountain production [5]. Falling wood, abandoned timber and truncated logging residues; forest logging residues are mainly shrub stubble residues, economic forest logging residues, and urban greening pruning. The available amount is shown in formula (4):

$$P_4 = \sum_{r}^{n} L_r \times Z_r \times Z_r \tag{4}$$

In formula (4), P_4 is the resource amount of tree growth residues L_r is the γ tree resources, Z_r is the conversion coefficient of the r tree residues, and Z_r is the available coefficient of the γ tree residue.

According to the National Greening Commission's statistics, the collectible amount of urban greening and pruning in China is 20 million tons. The total urban afforestation area is 142,000 hm^2, accounting for 7% of the total. Million t. Due to the high stability of forest resources and no significant changes in the short term, only the production of biomass waste used by forestry in 2020 is counted (Table 7). Among them, shrub forest 111.4 hm^2 and economic forest 200.1 hm^2, the possible source utilization of forestry biomass waste are 2.2157 million tons and 3.130 million tons, and the total possible source utilization amounts to 6,746,300 tons. According to the average low calorific value of forestry, biomass is 20 GJ/t, the available energy of forestry biomass waste is 134.93PJ in 2020.

(2) Wood processing residues refer to the production and processing residues formed during the production or processing of forestry products, such as waste bark, wood chips and shavings in the production of forest products by pulp mills sawmills. The amount of forestry processing residues is about 15% to 34% of the log, and the output ratio of forestry processing residues is calculated at 25%. Considering that the processing residues are mostly generated and treated as waste in the factory, which is ignored in the collection

Table 7 Biomass waste available for forestry in 2020

Forestry Residues	Shrub Stubble Residue	Economic Forest Felling Residue	Greening and Pruning Residues	Total
Total resources/$\times 10^3$hm^2	119.9	217.4		
Residual conversion factor/%	33	100		
Weight loss (/t·hm^{-2})	10	7.2		
Energy availability coefficient/%	56	20		
Available amount/(ten thousand tons)	221.57	313.06	140	674.6

Table 8 2016–2020 utilization of wood processing residues

Area	2016	2017	2018	2019	2020
Beijing	2.5	2.5	3.5	5.25	3.25
Tianjin City	5.25	2.5	2.75	3.75	3.75
Hebei Province	17.75	17.75	18.75	21.25	22.5
Total	25.5	22.75	25	30.25	29.5

process, the collection ratio is 100%. According to Table 8, Hebei is the primary source of forest biomass waste, accounting for more than 70% of the forestry biomass waste that can be used. Except for a slight decline in 2016–2017, the output is on the rise. The average forestry processing in 5 years the possible source utilization of waste amounts to 266,000 tons, equivalent to 5.9 PJ of energy.

2.3 City Unit

Urban usable biomass waste mainly includes two major categories: municipal solid waste and faces. According to the "China Statistical Yearbook," Chinese urban waste is mainly processed in three ways: landfill, incineration, and composting. A Sanitary landfill is the only treatment method without resource utilization. This article regards the number of sanitary landfills as the available amount (Table 9).

Urban excrement is another significant component of urban biomass. Both Beijing and Tianjin belong to high population concentration areas, and infrastructure construction is relatively complete [6]. The excrement is removed and transported separately, and other areas are through sewage pipes. The network relies on the harmless treatment of urban sewage and

Table 9 2016–2020 urban waste biomass energy utilization

Sanitary landfill	2016	2017	2018	2019	2020
Manure removal volume	882.4	844.5	856.7	969.2	967.8
Sanitary landfill	331.7	324.2	325	333.3	345.7

cannot be used as an energy source. Therefore, this article uses the excrement removal volume released by the National Bureau of Statistics of China as the calculation basis.

