Research Article

The Analysis and Planning for Electricity Cost Reduction in Industry A Case Study of Trang Cannery Company Limited

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Abstract

This research presents an analysis to develop a plan to reduce electrical energy costs at Trang Cannery Co., Ltd. from 2022 to 2024. The objectives are to identify trends in energy consumption over the past three years, examine the relationship between production and electricity usage, and propose strategies to improve energy efficiency. Analysis reveals key trends in electricity consumption and its correlation with production volume. An analysis revealed that production efficiency in 2022 is higher than in 2023 and 2024. A consistent decline in efficiency is observed over the two-year period, as evidenced by the increasing electricity consumption per unit of output. This trend is primarily attributed to an imbalance between production capacity and machine size, as well as the lack of preventive maintenance (PM). Furthermore, this study proposes guidelines for measuring electricity consumption, which accounts for 82% of total plant operating costs. These guidelines aim to facilitate data collection in the industrial sector for production cost analysis, thereby enhancing competitiveness. Implementation of these measures is projected to result in a reduction of production costs by no less than 10%.

Keywords: Energy saving measures; Preventive meter; Energy consumption; Energy efficiency; Industrial energy management; Electricity consumption

1. Introduction

In Thailand, there are approximately 26,000 companies operating in the can manufacturing industry, according to data from Creden Data. (Alternatively, data from DataThai https://www.dataforthai.com /business/objective/25949 indicates 87 companies). Can manufacturing plants play a crucial role in the packaging industry, producing cans for a wide range of applications, including food, beverages, chemicals, and other industrial products. The can manufacturing process can be categorized based on the materials used and the intended applications, such as metal cans (aluminum or tinplate) or plastic cans. The company's products are illustrated in Fig 1.

Fig. 1 Trang Cannery Co., Ltd. Products.

Trang Cannery Co., Ltd. is a leading can packaging manufacturer in Thailand with more than 30 years of experience. Each year, the company improves and develops its production processes to align with customer needs and continuously integrates modern technology into its manufacturing operations. The company establishes clear strategic, tactical, and operational plans annually to enhance production efficiency and ensure quality energy usage in manufacturing. In the production process, energy consumption is a critical factor that directly impacts costs. Specifically, electricity costs are directly proportional to the volume of can packaging production. As electricity is a significant cost in both utilities and machinery-driven production processes, inefficient electrical energy management can lead to unnecessary expenses. Therefore, establishing a systematic approach to electrical energy cost management is crucial for the company to remain competitive among other operators [1, 2]. To reduce the unnecessary consumption of electrical energy at Trang Cannery Co., Ltd., which has incurred an average electrical energy cost of 183,510.98 baht per year from 2022 – 2024, the company aims to develop a plan to reduce these costs while maintaining or increasing production capacity. The measures to reduce energy costs must aim at cost reduction and a payback period of no more than three years.

2. Materials and Methods

The research process comprises the following steps:

2.1 Review of the Literature and Related Research

The researcher conducted a comprehensive review of the literature and studies related to the analysis of electrical energy consumption. The details are as follows:

Electrical energy consumption is measured using electrical metres, with the results displayed in kilowatt hours (kWh) [3]. In Thailand, electricity metres are categorised into eight types. Each type offers two tariff structures: a standard rate and a Time of Use (TOU) tariff. The TOU tariff charges different rates based on the time of day: during peak hours (on-peak), the rate is approximately 4 baht/kWh, while during off-peak hours, it is less than 3 baht/kWh. This off-peak rate is significantly lower than the standard rate. However, the use of a TOU metre requires effective energy management, as improper usage can lead to higher costs compared to a standard rate metre. These costs do not include the monthly service fee.

