Research on renewable energy conversion system utilizing harmful gases in poultry farms

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***Abstract* — This study presents a technology that converts harmful gases generated in poultry farms into renewable energy and applies it to lighting facilities in poultry farms, and analyzes its effectiveness. The experiment was conducted in Building A, which introduced renewable energy, and Building B, which maintained the existing system, and compared the electricity usage and cost for six months. Building A consumed an average of 124.65 kWh of electricity per day, while Building B used 175.25 kWh of electricity. Building A was about 32% more efficient, resulting in energy savings. In terms of cost, Building A was able to significantly reduce its electricity bill. The system proposed in this study verified the feasibility of converting harmful gases into renewable energy and the economic benefits for farmers through experiments, and we plan to expand the study to apply it to poultry farm power supply facilities including lighting facilities by utilizing it in more poultry farms in the future.**

Keywords—Samrt Agriculture, Poultry Farm, IoT, Renewable Energy, Harmful gases)

I. INTRODUCTION

The livestock and poultry industry plays an important role in the food supply, but harmful gases such as methane (CH_4), ammonia (NH_3), and hydrogen sulfide (H_2S) generated during the poultry farming process are increasingly causing complaints from residents around the farms every year. Failure to manage harmful gases generated in poultry farms can cause many adverse effects on chickens, including respiratory irritation, lung damage, and immune system damage [1].

In addition, due to the nature of poultry farms, light source facilities must be operated 24 hours a day [2], and due to the international energy explosion, electricity costs for maintaining light source facilities have skyrocketed, causing livestock farmers to suffer from rising maintenance costs [3].

To solve these problems, this paper summarizes the process of researching a system that efficiently collects harmful gases generated inside poultry farms and converts them into renewable energy.

First, we propose a system to capture harmful gases generated from chicken manure and convert them into renewable energy. Next, the converted energy is supplied to a battery connected to a lighting facility to maintain the lighting source inside the poultry farm, and a renewable energy supply algorithm is applied to maximize energy efficiency, and the process of operating according to the conditions is presented. Finally, for the verification of this study, an experiment in a local livestock poultry farm is conducted to check whether the energy saving rate is increased by utilizing harmful gases, and concludes with the expected effect and future research directions.related researches

II. HARMFUL GAS UTILIZATION RENEWABLE ENERGY CONVERSION SYSTEM DIAGRAM AND OPERATION PROCESS

A. System Diagram and Operation Process

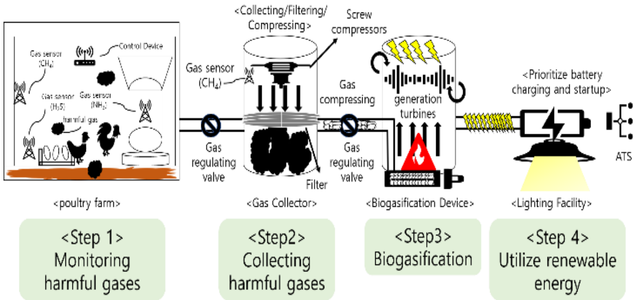

Figure 1 Harmful Gas Utilization Renewable Energy Conversion System Diagram and Operation Process

The system proposed in this study consists of several gas sensors (CH_4, NH_3, H_2S) installed on the top to monitor harmful gases such as methane gas generated from manure inside the poultry farm, as shown in Figure 1, and a control device that moves the gas through the gas pipeline when a certain concentration is detected. It also consists of a gas collector to collect, filter, and compress harmful gases moved through the gas pipeline, a biogasification device that converts the captured gas into renewable energy by running a generator turbine using the collected gas as fuel, and a charging line, battery, and automatic power transfer switch (ATS)[4] to deliver energy from the lighting facility that maintains the light source to the poultry farm.

B. Step by step process of operation

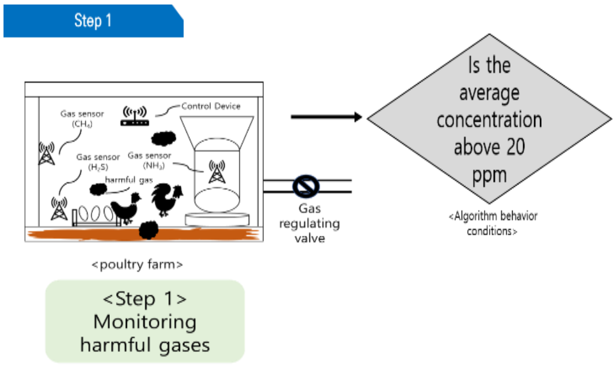

Figure 2 Step 1 : Monitoring harmful gases

The process of converting harmful gases from poultry farms into renewable energy is summarized in four steps. The first step is the collection of harmful gases, and as shown in Figure 2, when the harmful gas[5] generated by the chickens in the poultry farm reaches a certain concentration, the valve is operated through the control device and the harmful gas is delivered to the pipeline. This is done by determining whether the harmful gas exceeds an average of 20 ppm[6] from the installed gas sensor during the operation condition of the renewable energy supply algorithm. If this condition is met, the algorithm is set to move on to the next step.

