THE SCENARIO PLANNING OF BIODIESEL PRICE IN THAILAND

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ABSTRACT

This study was designed as a mixed method research approach to scenario planning for determining the factors which influence the biodiesel price in the oil market of Thailand during January, 2008 to December, 2017 and forecasting the biodiesel price of Thailand in next 19 years, during 2018 to 2036 along with the development in scenario planning for alternate futures in situation of biodiesel price to change. The source of data comes from the Energy Policy and Planning Office, Ministry of Energy of Thailand, monthly average retail price of regular grade biodiesel, during 2008 – 2017, 120 months in total consists of 1) Ex-refinery price, 2) Foreign Exchange, 3) TAX (Excise tax and Municipal tax), and 4) FUND (Oil fund and Conservation fund). This paper presents the factors which influences the biodiesel price in the oil market of Thailand during January, 2008 to December, 2017 by regression analysis and the biodiesel prices in Thailand with the time series decomposition method. This solution of time series decomposition method starts with decomposing data into a trend, a cycle, seasonal and any irregular components, and then calculates biodiesel prices with a multiplicative model. To this the end, this study developed biodiesel price scenarios planning toward renewable energy in Thailand.

The results were shows that all factors were significant (R^2 = 0.909). The Ex-refinery price has the highest effect (b = 0.673). The time series model shows that the trend of biodiesel prices has been continuously decreasing over the last 19th years. In the first year (2018), the biodiesel prices around 23.50 to 23.72 THB/liter. In the final year (2036), on December the retail price has fallen to the lowest price 14.05 THB/liter. While, we use the patterns of the change in future in two mains scenario

logics as follows: 1) development of vehicle technology (Technology as usual and Advanced Technology Development), 2) The situation of biodiesel price in the future (Low and High). The four scenarios developed are Green energy, Combined green and electrical energy generation, Fuel energy generation, and electrical energy generation.

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CHAPTER I

INTRODUCTION

Statement of purpose

In the past, the importance of major energy sources on earth was petroleum, natural gas, coal, hydro and nuclear (1). The basic problem of using petroleum fuels is air pollution comes from the use of diesel fuel. Diesel fuel ignition is the main source of Greenhouse Gases (GHG). Apart from Greenhouse gases (GHG) emissions, diesel fuel is also the source of other air contaminants such as Nitrogen Oxide (NOx), Sulfur Oxide (SOx), Carbon Monoxide (CO), particulate matter and volatile organic compounds (2). But nowadays, Bioenergy is the most important factor that helps to reduce the emission of greenhouse gases, and it can compensate fossil fuel usage (3), especially, biodiesel is the alternative energy that made by vegetable oil instead of using diesel. The Biodiesel's benefit is reducing the unburned hydrocarbons, carbon monoxide and particulate matters and renewable energy.

Moreover, the past trend study in biodiesel consumption found that many countries in the world still heavily depend on bioenergy as their main source of electricity, transportation fuel, and transport industry. Its consumption has been high in the past few years. For example, from the report of the U.S. Energy Information Administration (EIA) for using biofuels found that the consumption of biodiesel increased from 326 million gallons to 878 million gallons in 2009 to 2011 after it declined in 2010 (4). While, Thailand has been affected by the increase in fuel consumption and high volatility of crude oil prices due to the surge of oil demand in Southeast Asia and the political instability in major oil supplying regions which in 2013, biodiesel blending ratio varies between 3% and 4% (or B3 to B4) due to the plan of inconsistency feedstock supply.

But in the current situation, Thailand needs to rely on the imported fuel to serve the high number of demand in the country, especially, the implications of energy policies for Thailand does have some domestic energy production, it is primarily an energy importer. According to the report of Energy Planning and Policy Office (EPPO),

Ministry of Energy (MOE), Thailand has imported between 55% and 62% of its total petroleum fuel every year between 2008 and 2017 (5).

Table 1 summarized production, consumption, and net export of fuels and this show that Thailand had an average net import of 1,050,829 billion barrels (crude oil equivalent) between 2008 and 2017 (5).

