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STUDY ON ETHANOL PRODUCTION PLANT PROBLEMS IN THAILAND

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Abstract: This research investigates the challenges faced by ethanol production plants in Thailand and offers preliminary guidelines for addressing them in the government sector and for ethanol plant operators. This study collected data on the identified problems through surveys conducted at 11 of Thailand's 26 ethanol production plants. The study used questionnaires to interrogate seven aspects of ethanol production, namely raw materials, production processes, transportation, pricing, government support, engineering, and environmental considerations. Consequently, the data revealed notable correlations between the production period and the problems encountered. It was discovered that all types of ethanol production plants experienced the most significant difficulties with obtaining raw materials and pricing, both being major problems. The production of raw materials such as molasses and cassava, fluctuates seasonally, resulting in unstable yearly yields. Another moderate concern for ethanol production plants is the government policy to promote the use of ethanol fuel.

Keywords: Ethanol, ethanol production plant, raw materials, prices, government support.

Introduction

Ethanol also known as ethyl alcohol is derived from plants with high sugar or starch content or from plant waste rich in cellulose or hemicellulose. These materials, including sugarcane, sugar beet, rice, straw, corn, grains, starch, and cassava, undergo fermentation to produce ethanol (Ayas, 2018). Note that ethanol serves various purposes. It is used as a liquid fuel, independently or blended with gasoline and in other industrial applications including food and beverage production and medicinal products.

Ethanol demand has exhibited steady growth over the past decade. Between 2012 and 2019, global ethanol demand increased from 100.7 billion to 132.1 billion litres annually, reflecting an average annual growth rate of 3.3%. Concurrently, yearly production saw a rise of 3.2% (OECD-FAO, 2021). The United States, Brazil, and China emerged as ethanol's primary consumers and producers, collectively constituting approximately 80% of global production (Figure 1) and consumption. However, in 2020, global production experienced a decline due to the pandemic and had yet to return to pre-pandemic levels in 2021. Ethanol demand in 2021 remained 4% below the 2019 levels and was not considered likely to recover until 2023 fully. This delay was primarily attributed to high ethanol prices in Brazil and reduced gasoline demand in the United States (IEA, 2021).

Thailand is the world's seventh-largest producer and consumer of ethanol (OECD-FAO, 2021). Most ethanol produced in Thailand is used for transportation after being blended with petrol to create gasohol, thereby contributing to the partial substitution of fossil fuels. The utilisation of gasohol in Spark-Ignition (SI) engines has been linked to reduced emissions of pollutants such as Carbon Monoxide (CO), Sulfur Dioxide (SO_2), and Isocyanic Acid (HNCO) and a decrease in harmful Polycyclic Aromatic Hydrocarbons (PAHs) in particulate

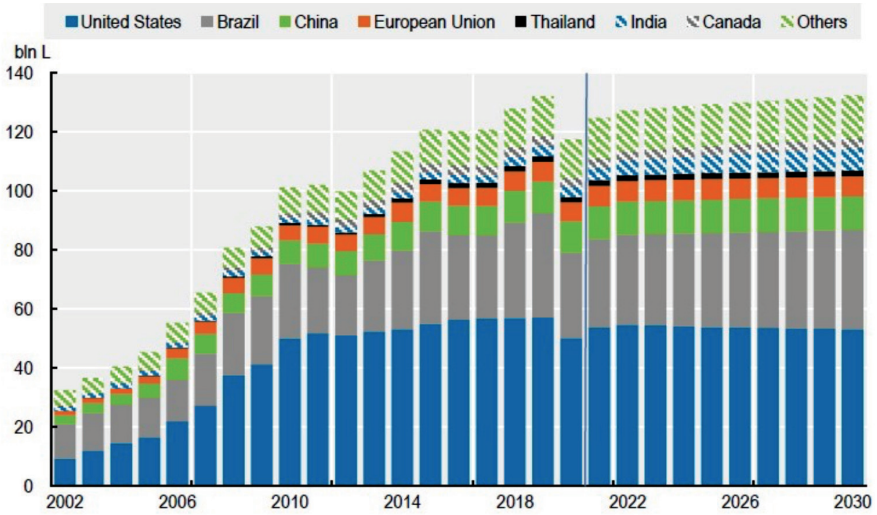

Figure 1: Development of world ethanol consumption
Source: OECD-FAO (2021)

