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Integrated Cost Dataset under the Whole Life Cycle of Biogas, Straw and Coal Power Generation

Wang, K. Y.[1] Wang, H. G.[2*]

1. School of Accounting, Zhejiang Gongshang University, Hangzhou 310018, China;
2. School of Economics and Management, Jiangxi Agricultural University, Nanchang 330045, China

Abstract: We calculate the production cost and revenue of biogas, straw and coal-fired power generation based on the 2018 research data of biogas power generation in Xinyu Nanying Reclamation Farm, the 2018 annual financial report data of Lankao Ruihua Environmental Power Co. and Datang Huayin Power Co. and then figure out the environmental cost per unit of power generation according to the emission inventory of biogas power generation, straw power generation and coal-fired thermal power generation to the environment. The integrated cost calculation dataset under the whole life cycle of biogas, straw and coal power generation is obtained. The dataset includes both tabular and graphic data. The table data are (1) basic data of biogas power generation in Xinyu Nanying Reclamation Farm (2018); (2) production cost and revenue of biogas, straw and coal-fired power generation (2018); (3) emission inventory of straw power generation to the environment; (4) emission inventory of biogas power generation unit electricity to the environment; (5) emission inventory of coal-fired power generation unit electricity to the environment; (6) emission reduction inventory of electricity from biogas power generation units to the environment. The image data are the information collected from the author's field research on biogas power generation. The dataset is archived in .xlsx and .jpg data formats, and consists of 4 data files with data size of 542 KB

Keywords: biomass power generation; life cycle evaluation; integrated cost per unit of power generation; biogas-straw-coal

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2021.04.03.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2021.04.03.V1.

1 Introduction

Global warming caused by the increase of greenhouse gas concentration has caused serious impact on the natural ecosystem and human living environment, which has become a major problem that urgently needs to be solved in human society today. The increase of greenhouse

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***Corresponding Author:** Wang, H. G., School of Economics and Management, Jiangxi Agricultural University, 412163218@qq.com

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gas concentration is closely related to NO_x, SO_2 and CO_2 released by fossil fuels. It is reported that 85% of SO_2, 75% of CO_2, and 35% of suspended particles in the atmosphere come from the combustion of fossils[1]. It is also known from the 2012 statistics of China's Annual Report on Environmental Statistics that 7.97 million tons of SO_2 and 10.187 million tons of NO_x were emitted by the power industry, and the economic losses from these emissions were 351.78 billion and 124 billion Yuan, respectively. On September 22, 2020, President Xi delivered an important speech at the general debate of the 75th session of the United Nations General Assembly, proposing that China will increase its independent national contribution, adopt more vigorous policies and measures, and strive to peak CO_2 emissions by 2030 and strive to achieve carbon neutrality by 2060. Therefore, the development and utilization of biomass energy, which is resource-rich, renewable and conducive to environmental improvement and sustainable development, has become a common issue for the power generation industry at home and abroad[2,3]. At present, most scholars have done a lot of research on environmental value criteria for pollutants[4], full-cycle emission inventories for straw, biogas and coal power generation[5–11]. The purpose of this paper is to compare the life-cycle costs of biogas, straw, and coal based on literature and field research data, and to provide scientific data to support biomass power generation subsidies, so as to realize the vision of "green water and green mountain is the golden mountain".

2 Metadata of the Dataset

The metadata of Life cycle cost dataset of biogas, straw and coal power generation dataset[12] is summarized in Table 1.

Table 1 Metadata summary of the Life cycle cost dataset of biogas, straw and coal power generation

Items	Description
Dataset full name	Life cycle cost dataset of biogas, straw and coal power generation
Dataset short name	Cost_BiogasStrawCoal_PowerGeneration
Authors	Wang, K. Y., School of Accounting, Zhejiang University of Technology and Business, 657839067@qq.com Wang, H. G., School of Economics and Management, Jiangxi Agricultural University, 412163218@qq.com
Year	2018 Data format .xlsx, .jpg Data size 75.75 KB
Data files	1 data worksheet with 6 table data; 2 picture data
Foundations	National Natural Science Foundation of China (71663030, 71963018)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
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Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[13]
Communication and searchable system	DOI，CSTR，Crossref，DCI，CSCD，CNKI，SciEngine，WDS/ISC，GEOSS

