Application of Cogeneration Technology Based on Energy Environment System Engineering

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Abstract. To explore the efficient energy production way integrating biomass energy, heat and electricity and achieve biomass power grid, a livestock waste treatment centre for the new mode of the enterprise was set up, to explore the establishment of livestock manure - methane – heat and power cogeneration - comprehensive utilization circular three-dimensional ecological comprehensive mode and virtuously circular new agricultural production system. The results showed that the use of this system could increase the annual income of 23.328 billion yuan for the biogas project and reduce emissions of 599 million t/tce greenhouse gas CO2. It showed that overall planning and design of CHP was conducted by using the method of system engineering. On the one hand, the pollutants produced by farm is conducted with unified reduction and harmlessness resource processing, so as to reduce the pollution of pollutants to people, water, and air environment. On the other hand, with the increasing demand for green and pollution-free agricultural products, the market of organic and inorganic compound fertilizers made from organic wastes is wide.

Keywords. Comprehensive model of cyclic three-dimensional ecology; new agricultural production system; CHP.

1. Introduction
Energy is the driving force and foundation of national economic development, and is closely related to people's daily life. For one hundred or two hundred years, people have been used to connect energy and coal, oil and natural gas. According to the current trend of mineral energy consumption, the wealth that has been accumulated over millions of years in the foreseeable future will eventually become scarce and depleted. From the perspective of long-term development, it is not suitable to set up economic development on the basis of non-renewable energy such as oil and coal. Only by saving energy and developing new alternative energy can this problem be solved [1].

At present, there are many problems in biomass energy development, such as high production cost, low energy output and low investment efficiency. Therefore, it is urgent to develop technologies that are suitable for all levels of economic development, improve energy efficiency and reduce production costs [2]. In conclusion, the development strategy of biomass energy in China must be combined with our country's resource tickets, combined with the needs of environmental protection and combined...
with the goal of increasing farmers' income, to take the development path of biomass energy suitable for China's national conditions.

According to the analysis of obstacles faced by cogeneration done by the National Renewable Energy Laboratory in 2000, technical barriers for thermal power plant to power grid have been solved. The policies and regulations that do not develop with the progress of technology are the real obstacle to the development of thermal barrier. Therefore, one of the important foundations for promoting the development of CHP is to adopt laws and regulations to ensure the right of grid connection of thermal power plants, and to break the situation that power companies use the standards of grid connection as tools to restrict competition. Texas and California have developed a grid access standard (CEC2002 and TNRCC2001) with state level [3, 4]. It provides a guarantee for the cogeneration power plant to obtain the grid access rights equal to the traditional power plant and the standards provide a relatively quick and standard operating procedures standard for all grid demand generators.

Nowadays, our country can produce a series of heating units with single capacity less than 50MW, and can also produce 200-300MW heating units in batch. China is cooperating with foreign countries to develop an advanced heating unit [5], which has a single capacity more than 300MW. China's manufacturing cogeneration boiler series includes pulverized coal boiler, reciprocating grate boiler and cyclone boiler. In recent years, circulating fluidized bed boiler has been used for the cogeneration project. The capacity of circulating fluidized bed boiler has been running is 75t/h and the capacity of circulating fluidized bed boiler to be put into operation is 200 t/h. There are only 220 thermoelectric enterprises, and the whole country's large and small thermal power plant (including less than 6000 kilowatts) is close to 2000 [6].

2. Technical scheme of combined power and power supply for energy and environmental engineering

2.1 Necessity and feasibility of research on cogeneration and development of energy and environmental engineering

At present, coal is mainly used as fuel for cogeneration in China, which is generally used in small and medium-sized cities and industrial areas. Firstly, they are used for fertilizer plants and chemical plants. Secondly, they are applied in iron and steel industry's low temperature and low pressure waste heat recovery. Thirdly, they are adopted for the thermoelectric combination of sugar industry. Fourthly, they are utilized in the comprehensive utilization of oil refining industry and the utilization of low temperature waste heat. It is a new idea to take rural areas as the main object of CHP. At present, it is rarely found that the potential of combining the pig farm with biomass as a fuel is also great.

