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## Economic Analysis of Biogas Desulfurizing Systems

A Business Case Study for Eang Chenda & Heng Mean Pig Farms



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## I. Overview of Pig Farms:

Company name	Eang Chenda Pig Farm	Heng Mean Pig Farm
<i>Farm operating type</i>	All-in-Out	All-in-Out
<i>Type of pig raising</i>	Fattening Pig	Fattening Pig & Sows
<i>Heads</i>	8,000 fattening pigs	4,500 fattening pigs & 500 sows
<i>Technology</i>	Complete Commercial Biogas System <sup>1</sup>	Complete Commercial Biogas System <sup>1</sup>
<i>Covered lagoon volume (m<sup>3</sup>)</i>	4,725	5,000
<i>Genset(kVA)</i>	2x250 (Dual Engine)	370 kVA/450 kVA (Biogas modified gensets)
<i>Desulfurization unit</i>	10-30 Nm <sup>3</sup> /hr.	40-50 Nm <sup>3</sup> /hr.
<i>Annual Cost saving</i>	3,300 USD	12,000 USD
<i>Annual Energy production</i>	356,400 kWh/ year	124,425 kWh/year

<sup>1</sup>Complete Commercial Biogas System consists of covered lagoon/biogas plant, desulfurization units, genset, flow meter and manual flare.

Eang Chenda's Pig Farm is in Sprang commune, Kong Pisey district, Kampong Speu Province, 61 km away from Phnom Penh on National Road 41. The farm owner has a fattening farm with a total number of approx. 8,000 raised in 10 barns equipped with evaporative cooling systems. Under a contract with M's pig ACMC, the farm practices all-in-all-out systems. On annual basis, there are two cycles, each cycle spans five months. The farm uses a biogas system that has a covered lagoon with a volume of 4,725 m<sup>3</sup>, two dual generators (250 kVA in each genset) and a pretreatment system is small and non-functional. Regarding the non-functional desulfurization, the farm submitted the application to BTIC on the interest of installing the new biogas desulfurizing systems to improve the efficiency of genset performance. In addition to this, the flow meter and flare are included in this system to record biogas production and burn the excess gas avoiding venting biogas to atmosphere.

The second farm, called Heng Mean's Pig Farm, is owned by Mr. Lim Bun Long and the farm has been operated since 2019. The farm is located in Santuk district, Kampong Thom province, 148 km far away from Phnom Penh. In the previous time, the farm was under M's pig contract for feed supplies and piglets but after that, it was under Green Feed Co., Ltd. contract for feed supplies and piglets. Recently, the farm has stopped those contracts by raising their own sows (500 heads) to produce piglets for production. The farm raised both sows and fattening pigs in each cycle and there were 9 barns equipped with evaporative cooling systems. Basically, the farm raised approx. 750 fatteners in each stable. According to the farm

manager's information, the farm just started to input piglets into three barns with 700 heads in each barn. **Till now, the fattening barns are empty.** For biogas systems, the farm had two simple covered lagoon digesters with a total volume of 10,560 m<sup>3</sup> (one from sow barns with a volume of 8,000 m<sup>3</sup> and another one from fattening pig barns with a volume of 2,560 m<sup>3</sup>) for biogas production. Additionally, the farm had two gensets for electricity generation. The old one has a capacity of 370 kVA whereas, the second one is a 450-kVA modified genset. However, there has a pretreatment unit to reduce H<sub>2</sub>S concentration from biogas systems. Yet, it was not working properly due to the designs and trace elements in these desulfurizing tanks support of UNIDO on installation of a new desulfurizing system.

## **2. Installation of Biogas Pre-treatment Systems**

The desulfurizing system, as well as the flow meter and flare, was installed at Eang Chenda Pig Farm in November 2022 (Fig. 1), and the operation started in the mid of November 2022 connected with the dual genset (250 kVA) for electricity generation. The whole system was supplied and installed under a two-year guarantee by V.W Gas Co., Ltd., a local company specialized in biogas construction. The biogas pre-treatment system weighs 3500 kg and consists of two desulfurizing tanks connected in parallel, a cyclone for dust and water removal. To reduce H<sub>2</sub>S concentrations down below 200 ppm, each of the tanks must be filled with 400 kg of iron pellets and the replacement must be done every 3 months for full operation (24 hr.) to ensure the pretreatment system efficiency. Regarding this dual engine, the average biogas flow through the systems is approx. 30 Nm<sup>3</sup>/hr. Since the first testing, the desulfurizing unit has run soothly with the dual generator.