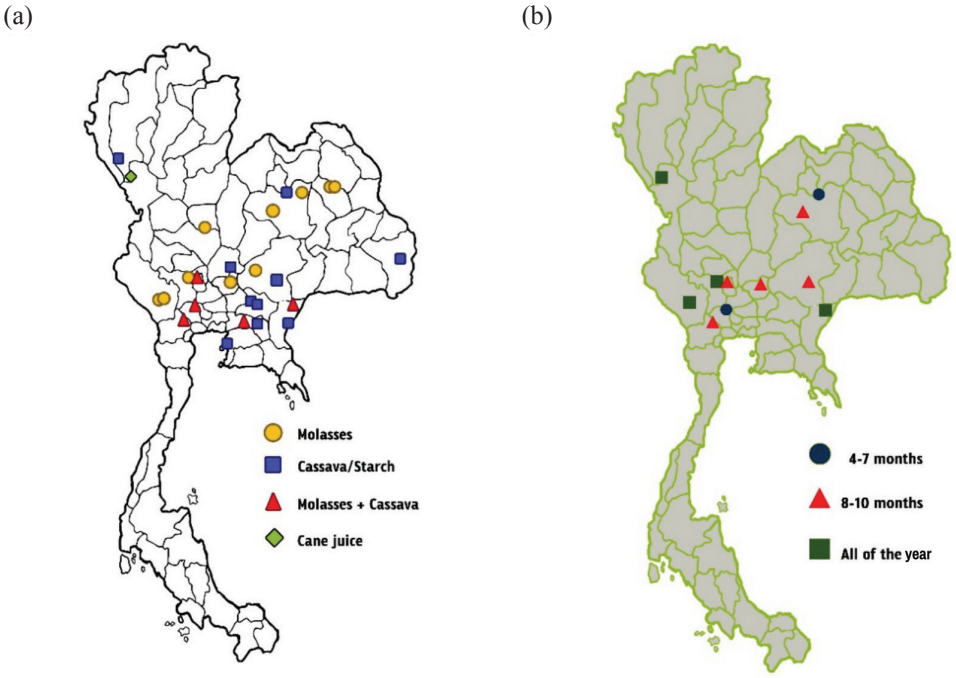

Figure 2: Map of the location of: (a) Ethanol factories in Thailand based on the raw material used for ethanol production (Krungsri Research, 2021) and (b) ethanol production plants in this study based on the production period each year

matter (Agarwal *et al.*, 2020). This reduction in emissions may potentially influence the cost of producing transportation fuel, especially if carbon taxes on greenhouse gases increase (Štreimikienė & Bubnienė, 2005) and have an impact on economic performance (Makieła & Misztur, 2012; Zhang, 2023).

The ethanol market in Thailand is dependent on the domestic demand for liquid fuels and responds to government policies. Since 2001, the government has mandated that regular petrol sold to the public contain 10% ethanol, producing gasohol 91 and 95. In 2008, higher ethanol blends of 20% (E20) and 85% (E85) were introduced, leading to increased demand for ethanol (Krungsri Research, 2021). Note that molasses, cassava, and sugarcane juice are Thailand's primary raw materials for ethanol production. As of 2022, they accounted for 58%, 38%, and 4% of the country's ethanol production, respectively (DEDE, 2022).

Presently, Thailand has 26 ethanol production plants, which are predominantly owned by larger sugar or cassava companies located in the central and northeastern regions. These plants collectively produce 5.97 million litres of ethanol daily with molasses contributing 2.6 million litres, cassava (2.09 million litres), a mix of cassava and molasses (1.05 million litres), and sugarcane juice (0.23 million litres).