As shown in Figure 1, according to the principle of ecology and biology, planning and design are conducted by the method of system engineering. The pollutants in aquaculture produces are carried out with centralized and unified harmless and resource processing, to set up the environmental new agricultural production system with livestock and poultry manure sewage treatment centre as the main body, and with developing "livestock manure - methane – heat and power cogeneration - comprehensive utilization" as the goal. At the same time, the water quality is improved, and the environmental pollution discharge fee is also saved. It has obvious economic, environmental and social benefits.
2.2 Technical scheme and description of energy environment engineering

This project aims at dealing with intensive fecal sewage, recovery and utilization of new energy and biogas, and harmless disposal of biogas. According to the characteristics of fecal sewage, water is treated by solid-liquid separation - preliminary precipitation - anaerobic digestion - aerobic biochemical discharge – standard discharge process. The main body treatment unit is anaerobic and aerobic two-stage biological treatment. Anaerobic digestion system mainly adopts the form of methane tank which is suitable for the characteristics of fecal sewage, and has stable operation and effect. The up-flow anaerobic digestion reactor is recommended, abbreviated as USR. The aerobic biochemical system is mainly, based on the requirements of treatment and design specification, choosing the suitable aerobic biochemical process. This design recommends the improved SBR processing technology. The biogas slurry irrigates the farmland. Fecal dung is used as the raw material for the organic fertilizer plant.

We use special cars to pull feces and sewage from farms and slaughterhouses to fecal and sewage treatment centres. They come to a centred pool, and through the slurry pump sump in ascending, enter the solid-liquid separator for slag water separation. Dry slag is transferred by spiral squeezing machine to manure storage tank and sewage enters the sedimentation tank. The sedimentation tank can separate SS easily perceptible in the sewage and discharge the sedimentation tank sludge to the dry field by way of slagging and the supernatant enters anaerobic tank for digestion. The sewage is decomposed and digested by most of the organic pollutants in the sewage by anaerobic acidification and meth nation of different anaerobic bacteria in the digestion tank (usually up to 80% or more). The effluent from the digestion tank will enter SBR into the anoxic section of the front part of the pond, and the bottom sediment of the digester will be regularly drained to the drying field. The sewage, in the SBR pool after combination of pre anoxic and anaerobic period and subsequent aerobic stage, completes the removal of organic pollutants, nitrogen and phosphorus in the sewage and the integrated design of biochemical area and the precipitation area is applied. At last, the effluent can reach the standard and be discharged directly or used in form of drip irrigation. In addition to dry sludge regularly removed off the precipitation area, the rest are back to the anoxic section of SBR pool. Dry slag and dry mud in the drying field are regularly transported to other places to produce economic benefit as agricultural fertilizer returning to the soil. A small amount of dry landfill leachate flows back into the collecting tank and then enters the processing system. The fecal residue is treated by mixing, fermentation, crushing and sieving.
Figure 2. Process flow chart of sewage treatment

Table 1. Taking pig farm pig manure sewage water quality as an example

| Name                  | Cods/mg/L | BOD5/mg/L | SS/mg/L | NH4-N | PH   |
|-----------------------|-----------|-----------|---------|-------|------|
| Data                  | 6000      | 3000      | 2000    | 500   | 6.5-8|

Discharge standard: according to the requirements, the effluent must meet the first grade standard of GB8978-96 "comprehensive sewage discharge standard". That is, Cods ≤ 100mg/L, BOD5 ≤ 30mg/L, SS ≤ 70mg/L, NH4-N ≤ 15mg/L, pH: 6-9.

2.3 Flow chart and description of the power generation process of the biogas boiler

As shown in Figure 3, after anaerobic fermentation, biogas produced enters the gas tank and then generates power the gas sent to the boiler system with rated steam pressure of 3.82MPa, superheated steam temperature of 450 DEG C, to drive the turbine exhaust steam pressure of 0.078MPa, extraction pressure of 0.49MPa, steam temperature of 240 DEG C, steam inlet of 16.2t/h and steam inlet temperature of 435 DEG C. The steam generated by the biogas boiler is 268 DEG C and the steam pressure of 0.98MPa is sent to the heating user, so as to achieve grid generation in summer and participate in power peak adjustment, that is, CHP, achieving the purpose of cogeneration. The comprehensive efficiency can reach 80%-85%, which can obviously improve the thermal economy of the system. The advantages of cogeneration are mainly focused on the reduction of power generation costs, the improvement of heating energy and the good environmental protection effect. On the one hand, we should adjust the temperature in the livestock house and abandon the traditional biogas insulation lamps. Instead, we should use fin heating to avoid biogas poisoning and death accidents. We can solve the problem of heating up no less than 20 DEG C in four months in winter in the province. Especially in the north area, the temperature is relatively low for a long time. Under the condition of mature technology, steam can be used to heat up the anaerobic fermentation process to increase and stabilize gas production and achieve stable gas volume.
3. Results and discussion

