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Energy Conservation in Palm Oil Mill by Installing Inverters for Motors

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ABSTRACT

Thailand is the third largest palm oil producer, accounting for 3.9% of global palm oil production, approximately 84.6%. Energy Efficiency Plan 2018 (EEP2018) aims to reduce energy consumption (Energy intensity) by 30% in 2037. This study investigates the conversational energy of palm oil mills (POM) by installing motor inverters to save energy and reduce the cost of electricity. The experiment was an energy consumption estimate pre- and post-installation of a motor inverter for Thongmongkol Palm Oil Industry Co., Ltd. That analysis used energy consumption and a payback period. The result was that Thongmongkol Palm Oil Industry Co., Ltd. used energy consumption of 4,923.09-6,364.54 MWh. The factory can generate energy for approximately 99% of the factory and purchases from the Electricity Generating Authority of Thailand (EGAT) approximately 1%. These are several motors of 229 units, a Power of 2,785.44 kW, and a horsepower of 3,742.97 HP. Station 4 is the primary process of the oil palm mill. Installing the motor inverter decreases the electricity power consumption by 10.43%. It can save energy costs of 51,091.35 Baht/year. Specific energy consumption (SEC) of 0.013 MWh/ton from 0.015-0.20 MWh/ton. It reduced SEC by 13.33-35.00%. The payback period for installing the motor inverter is 3.16 years.

1. Introduction

At present, it is evident that the world is at our fingertips, and one need only look around. Many of today's prominent industries have either been created or drastically altered by using fossil fuels, which have transformed since the beginning of the industrial revolution [1-3]. This chart indicates how GHGs have decreased with the introduction of new fuels. However, these gains have been nullified due to increased energy demand [4].

Thailand is the third largest palm oil producer, accounting for 3.9% of global palm oil production. Approximately 84.6% of Thailand's oil palm plantations and processing facilities are in southern Thailand. The provinces of Krabi, Surat Thani, and Chumphon own 60% of the country's oil palm plantations. Global palm oil production was around 78 million metric tons in the marketing year 2023 [5-6]. Energy consumption is an essential factor in production costs and the value of investing in entrepreneurs. The recent energy crisis has dramatically affected industrial progress. Industrial factories and various businesses must have energy conservation measures or find alternative energy sources to reduce their limitations. Energy prices tend to increase continually. In 2022, Thailand had a total final energy consumption of 84,178 kTOE. That is an increase of 16.7% from 2021, representing a total energy consumption value of more than 2,089,316 million baht, with the industrial sector having the highest final energy consumption at 32,985 kTOE. The proportion is 39.2%, an increase of 7% from 2021 [7]. The palm oil mill consumes more energy from purchasing and producing within the industry. Thailand established targets for reducing future energy demands, which led to Thailand's Energy Efficiency Plan 2015 (EEP2015). The EEP2015 is an energy conservation plan; it includes demand-side management and deployment of advanced energy efficiency technologies in terms of appliances, machinery, and energy consumption behaviors as of the end of 2036 [8]. The EEP from 2018 to 2037 aims to achieve a 30 % reduction in energy intensity (EI) by 2037 [9].

Thailand's industrial sector is the largest energy-consuming sector, which consumes 45% of total final energy consumption in 2021 [10]. Thailand began a compulsory energy conservation campaign by promulgating the Energy Conservation and Promotion Act (ECP Act) B.E.2535 in 1992. The law enforces all the country's designated facilities, covering designated factories and buildings (DFBs), which have electric power meters from 1,000 kW or a total installed transformer of 1,175 kVA or an annual energy consumption of 20 million MJ annually [11]. Even though the total number of DFBs is less than 10,000, those facilities have a significant proportion of electricity and thermal energy in the country's industry and service sectors. This paper illustrates the energy data reporting system and the analysis from all DFBs, including the policy recommendation for energy arrangement. Therefore, there is a need for efficient energy management. In addition to reducing the environmental impact, it also plays an essential role in reducing operating costs. There has been an Energy Efficiency Plan 2018 (EEP2018) to reduce energy consumption (Energy intensity) by 30% by 2037 [11-12]. It outlines