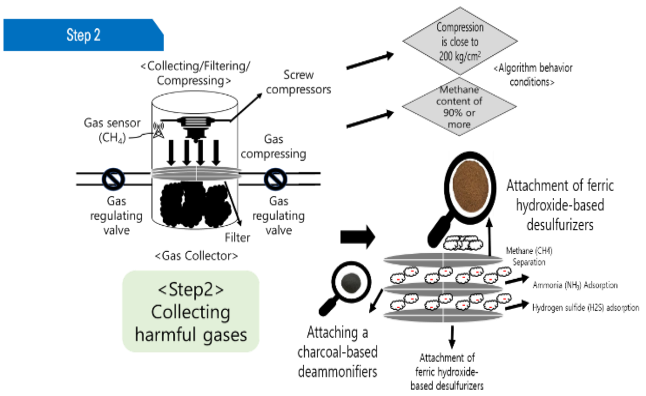

Figure 3 Step 2 : Collecting/filtering/compressing harmful gases

The second step is the collection, filtering, and compression of harmful gases delivered through the pipeline. As shown in Figure 3, harmful gases are collected through a gas collector, and impurities (H_2S, NH_3, etc.) except methane are removed through a triple filter. The triple filter is designed to adsorb impurities by attaching ferric hydroxide desulfurizer[7] on the first floor and charcoal deammoniator[8] on the second floor, so that only methane gas is filtered as much as possible on the third floor. A gas sensor installed on the top of the gas collector determines whether the methane content is sufficient. The separated methane is then compressed through a screw compressor installed inside to reduce its volume and provide stable storage as a fuel. During this process, the renewable energy supply algorithm checks whether the separated methane gas content is more than 90% through a filter[9] and ensures that the compression amount is close to 200kg/cm2 while compressing. This is the optimal amount of fuel to run the biogasification unit in step 3.

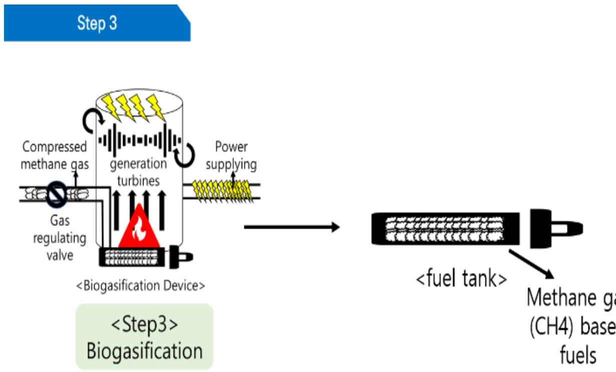

Figure 4 Step 3 : Biogasification for Renewable Energy Conversion

The third step is biogasification for renewable energy conversion, where the compressed methane gas from step 2 is transferred through a connected pipeline to the biogasifier's fuel tank, where it is utilized as fuel to run the power turbine, as shown in Figure 4. Once fueled, the biogasifier spins the turbine for six hours, generating electricity.

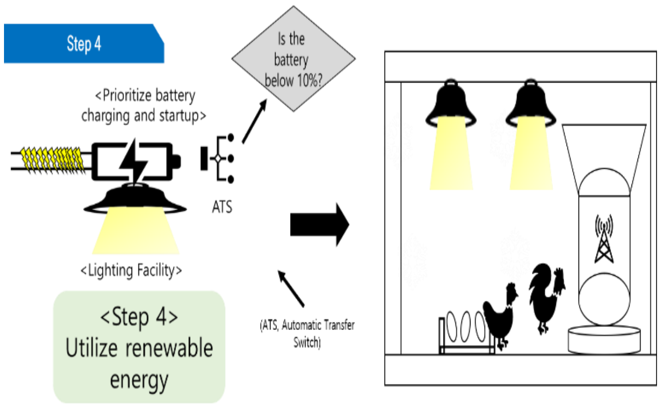

Figure 5 Step 4 : Utilize renewable energy

The fourth and final step is the power supply, where the power generated in step 3 charges the batteries that will deliver energy to the poultry farm's lighting facilities via the charging line. The controller then switches the ATS from commercial electricity mode to battery mode, and the lighting facility utilizes the battery first to maintain the light source in the poultry farm until the battery capacity is close to 10%. The renewable energy supply algorithm then determines if there is 10% battery remaining, and if so, the controller activates the ATS and switches to commercial electricity mode.