On the other hand, another desulfurizing system (not included flow meter and flare) was also installed at Heng Mean's Pig Farm in November 2022 (Fig. 2), and the operation started late in the first week of December 2022 equipped with the biogas generator with a capacity of 370-kVA for electricity generator and full connection of the grid. This desulfurizing system was designed by the German expert who worked as the technical consultant of BTIC and manufactured by Don Bosco School. This system was installed and provided for the O&M training by the BTIC team. Mainly, this biogas pre-treatment system weighs 700 kg and consists of two desulfurizing tanks connected in series and flexible to use a bypass, a cyclone for removal of dust and water. To reduce H<sub>2</sub>S concentrations, each of the tanks must be filled with 400-600 kg of iron oxide pellets and the replacement must be done every 2 months for a full operation (24 hr.) to ensure the system efficiency. Regarding the manual, the average flow through the system is 60 Nm<sup>3</sup>/hr. Due to not enough gas, the farm has not been running for a full loading.



Fig.1: Side view of the desulfurizing system at Eang Chenda Pig farm in Kampong Speu province



Fig.2: Side view of the desulfurizing system at Heng Mean farm in Kampong Thom province

### 3. Impact of the project:

Before and after joining the project, both farms have the same number of pig heads as the previous time, but the only Heng Mean's Pig Farm stops contracts with private companies to supply piglets and only purchased the feed. However, both farms already had biogas systems, but did not have desulfurizing systems before joining the project. This tends to cause the gensets to break down fast. After joining the project, the gensets work much better, which can help prolong their lifespans and cut O&M costs in the long run. The longer lifespan of the gensets is due to the reduction of  $H_2S$  concentrations; as a result, the farms can make considerable amounts of savings. Although the dual generators on Eang Chenda's Pig Farm consumes similar amounts of diesel when the desulfurizing system is used, they tend to run more smoothly and do not need to change lubricant very often for full operations.

On the other hand, with this project, an equivalent of 1,903 tCO<sub>2</sub>eq is reduced on annual basis for Heng Mean's Pig Farm. Meanwhile, an equivalent of 2,509 tCO<sub>2</sub>eq is also reduced on an annual basis for Eang Chenda's Pig Farm. However, this farm still sends off CO<sub>2</sub> into the atmosphere, which is about 79.6 tCO<sub>2</sub> eq/year because of using the dual engines. In this regard, using a pure or modified biogas generator is more beneficial in economic and environmental terms.

**Table 2: Comparison of pig number, manure, wastewater, and biogas production between Eang Chenda farm and Heng Mean farm**

<b>Description</b>	<b>Unit</b>	<b>Eang Chenda Farm</b>	<b>Heng Mean Farm</b>
Sow	head	NA	500
Fattening	head	8,000	4,500
Total number	head	8,000	5,000
Manure production	t/d	12	8.5
Total wastewater	m <sup>3</sup> /d	267	197
Biogas production	Nm <sup>3</sup> /d	792	552
Potential electricity production	kWh/d	1,188	829.5

### **3.1 H<sub>2</sub>S reduction through the project**

Before the pre-treatment system was set up on the farms, biogas quality was not good enough because of high H<sub>2</sub>S concentration (around 2,000 ppm). It was reported that the generator very often did not run smoothly and needed frequent repairs and maintenance, which creates an irritating task. After the setup, the H<sub>2</sub>S content was reduced to an acceptable level recommended for generator operation (<200 pm). For effective desulfurization, iron oxide pellets used for the pre-treatment system and must be replaced every 2 months for Eang Chenda's Pig Farm and for every 3 months for Heng Mean's Pig Farm. It was observed that H<sub>2</sub>S content was low 10 ppm within the first two weeks and increased to 0-200 ppm in another 6 to 8 weeks of full operation with the generators. 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.