Phomprasit. S. [2], conducted a study on measures to reduce production costs at Thammarat Concrete Co., Ltd. by replacing light bulbs and improving the power factor. This resulted in electricity savings of 29,735.90 kWh/year, equivalent to 155,578.6 baht/year or 15.44% of the total electricity cost in 2014. The investment cost was 84,885 baht, with a payback period of 1.95 years (23.40 months). Apiwong-ngam.B. et al. [4] implemented a plan that involves adjustments to machine operating schedules and control of production rates, resulting in reduced electricity costs in the frozen edamame production process. By shifting peak electricity consumption to off-peak hours, the plan achieved electricity savings of 9,416.92 baht/day and reduced electricity costs during June-July 2015. Kulkarni, V.A. and P.K.Katti [5], studied global energy demand is rising; energy

efficiency (EE) in small-scale industries (SSIs) is a key solution. This paper explores EE strategies, particularly energy management (EM), and demonstrates successful implementation in an SSI case study. Paracha, Z. J. and Doulai, P. [6], studied, examines load management techniques for electric power systems. Using various methods, utilities can provide reliable, efficient, and economical service. Implementing these techniques with customer cooperation improves load profiles, benefits both utilities and customers, and reduces environmental pollution. Maorasi. P, Panyakapo. M, [7], analysed electrical energy consumption at Photharam Technical College. Laboratories, workshops, offices, and classrooms represented 85.50% of consumption, with air conditioning being the largest single user (32.50%). The study proposed short-term measures such as shutdown of lunchtime equipment and long-term solutions such as replacing old air conditioners, switching to LED lighting and regular maintenance of machinery. Thitisoowaranon. R et al. [8], introduced a mixed CUSUM-Tukey control chart (CUSUM-TCC) for process dispersion detection using a range, applicable to symmetric and asymmetric distributions. Compared to TCC, CUSUM, and EWMA-TCC (using ARL at ARL_0 = 370 and 500), CUSUM-TCC excels in asymmetric cases (Monte Carlo simulation). However, with Laplace distribution, ARL_0 = 370, and n = 1 and 5, EWMA-TCC outperforms when $\delta \leq 1.60$. At ARL_0 = 500, and n = 1 and 5, EWMA-TCC is superior across all δ values. Poovatanakul. V, et.al [9], studied explores electrical energy savings in schools through E-Plus system innovation, including management (planning, organising, etc.), knowledge dissemination, and behavioral change. Using E-Plus, a hybrid air-cooling technology with inverter control for enhanced energy efficiency ratio (EER), schools can achieve effective energy conservation.

2.2 Data Collection

The data used for analysis include electrical energy consumption, electricity costs, and can production volume for each month over the past 3 years. The electrical energy consumption data includes electrical measurement units such as voltage (V), current (A), electrical resistance (R), electric power (P), and electrical energy. Electrical energy is the main focus of this research. Electrical energy is the amount of electric power used in one hour, measured in watt-hours (Wh). Electricity metres of various sizes are used, depending on the amount of electricity consumption at each location. When 1,000 Wh (1 kWh) is used, it is equivalent to 1 unit [1]. Electricity pricing for businesses or industries ranges from approximately 2-6 baht/unit, depending on the efficiency of electricity usage management within the factory, both in terms of time and overall efficiency. These data will be used to identify trends in electrical energy, determine the relationship between production output and energy units, and analyses the relationship between electricity costs and energy units. The details are as follows:

2.2.1 Electrical Energy Demand of Trang Cannery Co., Ltd.

The values specified in the monthly electricity bills from 2022 – 2024, received from the Trang Province Provincial Electricity Authority, were used to compile the data on electrical energy consumption, separated into electrical energy demand, average, and total electrical energy consumption, as shown in Table 1. The information obtained from the electricity bill indicates that the company is classified as a Type 3 electricity user, medium-sized business, for use of electricity in business and industry and is charged at the normal rate.

Table 1 Electrical energy consumption by month (past 3 years).

Month	Year 2022 (kWh)	Year 2023 (kWh)	Year 2024 (kWh)
January	36,228	21,984	29,934
February	34,701	28,590	34,494
March	40,554	23,616	46,194
April	47,562	28,416	26,628
May	50,094	43,116	36,522
June	50,472	29,772	36,270
July	35,526	28,146	44,154
August	37,770	35,418	46,626
September	33,714	31,422	46,014
October	52,542	24,150	57,870
November	52,734	31,308	40,404
December	44,388	41,370	45,066
Total	516,285	367,308	490,176
Average	43,023 ± 7,415	30,609 ± 6,586	40,848 ± 8,574

2.2.2 Electricity Costs of Trang Cannery Co., Ltd.

The values specified in the monthly electricity bills from 2022 – 2024, received from the Trang Province Provincial Electricity Authority, were used to compile electricity cost data, separated into electricity costs, average and total electricity costs, as shown in Table 2.