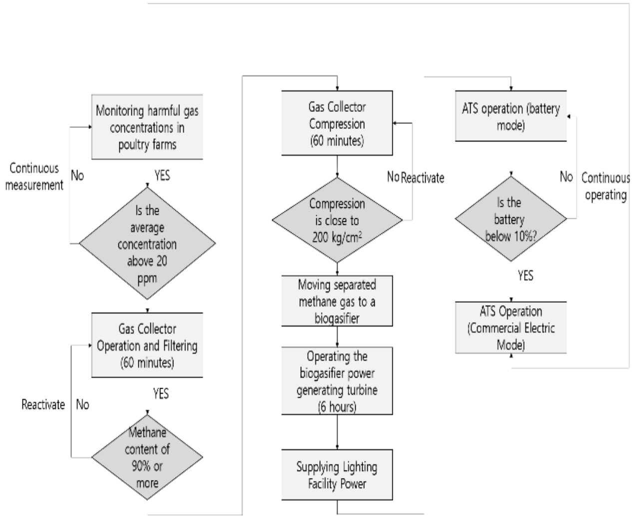

Figure 6 Renewable Energy Supply Algorithm

As such, the system proposed in this paper is designed to convert renewable energy utilizing harmful gases in the system by repeating steps 1 through 4 according to the operation conditions of the renewable energy supply algorithm as shown in Figure 6.

III. EFFICIENCY VALIDATION EXPERIMENTS

Figure 7 System Efficiency Verification Experiments

To verify the efficiency of the system proposed in this paper, we selected a poultry farm located in Jeollanam-do as shown in Figure 7, and measured the electricity usage of Building A (experimental group) and Building B (control group), which introduced the renewable energy system, and compared the average monthly electricity usage and electricity bills. First, the experiment was conducted for six months to secure sufficient data, and the amount was set based on the average electricity bill of about KRW 57 per kilowatt-hour for livestock farmers based on a differential pricing system[10]. In Building A, a lighting facility utilizing renewable energy was installed, and in Building B, a lighting facility utilizing conventional commercial power was used. In addition, electricity usage was recorded through a power meter measurement device in Building A and Building B every five days.

TABLE I. COMPARE EXPERIMENTAL FARM POWER USAGE

Category	Building A (experimental group)	Building B (control group)
Average daily electricity usage	124.65 kWh	175.25 kWh
Category (kWh)	Building A (experimental group)	Building B (control group)
Average Monthly power usage (kWh)	3,739.4 kWh	5,257.5 kWh
Cost per kWh	57 KR Won	
Average monthly light source maintenance cost (KRW)	213,143 KR Won	299,678 KR Won

As shown in Table 1, Building A used an average of 124.65 kWh per day, and Building B used 175.25 kWh per day. Based on this, we calculated the average monthly power usage and light source maintenance cost.

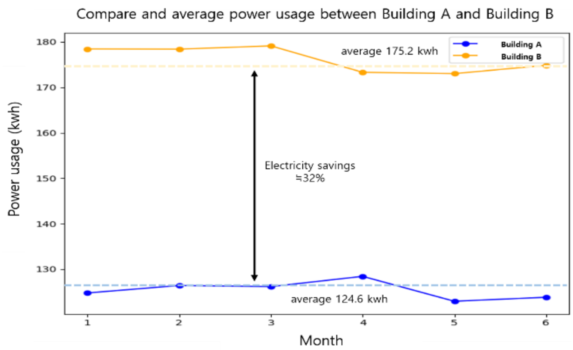

Figure 8 Compare monthly power usage

In this comparison, Building A used about 32% less power than Building B, as shown in Figure 8, resulting in a total savings of KRW 86,535 in light source maintenance costs.

IV. CONCLUSION

This study proposed a solution to collect harmful gases generated in poultry farms and convert them into renewable energy, and apply it to the maintenance of lighting facilities in poultry farms. Through an experiment, we compared the electricity consumption and light source maintenance costs between Building A, which introduced new renewable energy, and Building B, which maintained the existing system, and found that Building A reduced electricity consumption by about 32% compared to Building B, and significantly reduced light source maintenance costs. These results suggest that by recycling harmful gases generated in the livestock industry into energy, farmers can reduce the burden on maintenance costs and maximize cost efficiency. In addition, we derived the possibility of utilizing harmful gases generated in poultry farms and expanding the research to maximize the development of odor reduction and renewable energy technologies in the future. The system proposed in this study verified the feasibility of converting harmful gases into renewable energy and the economic benefits for farmers through experiments, and we plan to expand the study to apply it to poultry farm power supply facilities including lighting facilities by utilizing it in more poultry farms in the future.

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