Figure 2 (a) illustrates the spatial distribution of ethanol factories categorised by raw materials including 10 molasses factories, 10 cassava starch factories, five molasses and cassava factories, and one sugarcane juice factory. The locations of the 11 ethanol production plants that agreed to give information for this study are depicted in Figure 2 (b). In addition, the ethanol plants are divided into three categories according to the duration of ethanol production: 4 to 7 months, 8 to 10 months, and throughout the year.

The ethanol industry in Thailand is largely supported by the Alternative Energy Development Plan (AEDP) (DEDE, 2018), which aims to promote gasohol, encourage the use of vehicles capable of running on E85 gasohol, and enhance the availability and distribution of biofuels (E20 and E85) nationwide. These policies have fostered growth in the ethanol market and are projected to sustain ethanol demand into the future. Krungsri Research forecasted a 2.4% to 3.6% annual growth in ethanol demand from 2021 to 2023, reaching 4.2 to 4.5 million litres daily. The ethanol market's trajectory will rely on gasohol E10 and E20 sales, with the latter expected to increase from 21% of all gasohol sales in 2020 to 25% to 30% by 2023. This shift would elevate the share of ethanol used in gasohol blends to 55% to 60% of all end uses.

However, the ethanol industry still grapples with several challenges and issues including a potential feedstock shortage due to the industry's reliance on weather-dependent production and yields (Peng *et al.*, 2004; Roudier *et al.*, 2011); transportation and engineering process challenges within biorefineries (OAE, 2018); and competition for molasses and cassava from food, beverage, animal feed, and emerging downstream alcohol industries. Cassava is the second-most important root plant for human consumption and the demand for cassava by Chinese alcohol manufacturers adds to this competition (Rosenthal *et al.*, 2012). Furthermore, the increasing cost of raw materials (OAE, 2018) may impact the industry's production costs and profit margins.

Consumer concerns about high-ethanol gasohol blends persist with complaints about engine problems and increased fuel consumption compared to low-ethanol blends (Barakat *et al.*, 2016). The ethanol industry faces the looming threat of losing market share to hybrid and electric vehicles, which would diminish the demand for transport fuels. This trend is reflected in the revisions made to the AEDP2015 plan as evidenced in the AEDP2018 version. Meanwhile, the former aimed for 11.3 million litres of daily ethanol production by 2037. The latter reduced this target to 7.5 million litres with a greater portion allocated to electricity generation.

Considering the issues and challenges mentioned earlier, this research aims to investigate the problems encountered by ethanol production plants in Thailand and offer initial guidelines for addressing these issues, both for the government sector and ethanol plant operators. The study collected data about challenges and problems from 11 ethanol production plants in Thailand using questionnaires to explore issues across seven aspects: Raw materials, production processes, transportation, pricing, government support, engineering, and environmental considerations.

Materials and Methods

Population and Sample

According to data from the Department of Alternative Energy Development and Efficiency, Ministry of Energy in 2022 (DEDE, 2022), there are 26 ethanol production plants in Thailand, as illustrated in Figure 2 (a). Four plants are located in the western region, seven in the eastern region, eight in the northeastern region, and seven in the central region. Consequently, questionnaires sent by conventional post and telephone interviews were employed to evaluate the problems the ethanol production plants faced. 11 ethanol plants agreed to provide information for our survey activities as depicted in Figure 2 (b). The general information on the ethanol factories in this study is presented in Table 1.

Before the analysis, a one-way ANOVA was performed to ascertain the important parameters of the problem level. From the four selected variables: (a) Ethanol production period, (b) type of raw materials used in production, (c) technology used in production, and (d) ethanol fermentation methods, it was determined that only the production period has significant effects on the problems that arose in ethanol production plants (Sirisomboon *et al.*, 2023). Consequently, the ethanol production plants in this study were categorised according to the ethanol production operation period into three categories: 4 to 7 months, 8 to 10 months, and throughout the year.