Table 2 Monthly electricity costs (past 3 years).

Month	**Year 2022 (Baht)**	**Year 2023 (Baht)**	**Year 2024 (Baht)**
January	158,272	139,406	148,253
February	152,765	176,311	158,664
March	172,950	150,631	210,043
April	195,410	177,019	134,581
May	214,984	221,612	171,415
June	217,060	163,027	172,156
July	163,525	153,571	202,433
August	170,542	186,036	212,186
September	182,216	145,663	209,109
October	264,817	116,180	255,819
November	261,498	143,491	188,211
December	228,578	182,350	205,593
Total	2,382,624	1,955,302	2,268,469
Average	198,551 ±38,765	162,941 ±27,611	189,039 ±33,630

2.2.3 Can Production Volume of Trang Cannery Co., Ltd.

From 2022 – 2024, the company's production output fluctuated due to certain products being manufactured only upon customer order, resulting in some machinery being idle or used for short periods. Therefore, to calculate the electrical energy consumption for various sections, the average values will be used to represent the data, as shown in Table 3.

Table 3 Monthly can production volume (past 3 years)

Month	**Year 2022** (cans)	**Year 2023** (cans)	**Year 2024** (cans)
January	6,200,798	1,744,132	2,714,001
February	5,862,301	2,054,112	2,898,096
March	7,475,127	2,031,708	3,582,191
April	8,119,660	3,408,698	2,310,716
May	8,775,210	5,433,690	2,717,998
June	8,420,690	2,985,520	2,365,062
July	3,736,474	2,167,784	2,132,374
August	5,160,206	4,115,227	3,375,730
September	4,273,197	2,936,768	2,729,210
October	8,006,515	1,953,682	4,102,786
November	7,935,810	2,981,879	3,775,273
December	4,264,908	3,044,469	4,219,988
Total	78,230,896	34,857,669	36,923,425
Average	6,519,241 ± 1,825,304	2,904,805 ± 1,062,940	3,076,952 ± 712,912

From Table 1, the electrical energy consumption for each month over the past three years, based on the company's use of a Type 3 electricity meter and standard rate charges, indicates that managing electricity usage during off-peak hours with lower unit costs is not possible without changing to a Time of Use (TOU) tariff. This makes it difficult to reduce electricity costs in this area. However, if a TOU tariff is adopted, it is estimated that the company could reduce costs by at least 10% per year.

Over the past three years, this would amount to approximately 60,000 baht in savings. These potential savings can be calculated using the Provincial Electricity Authority's website through its electricity cost estimation system, although the input details may lack clarity. With this information, the company can effectively design and plan its future electricity use.

When comparing the electrical energy consumption in Table 1 with the volume of can production per unit in Table 3, it is observed that the electrical energy consumption per production unit increased by 46 and 49% in 2023 and 2024, respectively, compared to 2022. Similarly, when comparing the electricity costs in Table 2 with the volume of can production per unit in Table 3, it is found that the electricity costs increased by 38 and 49% in 2023 and 2024, respectively, compared to 2022. Upon examining the annual can production volume, it is observed that 2022 had a production volume of approximately 6 million cans, while 2023 and 2024 each had a production volume of only about 3 million cans.

Considering this data in relation to the electrical energy and electricity cost per production unit, it is evident that a reduction in can production volume results in a 38 – 49 % increase in unit costs. This could be attributed to two main factors: 1) The factory's machinery was designed for a production capacity of approximately 6 million cans per year, so a decrease in production with the same machinery capacity leads to similar energy consumption but lower output. 2) The efficiency of the machinery has decreased. Therefore, the factory should implement preventive maintenance (PM) to ensure that the machinery and equipment are consistently ready for operation. The benefits of PM include continuous production, reduced errors during production, and prolonged and efficient machinery operation, all of which can contribute to a reduction in production costs by approximately 10% per year.