seven characteristics of energy conservation activities. These include improving combustion efficiency, preventing energy loss, recovering waste heat, fuel switching, enhancing electricity usage efficiency, utilizing energy-efficient equipment and materials, and complying with additional energy conservation measures specified in Ministerial Regulations. In assessing energy conservation, this study excludes measures related to fuel switching and waste heat recovery [13]. Energy management is an important means to improve energy efficiency; using specific energy consumption (SEC) to identify potential improvements in energy efficiency is seen as an important instrument of energy management. In both literature and international standards, SEC is frequently used as an energy performance indicator to evaluate or measure energy efficiency performance [14]. The palm oil mills (POM) uses more electricity, which is the motor. Staudacher M. et al. (2024) studied the efficiency of e-motor/inverter systems by increasing energy efficiency by 2% [15-16]. Motors are the backbone of the industrial sector; practically every step within a manufacturing process utilizes one or more motors during production. Understanding the requirements of a system and how to size the motor accordingly is an important first step in the motor [17] selection process. Ediwan E. et al. (2024) report motor using an inverter energy savings of 34.32% or 17.65 Baht/month [18]. This study investigates the conversational energy of oil palm factories by installing motor inverters to save energy and the cost of electricity [19].

2. Experimental detail

2.1 Research methodology

The POM consists of different processes, from fresh fruit bunch to crude oil, using sterilization, threshing, digestion, pressing, and clarification [20-23]. It starts with receiving fresh fruit from the plantation in bunch reception, followed by a sterilization process similar to another POM. Thongmongkol Palm Oil Industry Co., Ltd. has a palm oil extraction process consisting of 10 stations, shown in Fig. 1.

1. Loading Ramp is the primary processing for reception of raw palm bunch.

2. Sterilizer is a pouring area that can accommodate raw materials in a raw palm bunch steamer in Sterilizer.

3. The threshing station distributes palm bunches and sorts palm fruits from steamed bunches to a threshing machine.

4. Pressing is the process of squeezing empty palm bunches. The result is palm fiber and oil.

5. Empty Bunch is a station that separates palm fiber and palm pellets.

6. Kernel Recovery is an oil separation station that uses a vibrating sieve to separate the fibers and squeeze them again. The oil is then sent into the oil separator centrifuge.

7. Clarification is a station that reduces oil's moisture content and sends it to storage tanks.

8. Crude Palm Oil (CPO) Loading is stored crude palm oil.

9. Boiler is a station that produces steam for the boiler to generate energy for the factory.

10. Water Treatment is any process that improves water quality to make it appropriate for a specific end-use.

After estimating the energy consumption, we chose a station with high energy consumption for installing a motor inverter. Then, we compared the energy consumption before and after installation. Generally, SEC is calculated as a ratio of energy used for producing a product in Equation 1 [17].

$$\text{SEC (kWh/kg)} = \frac{\text{Energy used}}{\text{Product's amount (kg)}} \quad (1)$$

The payback period is calculated from the initial investment, and then we divide that amount by the estimated annual energy savings in Equation 2 [24].

$$\text{Payback period (year)} = \frac{\text{Total investment cost (Baht)}}{\text{Annual savings (Baht/year)}} \quad (2)$$

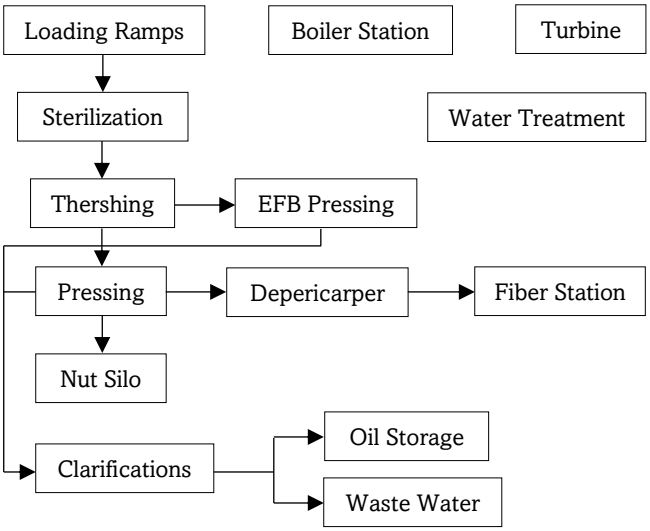

Fig. 1 Palm oil production process.