Table 1 Summary of the petroleum market in Thailand, 2008 to 2017

Unit: BBL/DAY (Crude Oil Equivalent)

Year	Production	Consumption	Net Imports	Crude Oil Imports
2008	765,110	1,545,497	978,863	763,858
2009	793,721	1,604,405	997,987	752,196
2010	848,354	1,618,725	951,995	765,697
2011	894,765	1,663,312	922,169	762,294
2012	988,589	1,782,908	1,001,150	786,243
2013	1,017,647	1,854,465	1,020,143	761,723
2014	1,082,135	1,981,846	1,082,449	819,173
2015	1,077,848	2,001,532	1,130,232	843,173
2016	1,072,287	2,052,595	1,171,247	798,226
2017	1,026,014	2,079,592	1,252,059	875,429
AVG			**1,050,829**	

Source: Energy Policy and Planning Office, Ministry of Energy (5)

Moreover, a similar pattern from 2000 until 2011, the demand for commercial energy in Thailand increased every year approximately 5%. To clarify, it increased from 63.7 MTOE in 2000 to 101.2 MTOE in 2011. Therefore, this higher number leads to high demand. Moreover, the statistic also shows that oil import also increased from 39.7 MTOE in 2000 to 64.4 MTOE in 2011; this proportion is more than 60% of all types of energy in Thailand. The Royal Thai Government had set the 15-Year Renewable Energy Development Plan (REDP: 2008-2022) where the national targets for biodiesel were set

for the future share of renewable energy at B2 (98% conventional diesel blend with 2% of biodiesel B100) nationwide in the year 2008 , then up to B5 nationwide in 2010; and B10 as an option in year 2013 and mandate nationwide in year 2022 where the target of biodiesel demand was to be approximately 4.5 million liters per day (6). More recently, this plan has been slightly revised in the new 10-year Alternative Energy Development Plan (AEDP: 2012-2021) where the biodiesel production is targeted to be approximately 6 ML/D (7). The main driving force behind the Alternative Energy Development Plan (AEDP2015) was to decrease the fuel import, control the sustainability of energy and strengthen the production of alternative energy by developing the industry; this also includes the researching process to develop the alternative energy (8). While, the Ministry of Energy also adopts the principle of renewable energy of the King's renewable energy policies as an example to create the stability of energy and fundamental of alternative energy in Thailand, especially, the way of using a biofuel that creates by the replaceable natural resource in the country instead of import benzene and diesel. Also, another goal of The Alternative Energy Development Plan is to decrease the usage of final energy by 30 percent in 2036 compared with 2010 (8).

Furthermore, this plan also includes the development of growing palm tree in the right area and gives the importance to the new type of energy such as jatropha and microalgae to replace diesel in the future (8). Additionally, the Ministry of Agriculture and cooperatives, and the Ministry of Energy also create the campaign to develop biofuel in 2008 as their goal is to expand the area for growing palm to increase the production of palm oil. In 2006, they expected that the agricultural sector in Thailand would have the combination regarding producing palm oil in the rank third of the world or contributes only 3.76% of the world's oil palm production.

According to the production of biodiesel is expected to grow significantly in that above make realized that energy planning efficiency of the primary estimate of biodiesel demand for the impacts of increased demand is more necessary. Currently, the most commonly used method for planning alternate futures in a situation of energy price to changes is the scenario planning.

Scenario Planning is the strategic planning that is used in some organizations for long term plan because it can be flexible, and it is also an effective way to use when there is an uncertain situation. It makes people can adjust the strategy when there is an unexpected situation occurs, so this can help us find the right direction or way to solve the problem. Moreover, this plan is an effective tool that allows us to know about the leading player and our capability. Scenario Planning is future planning when strategic planning is old-fashioned (9). The situation will be a good answer to this question: "This situation can occur or not?" or "What will happen if?" Therefore, this will be different from the prediction because prediction may not show the risk, but another one may help us to manage with the uncertainty in the future (10).

Therefore, the important of Scenario Planning of this study aimed to determine the factors influenced the biodiesel price in oil market of Thailand during January 2008 to December 2017 and forecasted the biodiesel price of Thailand in next 19 years, during 2018 to 2036 for developing the scenario planning of the future since the 2036s helps generating the leaders exploring ways in forward and make a better decision. Biodiesel Scenarios ask "what if?" question can help the leader to see the possible situation in the future. Also, the prediction of biodiesel price situation also supports the government and public corporation to understand the possibilities and uncertainty about the alternative energy price such as biodiesel in the future.

Objectives of the study

1. To determine the factors influencing the biodiesel price in oil market of Thailand from January 2008 to December 2017

2. To forecast the biodiesel price of Thailand in the next 19 years, from 2018 to 2036

3. To create the scenario planning for altering the future in the situation of biodiesel price.

The scope of the study

Generally, there are two different kinds of biodiesel in Thailand, including commercial biodiesel and community biodiesel. Commercial biodiesel is produced by market firms for general use, while community biodiesel is generated at a smaller scale,

and is primarily distributed in rural communities for use in farm equipment. This research only focuses on commercial biodiesel (sold to the general public at gas stations in Bangkok and Metropolitan areas), because community biodiesel is not an open market product. This research utilized a sequential design consisting of 3 phases as follows.