3.1. Economic performance
The annual output of biogas reached 28800m3 * 365d=0.10512 billion m3.

The calorific value is equivalent to 6.515250 billion the and the annual power generation is 6570000kWh.

The methane conversion coefficient is 0.768kgce/ m3 and the calorific value of biogas is about 23000KJ/Nm3.

Biogas engineering will not only produce biogas products, but also produce organic sludge and digestive juice. After proper processing, it will become an efficient organic fertilizer, which is an effective way to improve the economy of biogas engineering. The annual output of dry sludge with water content of 80% can reach 29160t, which is a high quality fertilizer. The lowest price of the market is 80 Yuan/t, which will increase the annual revenue of biogas project by 23.328 billion Yuan.

3.2. Environmental benefit
Biogas project has an annual output of 10.512 million biogas, and its combustible component is methane (CH4), accounting for 65%. It is a relatively clean fuel compared with coal, just like natural gas. If the annual output of gas is 10.512 million biogas replacing coal, it will reduce 118 million t/the, 8.260 million t/the and 140 million t/the per year, and the emission of soot will also reduce 599 million t/the of greenhouse gas CO2 emissions per year.

3.3. Social results
Energy and environmental engineering cogeneration technology will be conducive to the regulation of environmental protection and pollution prevention management regulations implementation, but also conducive to improve the environmental awareness of all levels of government and industry and agriculture, aquaculture and other polluting enterprises, to better promote them to take more effective action. The biogas action will also enhance public awareness of the environment and improve the image of the Chinese government on the international environment.
4. Conclusion
According to the principle of ecology, biology and environmental studies, we use the method of system engineering CHP for planning and design. On the one hand, the pollutants produced by farms are conducted with unified reduction and harmless resource processing, so as to reduce the pollution to people, water, air environment and so on great difficulties. On the other hand, with the increasing demand for green and pollution-free agricultural products, the market of organic and inorganic compound fertilizers produced by organic wastes is very large. A new mode of livestock manure disposal centre is set up to explore the establishment of "livestock manure - methane – heat and power cogeneration - comprehensive utilization circular three-dimensional ecological comprehensive mode and virtuously circular new agricultural production system". This not only improves the water quality, but also saves the environmental pollution discharge fee. It has obvious economic, environmental and social benefits and it is of great significance to alleviate the current situation of electric power tension.

References
[1] Li Z, Wu W, Shahidehpour M, et al. Combined Heat and Power Dispatch Considering Pipeline Energy Storage of District Heating Network[J]. IEEE Transactions on Sustainable Energy, 2015, 7(1):12-22.
[2] Mehdinejad M, Mohammadi-Ivatloo B, Dadashzadeh-Bonab R. Energy production cost minimization in a combined heat and power generation systems using cuckoo optimization algorithm[J]. Energy Efficiency, 2016, 10(1):1-16.
[3] S. A. Grigor’ev, A. S. Grigor’ev, N. V. Kuleshov, et al. Combined heat and power (cogeneration) plant based on renewable energy sources and electrochemical hydrogen systems[J]. Thermal Engineering, 2015, 62(2):81-87.
[4] Reutov B F, Lazarev M V, Ermakova S V, et al. Comparative analysis of cooling systems for energy equipment of combined heat and power plants and nuclear power plants[J]. Thermal Engineering, 2016, 63(7):463-470.
[5] Ito H. Economic and environmental assessment of residential micro combined heat and power system application in Japan[J]. International Journal of Hydrogen Energy, 2016, 41(34):15111-15123.
[6] Kikuchi Y, Kanematsu Y, Sato R, et al. Distributed Cogeneration of Power and Heat within an Energy Management Strategy for Mitigating Fossil Fuel Consumption[J]. Journal of Industrial Ecology, 2016, 20(2):289-303.