Table 1: General information of 11 ethanol factories in this study

No.	Age of Factory	Raw Materials	Ethanol Production Capacity Per Year (Million Litres)	Ethanol Production Operation Period
1	13	Molasses	99	Throughout the year
2	12	Molasses	78	Throughout the year
3	13	Molasses	54	Throughout the year
4	16	Molasses and sugarcane juice	78	Throughout the year
5	18	Molasses and cassava	100	8-10 months
6	38	Molasses and cassava	73	8-10 months
7	15	Molasses	99	8-10 months
8	19	Molasses	91	8-10 months
9	15	Molasses	55	8-10 months
10	15	cassava	32	4-7 months
11	29	Molasses and cassava	9	4-7 months

Questionnaire Structure

The survey questions were formulated based on issues pertaining to ethanol production plants through data gathered from news sources, interviews, and an academic literature review.

Table 2: Five-point Linkert scale for accessing the problem levels

Scale	Indication	Score
5	Severe	4.21 - 5.00
4	Major	3.41 - 4.20
3	Moderate	2.61 - 3.40
2	Minor	1.81 - 2.60
1	Insignificant	1.00 - 1.80

Then, to avoid ambiguity, Item-Objective Congruence (IOC) (Rovinelli & Hambleton, 1977) was employed to assess the items in the draft survey questions. The IOC committee comprised a language expert, an engineer responsible for a power plant and one of the interviewees from an ethanol production facility. Following revisions, the questionnaire was finalised and used.

The questionnaire comprised three parts: (1) General information about ethanol production plants (featuring both open-ended and closed-ended questions), (2) encountered operational issues, and (3) semi-structured interviews. Part 2 of the questionnaire employed table-type questions using a Likert scale (Likert, 1932) to gauge the severity of problems with five-level evaluation criteria as outlined in Table 2. The problems within ethanol production plants were categorised into seven main areas: (1) Raw materials, (2) production processes, (3) transportation, (4) pricing, (5) government support, (6) engineering, and (7) environmental concerns.

Part 3 comprised open-ended questions aimed at soliciting opinions and additional suggestions beyond the scope of parts 1 and 2 of the questionnaire. Other than that, conventional postal methods and telephone interviews were utilised for this survey to assess the challenges faced by ethanol production plants. The collected questionnaires were subsequently analysed using statistical tools.

Results and Discussion

The study's general information gathered from all 11 ethanol production plants reveals several common features. Approximately 82% of these plants were established between 10 and 20 years ago with about 64% boasting production capacities within 70 to 100 million litres per year. In terms of production operation periods, the plants can be categorised as follows: 4 to 7 months (18%), 8 to 10 months (46%), and operating throughout the year (36%). Most of these plants use molasses as their primary raw material and almost all consume more than 30,000 tonnes of raw materials per month.

Imported production technologies include Praj from India, Alfa Laval from India, and Maguin from France, each accounting for similar proportions (approximately 37%, 27%, and 27%, respectively). The most widely employed ethanol fermentation process is the semi-batch method, which accounts for about 64% of usage. All the factories used the molecular sieve absorption distillation technology. The survey discovered that most ethanol production plants obtained their raw materials by purchasing from intermediaries (47%), followed by direct purchasing from farms or production sites (40%), and by having their raw materials or receiving them from affiliated companies (13%).

This study recognises seven categories of problems encountered by ethanol production plants. The survey results on these issues are summarised in Table 3 and Figure 3. It was established that the most significant challenges facing ethanol production plants were pricing and obtaining raw materials. Moreover, seasonal variations cause fluctuations in raw material production, affecting prices.