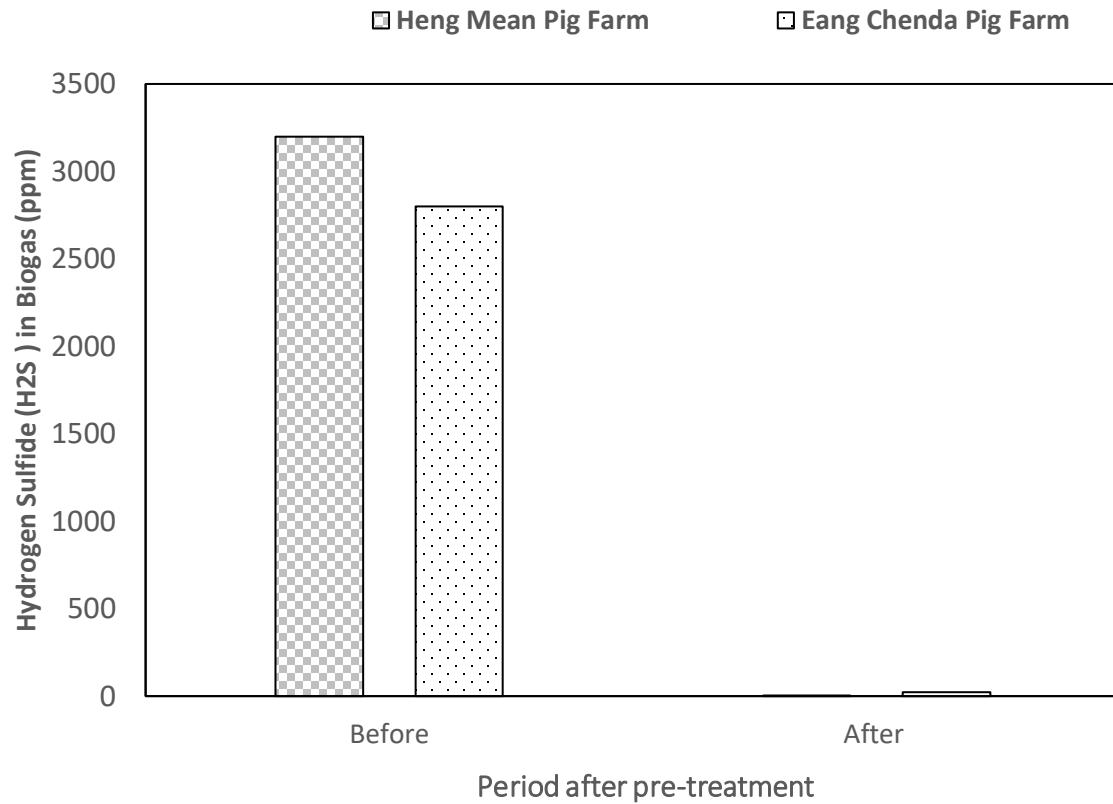


Fig 3. Comparison of H<sub>2</sub>S Concentration before and after the project

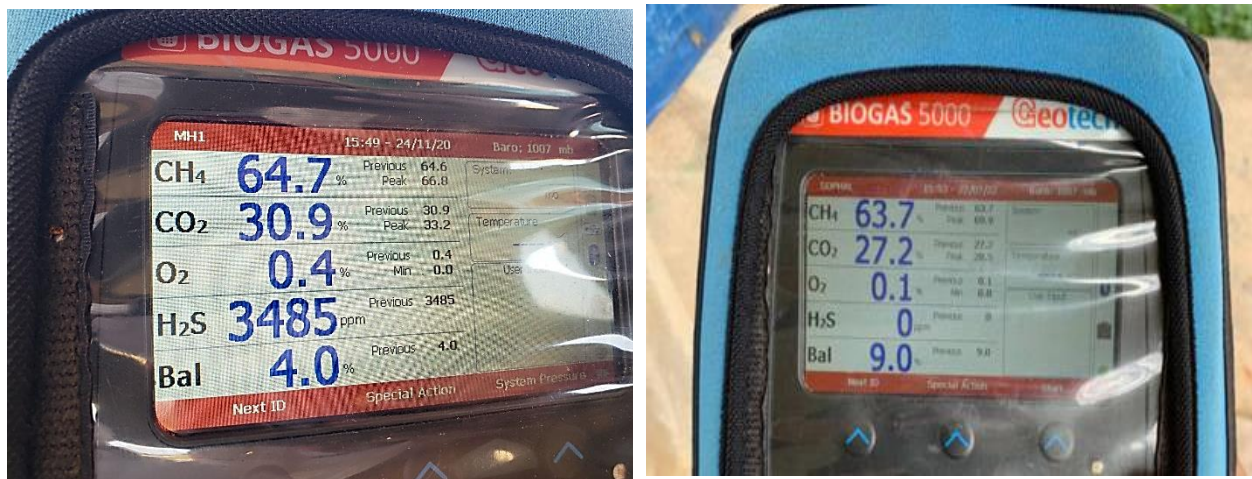


Fig 4. H<sub>2</sub>S concentration data before and after pre-treatment systems

### 3.2 Cost Savings

By comparing the total investment between Heng Mean's Pig Farm and Eang Chenda's Pig Farm, we can see that the total investment cost of Heng Mean's farm was 10,417 USD, 100% of which was for the biogas pre-treatment system setup. The rest included the costs for a flow meter (980 USD), a manual flare (490 USD), desulfurizing tanks (6,000 USD) and other spending. Meanwhile, Eang Chenda's Pig Farm invested 10,923 USD, 100% of which was for the biogas pre-treatment system setup. The rest included the cost for a flow meter (980 USD), a manual flare (490 USD), desulfurizing tanks (7,000 USD) and other spending. In overall, the total investment of Eang Chenda was a bit higher than that of Heng Mean's Pig Farm. The costs of operation and maintenance are estimated to be 1,513 USD per year for Eang Chenda's Pig Farm, while the costs of operation and maintenance are estimated to be 1,321 USD per year for Heng Mean's Pig Farm, which was lower than Eang Chenda farm. Without effective desulfurization, the lifespan of a biogas generator and dual generator is 8,000 hours, or 2 years. However, with the setup, it can increase to 20,000 hours or 5 years, thus reducing the generator depreciation cost. In principle, both farms faced the same situation for the reduction of generator lifespan in term of running without effective desulfurizing systems. The price of a second-hand 370-kVA biogas generator of Heng Mean's Pig Farm is 40,000 USD, and its annual depreciation cost of Heng Mean is 20,000 USD/year without the pre-treatment system and may be reduced to 8,000 USD after the installation of the desulfurizing system. Therefore, about 12,000 USD/year can be saved and compensated for the investment in the system for the farm. Compared to Eang Chenda's Pig Farm, the price of a second-hand 250-kVA dual generator is 11,000 USD and its annual depreciation cost of Eang Chenda is 5,500 USD/year without the pre-treatment system and may be reduced to 2,200 USD after the installation. Therefore, about 3,300 USD can be saved and compensated for the investment. For Eang Chenda's Pig Farm, it is estimated that the simple payback period is 1.7 years after receiving the installation of new desulfurizing systems from UNIDO, while simple payback period is only 6 months for Heng Mean's Pig Farm.

