Kingdom of Cambodia

Nation Religion King

Royal University of Agriculture
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Economic Analysis of Biogas Desulfurization System

A Business Case Study for M's Pig ACMC (CAMBODIA) CO., LTD Farm

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Supported by UNIDO/GEF project "Reduction of Green House Gas Emission through Promotion of Commercial Biogas Plants"

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OVERVIEW OF SWINE FARM

Company name	M's Pig ACMC (Cambodia) Co. Ltd.
Farm operating type	Mixed farm
Number of pigs	2,500 sows and 30,000 fattening pigs
Technology	Complete commercial biogas system[1]
Covered lagoon volume	approx. 76,000 m^3
Genset	2 units of 800 kVA biogas generator
Desulfurization unit	250 Nm^3/h
Annual Cost saving	48,000 USD
Annual Energy production	3,600,000 kWh

[1] Complete commercial biogas system consists of covered lagoon/digester, desulfurization unit, genset, flow meter and flare.

The M's Pig ACMC (Cambodia) Co. Ltd. belongs to the Mong Reththy Group and is located in Keo Pos Commune, Steng Hav District, Preah Sihanouk province. This farm is recognized as one of the largest pig farms in Cambodia, with 2,500 sows and 30,000 fattening pigs raised in full operation. According to the 2017 feasibility study, average daily wastewater was estimated to be 1,300 m^3/day by combining manure, urine, and daily water use. To treat this waste, the farm installed a biogas system to harness the energy for use. The system included four simple covered lagoons, with a combined volume of approx. 76,000 m^3; a pre-treatment system; and two second-hand biogas generators, each sized 800 kVA and run intermittently at 50% of their rated power. With the existing biogas system, the farm reported frequent problems with the generators.

CHALLENGES: INEFFECTIVE DESULFURIZATION UNIT

Biogas is a gas mixture that contains not only methane (CH_4) and carbon dioxide (CO_2), but also hydrogen sulphide (H_2S) which is known to be harmful to gensets. Biogas quality inspection was necessary to ensure smooth generator operation. With the technical support from the United Nations Industrial Development Organization (UNIDO), biogas quality at the farm was measured and the result found that the H_2S concentration was higher than 2,000 ppm for both before and after H_2S removal, which indicates that the existing desulfurization system constructed on the farm was not functional. Such a high H_2S concentration could potentially damage the generator, which may also hinder further biogas investment in the future. Normally, a recommended value of H_2S should be lower than 200 ppm for the smooth and effective operation of the generator, with its lifespan increased. To address this issue, in 2019, M's Pig Farm invested in installing a desulfurization system under the coordination and partial financial support provided by UNIDO, along with the technical facilitation from the Biogas Technology and Information Center Cambodia (BTIC) and a Dutch biogas expert. The proposed system included a set of biogas desulfurization system, a flow meter, and a flare in case of burning excess biogas.

Fig. 1 Old and ineffective desulfurization system at M's Pig Farm

SOLUTION: INSTALLATION OF BIOGAS DESULFURIZATION SYSTEMS

The desulfurization system, flow meter, and flare were installed at the M's Pig Farm in November 2019 (fig. 1), and a full operation was started in March 2020 because the farm needed time for full connection of the generators to the electricity grid. The whole system was supplied under a two-year guarantee by Camda New Energy Equipment Co., Ltd., a Chinese company specialized in biogas equipment. The biogas desulfurization system weighs 5,780 kg and consists of four desulfurizing tanks connected in series, a cyclone for removal of dust and water, a motor-run blower used to maintain a constant biogas flow, and an electrical panel for synchronous purposes. To reduce H_2S concentrations, each of the tanks must be filled with 600 kg of ferrous oxide pellets, and the replacement must be done monthly to ensure the system efficiency. According to the manual, the average biogas flow through the system is 250 Nm^3/h. Since the first operation, the desulfurization system has been under smooth operation.

Fig. 2 Installation of desulfurization system at M's Pig Farm *(a)* arrival of the equipment, *(b)* installation activities, *(c)* finished installation, and *(d)* commissioning/operating

IMPACT OF THE PROJECT

Before joining the project with UNIDO to set up the biogas desulfurization system, the farm had a total pig number of 32,500 heads of them 2,500 sows and 30,000 fattening pigs. With that number, daily manure and total wastewater were estimated to be 54 t/d and 1,300 m^3/d, respectively. Moreover, daily biogas production was estimated at 3,200 Nm^3/d, equivalent to 1,1520,000 Nm^3/y. Thus, daily energy production from biogas was estimated to be 7,000 kWh/d, or 2,520.000 kWh/y. In terms of daytime peak load, it was estimated to range from 250 to 300 kWh. However, right after the system setup, the pig number at the farm already increased to 41,100 heads, of them 3,100 sows and 38,000 fattening pigs. The increase was about 27%. As a result, daily manure production and daily total wastewater also increased to 68 t/d (26%) and 1,660 m^3/d (28%), respectively, when compared to the previous time. It was also surprising to observe 15% increase in daily biogas production from 1,520,000 Nm^3/year before the project to 1,746,900 Nm^3/year after the project. This huge increase was due to the real data collection of daily biogas production through the use of the flow meter. Anyway, as the pig number increased, the daytime peak load increased from 250-300 kW before the project to 350-400 kW after the project, which indicates a high demand of electricity for the pig-raising system. It was observed that the electricity production from biogas can only cover about 80% of the annual farm electricity demand, and 20% more was supplied by the grid electricity for full farm electricity demand.