Table 3: Summary of overall results of the ethanol production plant problems

Type of Problem	Average Scores of the Problem Level	The Severity Level of the Problem
Raw materials	3.70 ± 1.11	Major
Production process	2.35 ± 0.77	Minor
Transportation	2.42 ± 0.94	Minor
Price	3.41 ± 1.18	Major
Government support	3.35 ± 1.18	Moderate
Engineering	2.48 ± 1.15	Minor
Environment	2.45 ± 1.01	Minor
Mean	**2.88 ± 1.17**	**Moderate**

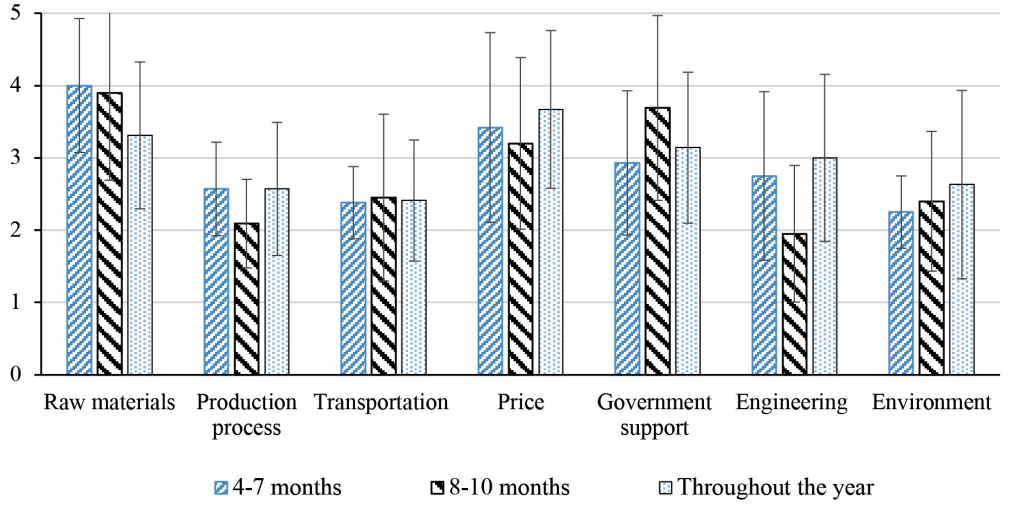

Figure 3: Summary of the results of seven problems in ethanol production plants categorised by the production operation period

Another concern of ethanol production plants, rated as a moderate-level problem is government policy promoting ethanol fuel usage. For instance, there is a need for government measures to support the cultivation of key raw material crops such as sugarcane and cassava, as well as mechanisms to incentivise consumers to use gasohol with a higher ethanol content.

This study presents that ethanol production plants experience seven main problems. The results from the problem survey are as follows:

Raw Materials

The raw material problems highlighted by the respondents are presented in Table 4. Ethanol production plants operating for 4 to 7 months ($\bar{x}$ = 4.00) and 8 to 10 months ($\bar{x}$ = 3.90) faced the most significant challenges. Their primary issue was fluctuating raw material prices, increasing production costs. These price fluctuations were influenced by seasonal variations and annual production volumes, which are also encountered in the wood biomass production process (Wysocka-Fijorek & Lachowicz,

2018; Górna *et al.*, 2023). Another major concern was the shortage of raw materials resulting from competition from other users. Despite having their own sources, most ethanol production plants depend on sourcing feedstock from neighbouring regions, exacerbating the competition for raw materials. Hence, good logistics management of raw materials can help reduce these problem issues (Rentizelas *et al.*, 2009). In summary, ethanol production plants experience moderate to severe levels of problems related to the procurement of raw materials.