3. Result and discussion

Elemental energy of POM, Thongmongkol Palm Oil Industry Co., Ltd. used electric power of 4,923.09-6,364.54 MWh in 2021-2023; they used high electric power because of the high oil palm production. Each year, the factory can generate electric power for the factory approximately 99% of the biomass in the process of palm oil factories and purchases from the Electricity Generating Authority of Thailand (EGAT) approximately 1%, as shown in Fig 2. Biomass in POM includes typically 20% empty fruit bunch (EFB), 13% fiber, and 7% shell. Therefore, using EFB as an energy source reduces the amount of energy produced and waste [25-33]. Because there are many potential causes of power loss, such as machines that operate at or above their maximum capacity, a lack of maintenance, damage to the machinery and equipment driven, and machines operating at or below their optimal capacity, it is necessary to purchase the high total electrical energy usage for the production process from the Electricity Generating Authority. Electrical energy is not entirely used to run the production process; it is also used for street lighting, office electricity, maintenance workshops, mess employees, weighbridges, and lighting inside the factory. [34-35]. Fig. 3 presents the electric power of each station. It was found that Stations 1-8 and 10 use a high energy of 1,365.17-1,764.89 MWh. Table 1 shows data on motors in palm oil factories: several motors of 226 units, a Power of 2,785.44 kW, and a horsepower of 3,742.97 HP. Station 4 has high motors but uses energy lower than station 5. However, station 4 is the primary process of the oil palm mill. This study focuses on conversation energy in station 4 and station 5, removing waste from the oil palm

mill, which depends on feeding fresh palm. The result shows that station 5 uses high energy to separate the fibers and squeeze them again. The oil is then sent into the oil separator centrifuge. Usually, pressing is highest at 71%, threshing at 22.32%, sterilizing at 3.75%, and bunch reception at 2.93% of energy consumption [21]. Also, that must be conversation energy for saving energy.

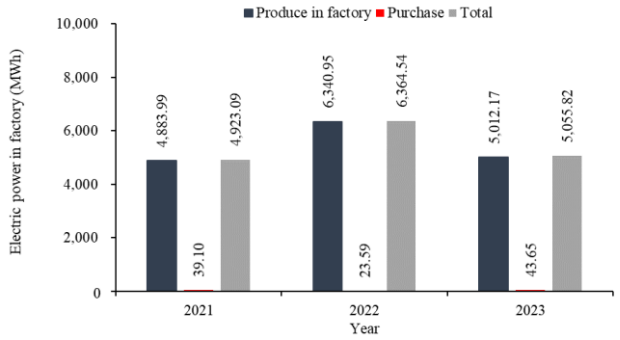

Fig. 2 Electric power consumption of palm oil factories in 2021-2023.

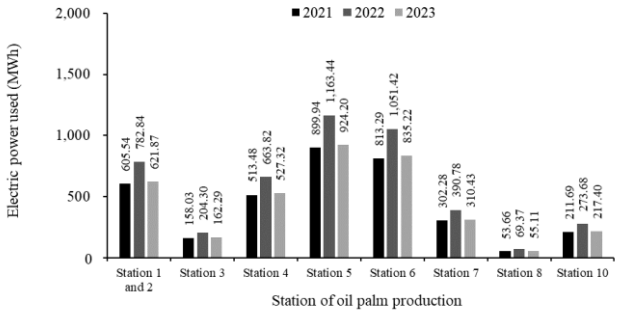

Fig. 3 Electric power consumption of palm oil factory stations.

Table 1 Data of motor in palm oil factory.

Station	Number of motors	Power (kW)	Horsepower (HP)
Station 1 and 2	29	253.48	342.38
Station 3	14	173.68	234.20
Station 4	26	803.20	1,071.70
Station 5	14	163.00	218.50
Station 6	37	227.30	308.00
Station 7	35	449.57	602.30
Station 8	5	38.05	53.00
Station 10	27	204.30	275.26
Total	226	2,785.44	3,742.97

Electricity power is used to install the motor inverter. Electricity power consumption installs motor inverter 1 unit in Station 4. That is considered pre-installing in 2021-2023 and post-installing in 2024. It was found that the deceased electricity power consumption increased from 53.01–83.17 to 47.53 MWh or a decrease of 10.43% due to the inverter helping control energy consumption and causing the motor to stop in periods of non-apply energy. According to Ediwan E. et al. (2024), motors using an inverter have energy savings of 34.32% [18] and reduce energy by 10-11% [35]. Also, the motor inverter can be installed for Thongmongkol Palm Oil Industry Co. Energy, Ltd. Fig. 5 shows installing inverters for motors before and after installation. The inverters for motors are electronic devices that change the motor's rotation speed by changing the frequency of the electric current supplied to the motor. As the provided electric energy frequency decreases, the motor's rotational speed, energy consumption, and head decrease. Reducing motor speed will minimize energy loss in friction and throttling by control valves or recycling [36].