Phase 1 (Quantitative research)

The main issues in this quantitative research are divided into two parts. The first objective is to determine the factors that influenced the biodiesel price in oil market of Thailand during January 2008 to December 2017 using multiple linear regression analysis. Multiple linear regression analysis with stepwise regression procedure for selecting the independent variables include 1) Ex-refinery price, 2) Foreign Exchange, 3) Tax (excise tax and municipal tax) and 4) Fund (oil fund and conservation fund) into the regression equation. The second objective is to forecast the biodiesel price of Thailand in the next 19 years, from 2018 to 2036 by time series analysis. The data set of four independent variables comes from the secondary data collecting from Energy Policy and Planning Office, Ministry of Energy of Thailand from January 2008 to December 2017.

Phase 2 (Qualitative research)

In a sequential explanatory study, the quantitative phase is follow-up by the qualitative phase. This section will focus on the qualitative stage, which served as a follow-up to the dominant quantitative phase. The qualitative phase involved focus on key persons, including leaders of the from government sector, private sector and education & other to better understand their attitude toward the current situation of biodiesel price focuses on explaining the biodiesel pricing situation and identifying risk factors that could result in changes in pricing over the next 19 years.

Phase 3 (Scenario Planning)

The scenario planning is a strategic planning method that organizations use to make flexible long-term plans. Thus, this study was conducted a scenario planning for developing the scenario planning for alternate futures in a situation of biodiesel price to change. The structure of this phase three is first to understand the various types of approaches developed. Moreover, this sector overview is mainly to study the factors that cause uncertainty to gain a deeper strategic insight into the market. Next, we discuss the

findings and analysis of the qualitative in-depth interviews and the proposed framework for the adaptation of scenario planning in organizations. However, the boundary of this study is limited to the biodiesel price of Thailand sector and does not claim to infer the findings in the use of scenario planning as a whole energy in Thailand.

The benefit of the study

There are three main benefits to this study, which are explained here.

1. The study examines factors that have affected the biodiesel price in Thailand in the past (2008-2017). The analysis demonstrates some of the long-term effects of competition in a market that has a high degree of government involvement, capacity issues, and some substitute products that may enjoy better subsidies and price supports. It provides novel information about the nature of the biodiesel market and the interaction of government support and market demand.

2. The study considers government biodiesel pricing policies. This aspect of the survey provides policymakers in Thailand and elsewhere useful information about the effect of strategies for energy security and increasing energy production, both on the energy stock targeted (in this case biodiesel) and the substitute good (in this case fossil diesel). The study also provides novel information for academics, by generating an overall assessment of long-term strategies and short-term activities of Thailand's Ministry of Energy and related departments in the transportation diesel market.

3. The study conducts scenario planning for biodiesel pricing in the future. This aspect of the study provides Thai energy regulators and policymakers with a realistic assessment of the likely effects of increasing the share of biodiesel fuels in the country's energy supply. It is essential because it will set expectations about how much support will be needed to develop the biodiesel industry to take over significant capacity from the import petroleum industry. Since the current share of biodiesel in the energy supply is very low (<1% according to the US EIA, this could be a significant investment, and it needs substantial support. This report provides evidence for policymaking that can be used to increase biodiesel capacity.

Definition of terms

Biodiesel

Biodiesel is the name used to refer to a diesel-equivalent fuel that has been obtained from biological sources, utilizing the transesterification reaction. Chemically, biodiesel is a mixture of methyl esters with long-chain fatty acids and is typically made from nontoxic, natural resources such as vegetable oils, animal fats, or even waste vegetable oils (11). A percentage of a blend of biodiesel in diesel is called B percent; for example, a 10% blend of biodiesel in diesel is called B10. Moreover, biodiesel products which can be used in place of regular diesel; doing so helps to reduce imports and develop the use of alternative energy. For instance, Biodiesel B10 which is the fuel that consists of 90 percent of diesel that comes from the fossil fuel, and combined with biofuel based in the proportion of 10%. Sometimes the proportion of biofuel based can be 2%, 5% or 20% , so it becomes biodiesel B2, B5 and B20 that use for commercial in petrol station. The objective of this research is to study about the overall picture of biodiesel price, and does not specify on any does not specify on any specific type of biodiesel.

Energy

Energy is defined in physics as the ability to do work. In general terms, energy refers to light, heat, electrical or chemical energy, or kinetic energy (12).

Scenario Planning

Scenario Planning is the practice of using forecasting and predictive techniques to identify future situations and changes, potential responded and their effects to inform strategy and policy information.