Production Process

The production process survey results for the problems are summarised in Table 5. Ethanol production plants operating for 4 to 7 months encountered minor-level problems ($\bar{x}$ = 2.57) in their production processes. They faced moderate issues such as excessive foaming during fermentation, incorrect fermentation temperatures, and insufficient nutrient concentrations for yeast feeding during fermentation. However, the biggest problem faced by ethanol production plants operating throughout the year was the blockage of the

Table 4: Mean levels of the problems related to obtaining raw materials classified by production operation period

Problems	4-7 Months	8-10 Months	Throughout the Year
Insufficient raw materials due to competition for procurement	4.50 ± 0.71	4.40 ± 0.55	2.50 ± 0.58
Lack of a definite source of raw materials	3.00 ± 0.00	2.80 ± 1.48	3.75 ± 1.50
Farmers switching crop types in response to changes in market demand	3.50 ± 0.71	3.60 ± 1.14	3.00 ± 0.82
Fluctuation in raw material prices	5.00 ± 0.00	4.80 ± 0.45	4.00 ± 0.00
Mean	**4.00 ± 0.93**	**3.90 ± 1.21**	**3.31 ± 1.01**

Table 5: Mean levels of the problems relating to the production process classified by production operation period

Problems	4-7 Months	8-10 Months	Throughout the Year
Contamination of other microorganisms in the fermentation process	2.50 ± 0.71	2.00 ± 0.71	2.75 ± 1.26
Improper fermentation temperature inhibiting yeast growth	3.00 ± 0.00	2.20 ± 0.45	2.25 ± 0.50
The alcohol percentage in the fermentation process does not meet the requirements	2.00 ± 0.00	2.60 ± 0.55	2.25 ± 0.50
Excessive foaming in the fermentation process results in decreased ethanol yield	3.00 ± 1.41	1.80 ± 0.45	2.75 ± 0.96
Insufficient concentration of nutrients used to feed yeast in the fermentation process	3.00 ± 0.00	2.00 ± 0.71	2.00 ± 0.82
Clogging of the distillation tower due to fouling	2.50 ± 0.71	2.40 ± 0.55	3.50 ± 1.29
Importing machines used in the refining process from abroad	2.00 ± 0.00	1.60 ± 0.55	2.50 ± 0.58
Mean	**2.57 ± 0.65**	**2.09 ± 0.61**	**2.57 ± 0.92**

distillation tower due to fouling. Continuous operation of the fermenter can lead to scale accumulation, resulting in blockages. Most of the problems ethanol production plants experienced in their production processes were on average, minor.

Transportation

The survey results for transportation problems in ethanol production plants are summarised in Table 6. All ethanol production plants experienced minor-level problems with transportation ($\bar{x}$ = 2.38 to 2.45). Plants operating for 4 to 7 months faced moderate problems with drivers lacking expertise in navigating the routes for transporting raw materials. Those operating for 8 to 10 months encountered moderate problems with the routes used to transport ethanol. These route problems faced by biomass production plants are the same as those observed by Garcia *et al.* (2014). However, plants that operate throughout the year face moderate problems due to the distance from the raw material sources to the factory and the risk of transporting ethanol due to its flammability. Overall, the findings indicate that transportation issues had minimal impact on ethanol production plants as all plants reported minor problems.

Price

The price-related problems of ethanol production plants are shown in the results in Table 7. The findings indicate that ethanol plants operating throughout the year faced significant price-related challenges ($\bar{x}$ = 3.67). The main difficulties were the high primary and secondary raw materials costs and low ethanol prices. Ethanol plants operating for 4 to 7 months and 8 to 10 months had major problems with the

Table 6: Mean levels of transportation problems classified by production operation period

Problems	4-7 Months	8-10 Months	Throughout the Year
Distance from raw material source to factory	2.00 ± 0.00	2.60 ± 1.34	2.75 ± 0.96
Delays in the transportation of raw materials	2.00 ± 0.00	2.20 ± 0.84	2.50 ± 0.58
Types of vehicles used to transport raw materials	2.50 ± 0.71	2.00 ± 1.00	2.25 ± 0.50
Routes used to transport raw materials	2.50 ± 0.71	2.60 ± 1.14	2.00 ± 0.82
Expertise of drivers in transporting raw materials	3.00 ± 0.00	2.20 ± 1.10	2.25 ± 0.96
Risks associated with transporting flammable ethanol	2.00 ± 0.00	2.60 ± 1.52	2.75 ± 0.96
Types of vehicles used to transport ethanol	2.50 ± 0.71	2.40 ± 1.14	2.50 ± 1.29
Routes used to transport ethanol	2.50 ± 0.71	3.00 ± 1.58	2.25 ± 0.96
Mean	**2.38 ± 0.50**	**2.45 ± 1.15**	**2.41 ± 0.84**