3. Results and Discussions

The researcher analysed the consumption of electrical energy and arrived at the following conclusions.

3.1 Analysis and Comparison of the Electrical Energy Demand at Trang Cannery Co., Ltd. from 2022 – 2024.

In 2023, Trang Cannery Co., Ltd. experienced a reduction in electrical energy demand compared to 2022 across all months. This decreased is attributed to a more than 50% reduction in production capacity during 2023 and 2024. This reduction is due to various factors that affect market demand, such as insufficient fish supply, rising fish prices, and changes in consumer preferences (Department of International Trade Promotion, Ministry of Commerce, Thailand; DITP, [10]). It was found that in 2024, Trang Cannery Co., Ltd. experienced an increase in average electrical energy demand compared to 2023. It was found that in 2024, Trang Cannery Co., Ltd. experienced a decrease in electrical energy demand compared to 2022. It was found that in 2024, the standard deviation was highest, at 8,574, indicating that this year had the highest volatility in electrical energy consumption. This means that the electricity consumption was inconsistent, with some months having unusually high consumption and others having significantly lower consumption. The second-highest standard deviation was in 2022, at 7,415, indicating moderate volatility in electrical energy consumption. This suggests that, while electricity consumption remained consistent in some months, there were other months with higher or lower than usual consumption. The lowest standard deviation was in 2023, at 6,586, indicating the lowest volatility in electrical energy consumption. This means that electricity consumption was very stable, with minimal variation between months. (See in Fig. 2).

3.2 Analysis Electricity Cost and Comparison of the Volume of Can Production at Trang Cannery Co., Ltd. During the Years 2022 – 2024.

It was found that in 2022, the standard deviation was the highest, at 38,765, indicating that this year had the highest volatility in electricity costs over the three-year period. This means that electricity costs varied significantly between months, potentially due to inconsistent energy consumption, increased energy costs in some months, and highly fluctuating Ft values in this year. The second highest standard deviation was in 2024, at 33,630, indicating moderate volatility in electricity costs. This suggests that some months had unusually high electricity costs, possibly due to increased energy consumption during certain periods and increased factory production adjustments. In 2023, the standard deviation was the lowest, 27,611, indicating the lowest volatility in electricity costs. This means that electricity costs varied less between months, possibly due to stable energy consumption and reduced factory production adjustments compared to other years. Additionally, the value-added tax (VAT 7%) is another factor influencing electricity costs. (See in Fig. 3 and Fig. 4).