Stakeholders

Stakeholders is a party (individual, group, institution, or another party) that has an interest in the outcome of the decisions of an organization or policy (13). Familiar stakeholders include customers, businesses, communities, and the environment.

Forecasting

Forecasting is the process of creating the hypothesis of future scenario as a tool to consider. For example, the prediction of the price regarding the economic and survival rate regarding science (14).

CHAPTER II

LITERATURE REVIEWS

Reviews of the literature in this chapter are divided into main six parts as follows:

The situation of the oil market in the world

Oil is one of the world's most essential commodities. Global daily oil demand reached 93.45 million barrels/day in Q1/2015, with global supply reaching 95.3 million barrels/day (4). About 32% of global production (30.49 million barrels/day) is produced by the 12-country Organization of Premium Exporting Countries (OPEC). This group is comprised of countries that hold the majority of the world's crude oil supplies. Other major oil producers and exporters include the United States, Russia, the North Sea countries, and Brazil and Argentina (15). Because oil is an essential commodity for energy production, transportation, and agriculture, oil prices have a significant impact on other markets (16). For example, there is a connection between food price and crude oil price because of the cost of fuel for agricultural production (including chemical inputs and fuel) and product transport (16). Thus, oil is important as both a primary commodity and as an input into other key industries. Historically, the price of oil has been relatively stable (17). However, in 1973 a politically driven embargo by OAPEC (a subset of OPEC including the Middle Eastern producers) led to a sudden drop in the global oil supply (18). This embargo, conducted in response to American support for the Israeli Yom Kippur War, was also motivated by a need to increase oil revenues for the poorly development oil producing countries. The embargo occurred during a period of growing demand for and reliance on fossil fuels, particularly in industrialized countries. The result was a dramatic increase in the price of oil over the next year, with the price climbing from 3 usd/bbl to 12 usd/bbl by 1974 (18). Prices were driven even higher by hoarding and panic buying, resulting in persistent supply shortages (19). In response to this oil price shock and resulting pricing and supply problems, many Western Countries increased production and began to develop energy independence

policies, using export restrictions and shifting to other energy sources in response (19). A second oil crisis was precipitated in 1978 following the Iranian Islamic Revolution (20). This revolution, in which the Shah of Iran was deposed by the religious movement directed by Ayatollah Khomeini, resulted in a substantial collapse of Iranian oil production. Production fell to 40,000 barrels/day because of withdrawal of Western firms that had previously been supplying about 10% of the global output. In 1978 and 1979 saw a reduction in production of two million barrels/day, even though other producers increased production. This shortage was exacerbated, as it was in 1973-1974, by panic buying and hoarding as well as export constraint (20). As Clayton (20) reports, the Iranian oil production had only begun to recover in 1979 when the Iran-Iraq War broke out, once again constraining supply and increasing cost. During 1978-1979, the price of oil doubles from 15 usd/bbl to 30 usd/bbl : in 1979-1981, it rose again to 38 usd/bbl (20).

The 1973 and 1978 oil crises, and a subsequent significant increase in demand have triggered increasing instability in the global oil market (17). Today, the market is extremely vulnerable to supply shocks and political manipulation. The 2001 terrorist attacks in the United States, and the subsequent and continuing military and political unrest in the Middle East, have led to highly variable prices and sustained high prices in the global market (17). This has been exacerbating by economic and political unrest in other oil-production countries, such as Russia and South American production countries (17). Thus, the oil industry is in a tenuous position, being both fundamental to the global economy and highly vulnerable.

Biodiesel

Biodiesel is an alternative fuel similar to petroleum diesel (a massive, high-energy fuel commonly used for transportation), but produced from vegetable oils such as palm, corn, or rapeseed, or animal fats (21). These oils cannot be used directly in most diesel engines because they are too viscous, but through a process composed of several steps, including dilution or blending with other oils, micro-emulsification, pyrolysis, or transesterification, the base oils can bé transformed to work properly in existing diesel engines (21).

Figure 1 shows the general process flow for generating biodiesel from vegetable sources using transesterification (a process of treating the oil with an alcohol to reduce viscosity) (21). However, the product must still be blended with fossil diesel to work in most diesel engines (21).