Table 7: Mean levels of the price-related problem classified by production operation period

Problems	4-7 Months	8-10 Months	Throughout the year
High cost of main raw materials	5.00 ± 0.00	4.80 ± 0.45	4.50 ± 0.58
High cost of other raw materials	4.50 ± 0.71	3.20 ± 1.10	3.75 ± 0.50
Low current price of ethanol	2.50 ± 2.12	3.60 ± 1.14	4.50 ± 0.58
Influence of other renewable energy sources on ethanol fuel prices	3.00 ± 1.41	3.00 ± 1.22	4.00 ± 0.82
High transportation costs per unit of ethanol	3.00 ± 0.00	2.40 ± 0.55	2.75 ± 0.96
High prices for imported machinery, e.g., due to import taxes	2.50 ± 0.71	2.20 ± 0.45	2.50 ± 1.29
Mean	**3.42 ± 1.31**	**3.20 ± 1.19**	**3.67 ± 1.09**

high costs of primary raw materials and the high prices of secondary raw materials posed a major problem for plants operating for 4 to 7 months. These issues contributed to increased expenses in ethanol production. Overall, the results suggest that ethanol plants faced significant price-related issues.

Government Support

The problems with government support are summarised in Table 8. The ethanol production plants operating for 8 to 10 months were identified as finding government regulations the most challenging ($\bar{x}$ = 3.69). Their main concerns, which were also major hurdles for plants operating throughout the year were government policies that promote ethanol fuel usage through price and tax incentives for various types of gasohol and support ethanol and related industries.

Furthermore, plants operating for 4 to 7 months encountered major issues related to prolonged delays in contacting relevant government agencies about factory setup. If biofuel production were genuinely supported by government policy, the risk of investing in the bioenergy industry would be reduced. This could reduce the country's dependence on oil imports, guarantee oil security, create employment opportunities in the industry, and promote the development of a sustainable low-carbon economy (Su *et al.*, 2015). In summary, ethanol production plants experienced moderate to major levels of problems with government support or lack thereof.

Engineering Aspect

The engineering problems experienced by ethanol production plants are presented in Table 9. Ethanol production plants operating throughout the year reported moderate technical or engineering-related problems ($\bar{x}$ = 3.00). They faced major difficulties due to the shortage of factory technicians capable of addressing machinery issues throughout the day, as well as moderate challenges related to the complexity of machine technology. Plants operating for 4 to 7 months encountered major issues with inadequate reserves of machine spare parts and moderate issues with the expertise of workers responsible for machine maintenance. Overall, ethanol production plants experienced minor to moderate levels of engineering problems.

Table 8: Mean levels of the problems with government support classified by production operation period

Problems	4-7 Months	8-10 Months	Throughout the Year
Ease of applying for a permit to establish an ethanol factory	2.50 ± 0.71	3.60 ± 1.52	2.75 ± 0.50
Prolonged delays in contacting relevant government agencies involved in setting up factories	4.00 ± 0.00	3.40 ± 1.14	2.50 ± 0.58
Policies supporting the use of ethanol fuel, such as promoting gasohol E20 as a base oil	3.50 ± 2.12	4.20 ± 1.30	4.00 ± 1.15
Policies encouraging ethanol factories to expedite ethanol production increase the cost of raw materials and address oversupply issues	2.50 ± 0.71	3.40 ± 1.52	3.50 ± 1.29
Promotion of ethanol production from alternative crops such as sorghum, rice, or wood chips	2.00 ± 0.00	3.00 ± 1.22	3.25 ± 0.96
Promotion of the use of all types of gasohol through price and tax incentives	2.50 ± 0.71	3.80 ± 1.64	3.75 ± 1.26
Promotion of industries related to ethanol such as the distilled vinegar industry	3.50 ± 0.71	4.40 ± 0.55	2.25 ± 0.50
Mean	**2.93 ± 1.00**	**3.69 ± 1.28**	**3.14 ± 1.04**