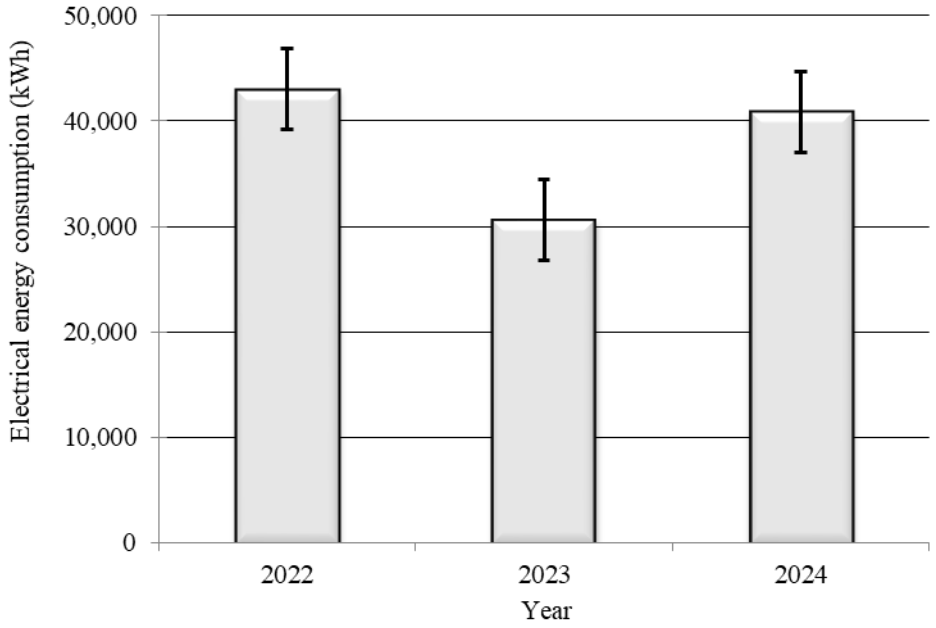

Fig. 2 Electrical Energy consumption from 2022 – 2024.

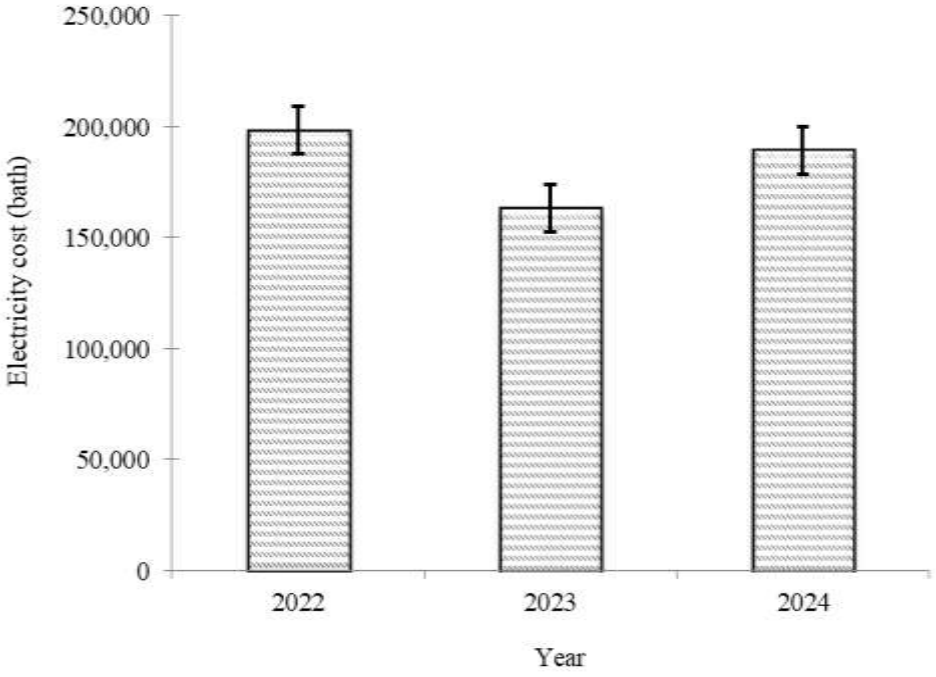

Fig. 3 Electricity cost from 2022 – 2024.