**Table 3: Description of total investment and revenue after the installation of the biogas pre-treatment system**

Description	Unit	Eang Chenda Pig Farm	Heng Mean Pig Farm
Total investment	USD	10,923	10,417
Operation and maintenance cost	USD/year	1,513	1,321
Revenue	USD/year	3,300	12,000
NPV	US\$	464	45,144
IRR	%	15	115
Simple payback period	Year	4.9	1.0
IRR on equity	%	55	187

Simple payback period on equity	Year	1.7	0.6
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#### 4. Conclusion

Both farms already had biogas systems before joining the project but faced a problem with quick generator downgrading. Without improving the biogas pre-treatment systems, it tends to invest more money than usual for the purchase of a biogas generator or dual generator every 2 years because it could run with untreated biogas. For higher generator efficiency and better system operation, biogas must be treated first to reduce H<sub>2</sub>S (below 200 ppm), and the lifespan of the generators can increase up to five years in both farms. The Heng Mean's Pig Farm made a total investment of 10,417 USD, whereas the Eang Chenda's Pig Farm made a total investment of 10,923. In return, the generator is operated smoothly, and its lifespan also increases, thus resulting in an annual saving of 3,300 USD for Eang Chenda's Pig Farm and 12,000 USD for Heng Mean's Pig Farm. With a partial financial support from UNIDO, the farm can compensate completely for the system in 1.7 years for first farm and 6 months for the second farm. To sum up, we can see that the installation of the new desulfurizing systems was effective in H<sub>2</sub>S reduction and prolong the lifespan in both biogas generator and dual engine. However, regarding the economic cost savings, consuming the desulfurizing systems with the 100% biogas genset obtained high savings with a short payback period compared to a dual generator. Anyway, both farm owner also shows great satisfaction after installing the system.