Table 9: Mean levels of the problem relating to engineering classified by production operation period

Problems	4-7 Months	8-10 Months	Throughout the Year
Insufficient reserve of machine spare parts	3.50 ± 0.71	1.80 ± 0.84	2.50 ± 1.29
Complexity of machine technology requiring specialised maintenance	2.50 ± 2.12	2.40 ± 1.14	3.25 ± 0.96
Lack of technicians available around the clock for machine repairs, leading to production interruptions	2.00 ± 1.41	1.60 ± 0.55	3.75 ± 1.50
Skill level of specialists responsible for machine maintenance	3.00 ± 0.00	2.00 ± 1.22	2.50 ± 0.58
Mean	**2.75 ± 1.16**	**1.95 ± 0.94**	**3.00 ± 1.15**

Environment Aspect

Environmental problems experienced by ethanol production plants are shown in Table 10. Ethanol production plants operating throughout the year faced moderate environmental problems ($\bar{x}$ = 2.63) and encountered moderate challenges with factory waste management. Similarly, plants operating for 4 to 7 months also reported moderate problems with factory waste management. Overall, the results indicate that the environmental issues experienced by ethanol plants ranged from minor to moderate.

Conclusions

The survey results show that the two critical issues consistently faced by all ethanol production factories are raw material problems and price fluctuations, rated at a major level. The high cost and volatile pricing of primary raw materials are significant challenges. These issues are interconnected, as the production of raw materials such as molasses and cassava, fluctuates seasonally, leading to unstable annual yields and subsequent price fluctuations. Moreover, the problem of insufficient raw materials due to competition from other customers exacerbates the situation, further driving up raw material costs.

Additionally, government policies aimed at increasing the use of ethanol fuel pose a moderate-level concern for ethanol production plants. For instance, the Thai government has yet to enact measures mandating gasohol E20 as a base fuel. Car manufacturers have not universally produced vehicles compatible with E20 fuel. These factors contribute to the moderate-level problem regarding the government's policies promoting ethanol fuel.

The abovementioned issues should be resolved as a priority because they have a significant impact on ethanol plants, so, we have proposed the following preliminary solutions:

- Ethanol plants should engage in forward contracts to procure raw materials, ensuring transparent pricing and clear specifications regarding quantity and delivery dates.
- Ethanol plants should proactively seek alternative sources of raw materials to

Table 10: Mean levels of the problem relating to the environment classified by production operation period

Problems	4-7 Months	8-10 Months	Throughout the Year
Complaints from nearby residents about waste odours, machine noise, water pollution, and air pollution	2.00 ± 0.00	2.00 ± 0.71	2.00 ± 0.82
Management of factory waste such as distillery slop	2.50 ± 0.71	2.80 ± 1.10	3.25 ± 1.50
Mean	**2.25 ± 0.50**	**2.40 ± 0.97**	**2.63 ± 1.30**

mitigate potential shortages or volatility in the supply chain.

- The government should implement supportive measures to encourage and facilitate the cultivation of key raw material crops such as sugarcane and cassava. This could involve allocating more land for cultivation and guaranteeing stable prices for harvested crops, instilling confidence among farmers and discouraging shifts to other crops based on market fluctuations.
- The government should establish price mechanisms to incentivise consumer usage of gasohol with higher ethanol proportions, including E20 and E85. Additionally, efforts should be made to incentivise automobile manufacturers to produce vehicles compatible with higher ethanol blends such as E85.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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