3 Data Development Methodology

3.1 Data Source

This data is based on the 2018 research data of Jiangxi Zhenghe Group Xinying Reclamation Farm large-scale biogas power generation base, the 2018 annual financial report data of two listed companies, Lankao Ruihua Environmental Protection Power Co. and Datang Huayin Power Co. , the Livestock and Poultry Farming Manure Pollution Monitoring and Accounting Methods and Production and Emission Coefficients Manual[14] and the existing published literature data[4–11]. The data development process includes: firstly, visiting power generation enterprises to investigate technical data, economic data, equipment manufacturing data and environmental data; secondly, collecting data published by relevant enterprises to the public and reviewing relevant literature data to calculate the economic cost per unit of power generation using the cost-benefit method and the environmental cost per unit of power generation using the environmental inventory; finally, based on the previously calculated data, the comprehensive cost per unit of power generation is derived.

3.2 Principal of Algorithms

To compare the integrated cost under the full life cycle of biomass and coal carbon, firstly, the energy consumption of 1 kWh full life cycle is obtained, then the environmental pollution emission inventory is calculated based on the energy consumption, then the environmental cost per unit of power generation cost is calculated based on the environmental pollution inventory and environmental value coefficient, again, the economic cost per unit of power generation is calculated based on the cost-benefit model, and the environmental abatement cost is calculated based on and finally, the integrated cost under the full life cycle of biogas, straw and coal power generation is obtained as follows.

(1) Environmental pollution calculation model per unit of power generation

The environmental cost generated by power generation from different raw materials is denoted as $EPS(k)$, and the calculation is based on the environmental pollution inventory and environmental value coefficient obtained from the literature, then we have equation (1).

$$EPS(k) = \sum_{j=1}^{m}\sum_{i=1}^{n} EP(j)_i \cdot V_j \tag{1}$$

where j denotes a certain emitted substance, mainly 8 kinds of CO_2, SO_2, NO_x, CO, TSP, dust, slag, wastewater, etc; V_j denotes the value coefficient of the j environmental pollutant; $EP(j)_i$ denotes the j pollutant emitted in the i stage of the whole life cycle.

(2) Economic cost calculation model per unit of power generation

The economic cost of power generation from different raw materials is denoted as $AP(k)$, then we have equation (2).

$$AP(k) = (\sum_{m=1}^{w} Q_m \cdot P_m - FC - VC(Q)) / Q \tag{2}$$

where Q denotes the amount of electricity generated, FC denotes the fixed cost, $VC(Q)$ denotes the variable cost, Q_m denotes the output of the m product, and P_m denotes the price of the m product.

(3) Environmental pollution reduction calculation model per unit of power generation

The environmental benefit of emission reduction of the first type of biomass power generation is denoted as $G(k)$, then we have equation (3).

$$G(k) = \sum_{j=1}^{n} V_{e_j} \cdot \Delta Q_j \tag{3}$$

where V_{ej} is the environmental value of the j pollutant, n is the total number of pollutants, and ΔQ_j is the emission reduction amount of the j pollutant.

4 Data Results

4.1 Dataset Composition

The dataset includes 1 data worksheet and 2 image data. The data worksheet contains 6 tables of data: table 1 is the basic data of biogas power generation in Xinyu Nanying Reclamation Farm (2018); table 2 is the production cost and revenue of biogas, straw and coal-fired power generation (2018); table 3 is the emission inventory of straw power generation to the environment, table 4 is the emission inventory of biogas power generation unit electricity to the environment; table 5 is the emission inventory of coal-fired power generation unit electricity to the environment; table 6 is the emission reduction list of biogas power generation units to the environment. The picture data are the information taken by the authors during the field research in Nanying Reclamation Farm, Xinyu city, Jiangxi province (Figure 1, 2).