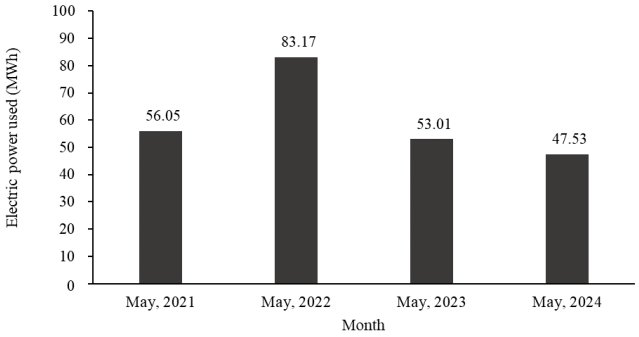

Fig. 4 Comparison electric power consumption of palm oil factories after installing inverters for motors.

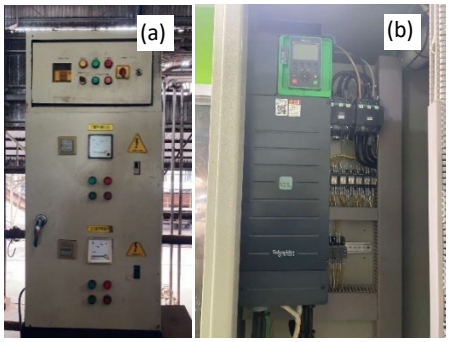

Fig. 5 (a) Before and (b) after installing inverters for motors.

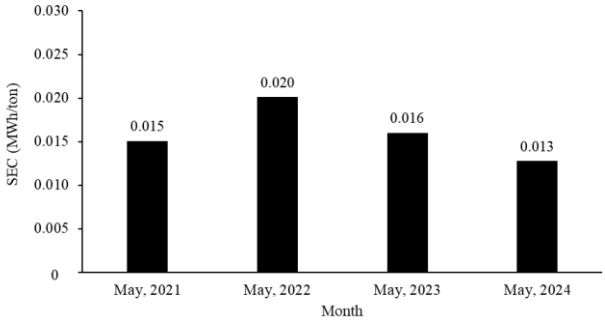

Fig. 6 Comparison SEC of palm oil factories after installing inverters for motors

Fig. 6 shows the SEC of POM before and after installing inverters for motors; it was found that installing inverters for motors can decrease SEC of 0.013 MWh/ton from 0.015-0.20 MWh/ton. It reduced SEC by 13.33-35%. SEC in the palm oil industry was 4.84 MWh/ton, with the low-value SEC (energy efficient) at 4.01 MWh/ton and the high-value SEC (energy inefficient) at 6.16 MWh/ton [37]. SEC is a value that can be used as an indicator to measure the optimization level in energy use.

The payback period for installing the motor inverter is usually Thongmongkol Palm Oil Industry Co., Ltd. Energy, Ltd., which will pay the electricity cost of 20,741,497.45 Baht/year in 2023. Installing the motor inverter 1 unit requires an investment of

161,260.70 baht, resulting in a price of electricity of 20,690,406 baht per year in 2024. It can save energy costs of 51,091.35 Baht/year. The payback period for installing the motor inverter is 3.16 years, as shown in Table 2. Generally, that has a payback period of 1-5 years [35].

Table 2 Payback period analysis of installing inverters for motors.

Detail	Amount
Investment (Baht)	161,260.70
Cost of electricity (Baht/kWh)	4.1025
Electricity consumption in 2023 (MWh)	5,055.82
Cost of electricity in 2023 (Baht/year)	20,741,497.45
Electricity consumption in 2024 (MWh)	5,043.37
Cost of electricity in 2024 (Baht/year)	20,690,406
Annual cost savings (Baht/year)	51,091.35
Payback period (year)	3.16

4. Conclusion

Thongmongkol Palm Oil Industry Co., Ltd. used energy consumption of 4,923.09-6,364.54 MWh. The factory can generate energy for approximately 99% of the factory and purchases from the Electricity Generating Authority of Thailand (EGAT) approximately 1%. These are several motors of 226 units, a Power of 2,785.44 kW, and a horsepower of 3,742.97 HP. Station 4 is the primary process. Installing the motor inverter decreases the electricity power consumption by 10.43%. It can save energy costs of 51,091.35 Baht/year. SEC of 0.013 MWh/ton from 0.015-0.20 MWh/ton. It reduced SEC by 13.33-35%. The payback period for installing the motor inverter is 3.16 years.

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