Urban landfill mixed waste contains a large amount of organic matter such as kitchen waste, paper, etc., accounting for more than 50% of the total dry weight. According to the second higher moisture content, it is generally about 25%. Landfill treatment produces a large amount of waste under anaerobic conditions. Landfill gas, which contains as much as 50% methane, can be effectively used for energy applications. Atomic analysis of landfilled domestic waste through a stoichiometric model yields the molecular structural formula: $C_6H_{9.6}O_{3.5}N_{0.28}S_{0.2}$ ignores non-methane compounds such as N and S. The molecular formula of mixed organic matter can be simplified to $C_6H_{10}O_4$. The chemical formula of anaerobic biogas production is as follows:

$$C_6H_{10}O_4 + 1.5H_2O = 3.25CH_4 + 2.75CO_2 \tag{5}$$

The content of easily degradable mixed organic matter in urban landfill mixed domestic waste is 70%, and the moisture content is 25%. From the equation, it can be concluded that after the organic matter in each ton of municipal solid waste is wholly degraded, 209.7m^3 of methane gas can be produced, which is equivalent to 4.4GJ of energy. From Table 10, it can be calculated: The amount of energy available for urban landfill mixed waste in 2020 Up to 42.40PJ.

3 Biomass Waste Energy Substitution and Environmental Benefit Analysis

3.1 Energy Substitution Benefits of Biomass Waste

Table 10 provides statistics on the amount of usable energy and theoretical energy of biomass waste in 2020. In 2020, the total amount of biomass waste that may be sourced and utilized will reach 107,802,300 tons, equivalent to 1955.28PJ of theoretical energy. Among them, agricultural units are the primary source of biomass energy accounting for 87% of the total, and the

Table 10 The quality and corresponding energy value of available biomass waste in 2020

Biomass Waste	Total Mass/10,000t	Theoretical Energy/PJ
Agricultural unit		
Straw waste	1938	310.31
Processing by-products	611.63	97.68
Poultry manure	6212.97	1299.01
Forestry Unit		
Woodland growth residue	674.63	134.93
Wood processing residues	29.5	5.9
City Unit		
Landfill volume	967.8	42.4
Manure removal volume	345.7	65.05
Total	10780.23	1955.28

potential sourced utilization potential is 1707PJ, as shown in Table 10. In 2020, the amount of usable energy and theoretical energy of biomass waste were counted. In 2020, the total amount of biomass waste that may be sourced and utilized will reach 107,802,300 tons, equivalent to 1955.28PJ of theoretical energy [7]. Among them, agricultural units are the primary source of biomass energy accounting for 87%. The potential source of utilization is 1707PJ, poultry energy consumption Volume refers to the total energy use of mining and oil and gas extraction, production, forestry, construction, transportation, agriculture, residential, public management commercial institutions. These energy sources include direct energy consumption, primary electric energy such as solar energy, wind energy, tidal energy, and indirect consumption of primary energy converted into secondary energy. The energy output is released during the energy use process. Biomass waste needs to be processed before it can be used as an energy source. Therefore, this article uses the existing domestic biomass power generation technology as an example to calculate the amount of biomass waste that can be used for power generation.

As shown in Table 11, the power generation efficiency of biomass waste is not high, and the conversion efficiency is about 31% to 40%. Under these conditions, the total power generation capacity of biomass waste in 2020 is about 182.091 billion kW·h, and the power generation potential of agricultural units is the largest. Among them, the power generation of livestock manure biogas reached 111.859 billion kW·h. The forestry unit's

Table 11 Power generation from biomass waste in 2020

Biomass Waste	Total Mass/10,000t	Theoretical Energy/PJ	Conversion Efficiency η/%	Power Generation (/100 million kW·h)
Agricultural unit				
Straw waste	1938	310.31	40	344.79
Processing by-products	611.63	97.68	40	108.53
Poultry manure	6212.97	1299.01	31	1118.59
Forestry Unit				
Woodland growth residue	674.63	134.93	40	149.92
Forestry production surplus	29.5	5.9	40	6.56
City unit				
Landfill volume	967.8	42.4	31	36.51
Manure removal volume	345.7	65.05	31	56.02
Total				1820.91

power generation and the urban units were 15.648 billion kW·h and 9.253 billion kW·h. Electricity consumption in 2020 will be 506.182 billion kW·h, of which local power generation will reach 348.939 billion kW·h, thermal power generation will be 340.868 billion kW·h, hydropower generation will be 1.585 billion kW·h, and biomass waste will replace 182.091 billion power generation. kW·h, which occupies 35.9% of the total electricity and 52.1% of the electricity generation in the region, effectively reduces the electricity supply pressure.