Figure 1 Biogas digester

Figure 2 Biogas generator sets

4.2 Analysis of Data Results

4.2.1 Cost-benefit Analysis

From the production cost and revenue of biogas, straw and coal-fired power generation in Table 2, it can be seen that the unit cost of the three power generation modes are 1.03 Yuan/kWh, 0.743 Yuan/kWh and 0.41 Yuan/kWh, respectively, and the cost of biogas power generation is 2.5 times of the cost of coal power generation, and the cost of straw power generation is about 2 times of the cost of coal-fired power generation. In terms of the composition of power generation costs, fuel and power costs of biogas power generation, straw power generation and coal power generation account for 41.28%, 64.68.21% and 70.52% of the total power generation costs, respectively; depreciation of assets in fixed costs account for 14.07%, 10.24% and 12.57% of the total power generation costs, respectively; financial expenses account for 13.01%, 0% and 6.12%, and administrative expenses accounted for 24.35%, 10.55%, and 1.25% of the total generation costs, respectively. It can be seen that the installed scale of straw and coal-fired power generation is much larger than that of biogas power generation, and the installed scale of biogas power generation project is relatively small so that the profitability per unit cost is weaker than that of straw power generation and coal power generation. Therefore, the depreciation of assets and management costs in fixed costs has a great impact on the economic efficiency of biogas power generation. For straw power generation and coal-fired power generation, the cost of straw fuel is higher than coal, because the low calorific value of straw fuel is generally 8000 KJ/kg, which is much lower than coal, plus the light weight of straw, large volume, huge transportation costs, which will lead to high fuel costs. If the price of straw and coal continues to rise, the unit cost of power generation will continue to increase with poor control of the three costs, such as Huayin Power's loss of 62.71 million Yuan in 2018 [15].

4.2.2 Ecological and Environmental Cost Analysis

From table 3, table 4 and table 5 of the dataset, the main pollutants emitted to the environment by three kinds of (straw, biogas and coal) power generation are CO_2, SO_2, NO_x, CO, TSP and dust, etc. From the emission list of three substances for power generation, it is clear that straw power generation is much cleaner than coal power generation, with very few pollutants, especially SO_2 emission. The ecological environmental cost per unit of electricity generation is 0.02 Yuan for straw, 0.071 Yuan for biogas and 0.157 Yuan for coal[15].

4.2.3 Ecological Emission Reduction Benefit Analysis

CH_4 is the main constituent of biogas, and its global warming effect is 25 times higher than that of CO_2. Biogas power generation is a clean engineering, which can well deal with the waste pollutants of livestock farms, reduce the emission of pollutant gas CH_4 and COD in sewage, and the methane and digestate can also replace the use of chemical fertilizers; straw power generation project makes straw into a treasure, which can properly reduce the air pollution caused by arbitrary burning, although straw will also pollute the environment when burning for power generation, but straw will also absorb when growing A large amount of CO_2, the environment has a purifying effect; in addition, the straw ash generated after power generation is rich in chemical components such as potassium, magnesium, phosphorus and calcium, which can be used as efficient agricultural fertilizer back to the field. According to the calculation results in Table 6, it can be seen that biogas power generation can save 0.467 Yuan/kWh in terms of unit abatement cost[15].

5 Conclusion

Using the LCA and LCC methods to measure and evaluate the cost per 1 kWh, generation cost and emission reduction cost of biogas and straw biomass power generation and conventional coal power generation projects from both environmental and economic aspects. The economic cost of coal power generation is 0.41 Yuan/kWh, while the cost of biogas and straw power generation is 1.03 Yuan/kWh and 0.743 Yuan/kWh, respectively, but it is significantly superior in terms of environmental emission reduction and social benefits, if environmental externalities are considered, the cost of coal power generation can be increased to 0.567 Yuan/kWh, the cost of straw power generation can be increased to 0.767 Yuan/kWh, and the cost of biogas power generation is reduced to 0.634 Yuan/kWh.

Author Contributions

Wang, K. Y. collected the data and wrote the data paper. Wang, H. G. designed the algorithm and did the general design for the development of the dataset.

Conflicts of Interest

The authors declare no conflicts of interest.

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