Table 2 Comparison of pig number, manure, wastewater, and biogas production before and after the project

Description	Unit	Before project	After project	% Increase
Sow	Head	2,500	3,100	24%
Fattening	Head	30,000	38,000	27%
Total number	Head	32,500	41,100	27%
Manure production	t/d	54	68	26%
Total wastewater	m^3/d	1,300	1,660	28%
Biogas production	Nm^3/year	1 ,152 ,000	1,749,600	52%
Potential electricity production	kWh/year	2,520,000	3,600,000	43%
Peak load	kW	250 -350	350 – 400	14-40%
% Of farm electricity coverage	%	N/A	80%	N/A

HYDROGEN SULPHIDE (H_2S) REDUCTION THROUGH THE PROJECT

Before the desulfurization system was set up at the farm, biogas quality was not good enough because of high H_2S concentration (> 2,000 ppm). It was reported that the generator very often did not run smoothly and needed frequent repairs and maintenance, which was an irritating task. After the setup, the H_2S content was reduced to acceptable levels recommended for generator operation (<200 pm). For effective desulfurization, ferrous oxide pellets used for the desulfurization system and was replaced every month. It was observed that H_2S content was low (50-100 ppm) within the first two weeks, and increased to 100-200 ppm in another two weeks. With these figures, it is reported that the generator runs smoothly and the farm is satisfied with the equipment and the amount of biogas produced.

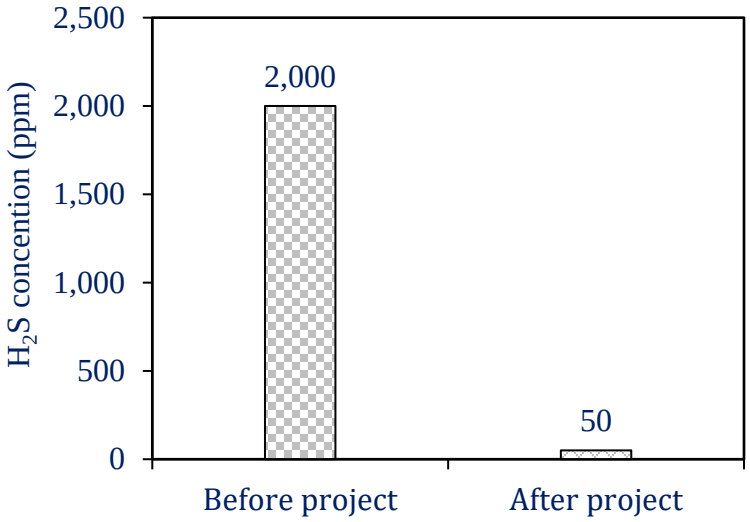

Fig. 3 Biogas quality measured before *desulfurization (left) and after desulfurization (right)*

COST SAVINGS

The total investment cost was 47,600 USD for the desulfurization system setup. Meanwhile, the costs for operation and maintenance were estimated to be 10,000 USD per year for replacement of ferrous oxide pellets and other related tasks. Without effective desulfurization, the lifespan of a biogas generator is 8,000 hours, or 1 year due to corrosion caused by high H_2S concentrations. However, with the setup, it can increase to 20,000 hours, or 2.5 years, thus reducing the generator replacement cost. The price of a second-hand 800-kVA biogas generator is 80,000 USD, and its annual cost of genset replacement is 80,000 USD/year without the desulfurizing system, and with the gas treatment, it will be 32,000 USD/year. Therefore, about 48,000 USD can be saved and compensated annually for the investment in the system. It is estimated that the simple payback period is 1.3 years, but this amount is reduced to 0.9 years after receiving an incentive of 11,900 USD from UNIDO. It was observed that the payback period of 1.3 years with the owner's sole investment seems to be highly economical for the farm, and it signals a good phase for biogas system development in the countries like Cambodia although the gas treatment system depends on foreign technology and imported equipment. In the long run, similar investments will be even further reduced when there is promotion of biogas policies, increase in local suppliers, involvement of local researchers and the private sector. All these factors may lead to cheap and viable biogas technology in Cambodia.

Farm saves up to 48,000 USD per annum.

Table 3 Description of total investment and revenue earned after the installation of the biogas desulfurization system

Description	Unit	Value (owner's investment)	Value (with UNIDO incentive)
Total investment	USD	47,600	35,700*
Operation& Maintenance cost	USD/year	10,000	10,000
Revenue	USD/year	48,000	48,000
NPV		163,372	171,675
IRR	%	88%	119%
Simple payback period	Year	1.3	0.9

Note: '*' means total investment was made after incentive of 11,900 USD from UNIDO

CONCLUSION

The farm already had a biogas system before joining the project but faced a problem with quick generator downgrading. Without improving the biogas desulfurization system, it tends to invest more money than usual for the purchase of a biogas generator because of high H_2S concentration. For higher generator efficiency and better system operation, biogas must be treated first to reduce H_2S, and the lifespan of the generator can increase up to 2.5 years.

The farm made a total investment of 47,600 USD for the desulfurization system. In return, the generator is operated smoothly and its lifespan also increases, thus resulting in an annual saving of 48,000 USD by reducing the frequency of generator purchase and repairs. With the owner's sole expense, the payback period is 1.3 years, and this is considered highly viable for the initial biogas development in Cambodia. However, with a partial financial support from UNIDO, the farm can compensate completely for the system in only 0.9 year. As a final note, the farm owner shows great satisfaction after installing the system, and is willing to invest more in a biogas system after his new farm is established.

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