3.2 Environmental Benefit Analysis of Biomass Waste Power Generation

Coal-fired thermal power plants can cause severe air pollution. In the Air Pollution Prevention and Control Action Plan issued by the State Council in 2020, it is proposed that thermal power units in the power grid will be phased out, and the proportion of coal power in the installed capacity of the North China power grid will be reduced. "Development Report 2015" shows that thermal power generation technology is mainly based on CF power generation technology. Biomass power generation technology is based on 4MW gasification power generation units and biogas power generation direct-fired

Table 12 List of environmental emissions for power generation

	CO_2	SO_2	NOx	PM10
Gasification power generation	0.73	2.58×10^{-4}	1.11×10^{-4}	3.37×10^{-4}
Biogas direct combustion power generation	0.41	0.27×10^{-4}	6.61×10^{-4}	0.36×10^{-4}
Thermal power generation (C-F)	1.07	1.48×10^{-3}	2.67×10^{-3}	0.41×10^{-2}

power generation units [8]. This article will pass the life cycle assessment of these three types of power generation technologies. The emission inventory (Table 12) conducts a quantitative study on thermal power generation and biomass power generation's environmental benefits.

In 2020, biomass waste power generation can replace the electricity supply of 182.091 billion kW·h. According to the power generation, environmental emission list, biomass waste power generation can emit $SO_2 1.90$ million tons, $NO_x 8.68$ million tons, and $PM_{10} 2.49$ million tons. Compared with thermal power generation, biomass power generation can reduce SO_2 emissions by 250,400 tons, NO_x emissions by 399,300 tons, and PM_{10} emissions by 49,700 tons.

CO_2 Emissions have been reduced from 194.8384 million tons to 94.171 million tons. The carbon emitted from biomass combustion is considered carbon-neutral because the same amount of carbon dioxide absorbs carbon dioxide in the atmosphere during plant growth. In particular, the biomass transformed by plants, which itself grows by absorbing carbon dioxide, can be calculated without considering the CO_2 released by biomass power generation when calculating environmental benefits [9]. Therefore, thermal power generation's replacement with biomass waste power generation has huge environmental emission reduction benefits.

The total emissions of various pollutants in 2020 are shown in Table 13. Among them, the main source of thermal power generation SO_2 and NO_x the replacement of thermal power generation by biomass power generation can significantly reduce the emissions of SO_2 and NO_x. After the replacement, the emissions of SO_2 and NO_x are reduced to 122.75. Ten thousand tons and 1.5464 million tons, respectively, accounted for 16.95% of total SO_2 emissions; 20.52% of total NO_x emissions. The overall contribution rate of thermal power generation to H emissions is relatively low, so the total amount of PM10 also has a smaller decline. The emission reduction accounts for 2.49% of the total [10]. Regarding the "Management Measures for the Collection of Pollutant Discharge Fees," that is, sulfur dioxide is 0.95

Table 13 Biomass power generation emission reduction potential and environmental, economic value in 2020

Pollutants	SO_2	NOx	PM10
Total emissions/(ten thousand tons)	147.8	194.58	199.46
Emission reduction/(10,000 tons)	25.05	39.94	4.97
After emission reduction/(10,000 tons)	122.75	154.64	194.49
Percentage/%	16.95	20.52	2.49
Environmental economic value/100 million yuan	2.38	3.79	1.08

yuan/kg; nitrogen oxide is 0.95 yuan/kg; PM10 refers to smoke and dust 2.18 yuan/kg, biomass power generation can directly reduce environmental, economic losses by about 726 million yuan.

4 Conclusion

Biomass resources have not yet been fully utilized. We should give full play to the advantages of concentrated science and technology to improve biomass waste resources' inefficiency as soon as possible. Strengthen policy incentives, improve the commercial process of biomass waste energy, and enable it to form an industrial concentration as soon as possible. Develop corresponding technologies in combination with future demand varieties, and accelerate the research and development and commercial application of biomass energy technology. Besides, speed up constructing the biomass waste collection management system, enhancing the supply of biomass raw materials, and introducing corresponding policy support to improve biomass energy's market competitiveness.

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