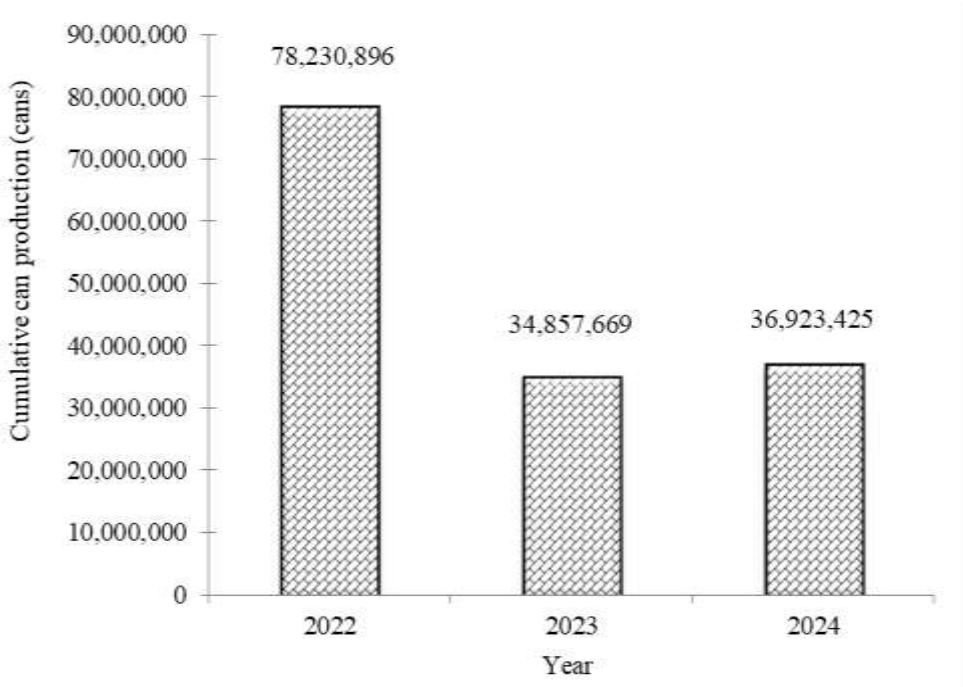

Fig. 4 Cumulative can production from 2022 – 2024.

3.3 Relationship Between Electrical Energy Consumption and Electricity Costs.

The correlation coefficient (r) between electricity consumption units and electricity costs was found to be 0.90441. This indicates a very strong positive correlation, meaning that as the number of units of electrical energy consumption increases, electricity costs also increase. The increase in units of electrical energy consumption directly impacts electricity costs. The coefficient of determination (R^2) is 0.81796, indicating a very high level of predictability. This means that electrical energy consumption units can predict electricity costs with 81.80% accuracy, while the remaining 18.20% may be due to other factors such as Ft rates, other fees, or energy consumption unrelated to production.

3.4 Relationship Between Electrical Energy Consumption and Can Production Bolum.

The correlation coefficient (r) between electricity consumption units and can production volume was found to be 0.65, indicating a moderate to strong positive correlation. This means that as the production volume increases, the number of electrical energy consumption units also increases, but not in a perfectly proportional manner. Other factors may also influence electrical energy consumption. The coefficient of determination (R^2) is 0.4233, indicating a low to moderate level of predictability. This means that the production volume can predict electrical energy consumption with 42.33% accuracy, while the remaining 57.67% may be due to other factors such as machine efficiency, energy losses in the factory, and energy consumption behavior unrelated to the production volume.

Based on an examination of the electrical energy consumption and electricity cost data for each year, as well as the historical can production capacity for each year, it was found that production costs have increased annually. This is due to several uncontrollable factors that all companies face. However, there are numerous controllable factors that the company has not yet addressed. Therefore, implementing improvements and developing efficient production processes will significantly enhance the factory's competitiveness with other companies.

4. Conclusion

The researcher has concluded the analysis of electrical energy consumption at Trang Cannery Co., Ltd. as follows:

Electrical energy consumption from 2022 – 2023 showed a decreasing trend. 2022 had the highest energy demand, followed by 2024, while 2023 had the lowest energy demand, despite an increase in production per unit.

In 2024, electrical energy consumption was inconsistent, differing from the previous two years. This is likely due to inadequate production planning and machinery age, such as machinery size being disproportionate to can production volume and a lack of preventive maintenance (PM). These factors impact production costs.

As the number of units of electrical energy consumption increases, electricity costs also increase. The increase in units of electrical energy consumption directly impacts electricity costs and can predict energy consumption with 82% accuracy. The remaining 18% may be due to other factors such as Ft rates, other fees, or energy consumption unrelated to production.

As the production volume increases, the number of units of electrical energy consumption also increases, but not in a perfectly proportional manner. Other factors may also influence electrical energy consumption. Can production volume can predict electrical energy consumption with 42.33% accuracy, while the remaining 57.67% may be due to other factors such as machine efficiency, energy losses in the factory, and energy consumption behavior unrelated to production volume.

The company should switch from a standard electricity meter to a time-of-use (TOU) tariff meter, which could reduce electricity costs by approximately 10% per month. Additionally, the company should install electrical energy monitoring equipment at various points to gather data for analysis and improve energy efficiency.

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