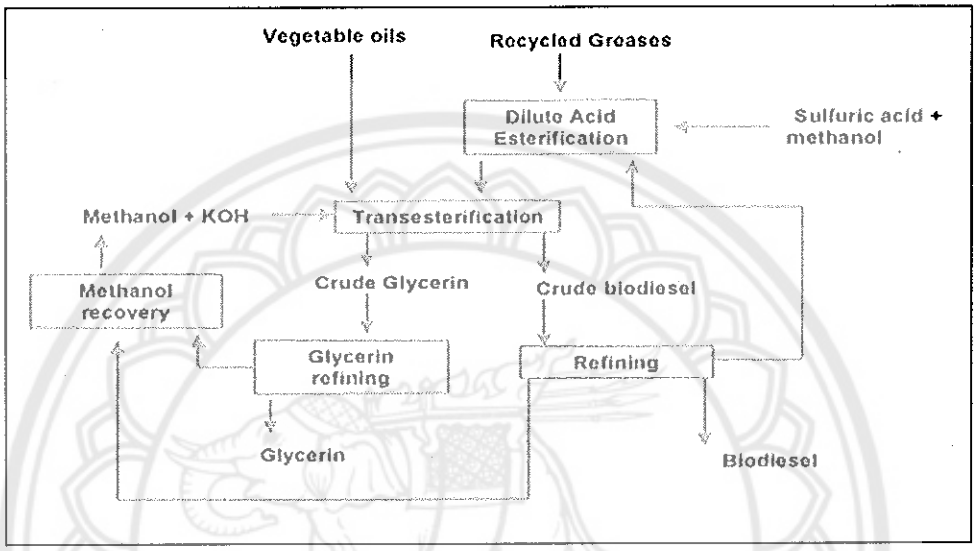


Figure 1 Producing biodiesel from vegetable fats using transesterification (21)

Source: https://s3-ap-southeast-1.amazonaws.com/erbuc/files/5627_51fa109c-543c-4a98-b056-5a1f42dce609.pdf

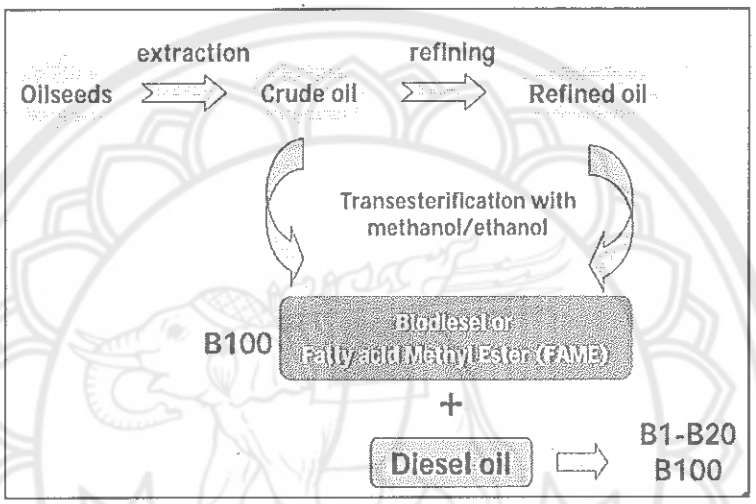
Biodiesel, along with other alternative fuels, is seen as an important substitute for fossil fuels (22). Alternative fuels are required for two reasons

1. To reduce carbon emissions to mitigate or slow climate change.
2. To substitute for increasingly scarce fossil fuel resources (22).

In Thailand, biodiesel came on the market in 2005 (23). It is one of some biofuels available, including ethanol and gasohol. Biodiesel is produced at two levels, including community biodiesel (primarily used in farm equipment) and commercial biodiesel (used in other diesel engines) (23).

Figure 2 shows the production process in Thailand. Domestic production can use some feedstocks, including coconut, palm, jatropha, or sunflower oil as well as waste cooking oil (23). Commercial biodiesel is sold at the gas station around Thailand

(23). The current mandatory blend is B7 (a blend of 7% biodiesel and 93% mineral diesel) (24). The AEDP requires a stepped implementation of increasing biodiesel inclusion, although the mix was temporarily reduced in mid-2014 due to a feedstock shortage that affected production (25). Higher blends are available, but no market data is available on price or demand. Consumer prices are a complex problem, and there has been little research done to determine factors in consumer price in Thailand.



Figures 2 Biodiesel product process in Thailand (23)

Biodiesel can be classified into two types of production, including commercial biodiesel and community biodiesel. Commercial biodiesel is refined from feedstock that is typically purpose-grown and selected for high yields and refined using highly efficient method (26). Commercial biodiesel production is designed for use on a large scale, with commercial distribution (for example, through a gas station and in bulk biodiesel/fossil diesel blends). Commercial biodiesel must use highly efficient production methods because of the capital costs involved in scaling up production, as well as the increased human resources costs associated with the production process (27). As these authors point out, commercial biodiesel production is still highly inefficient and is expensive enough that it is not economically viable without government supports such as price subsidies or production subsidies. The main reason for this is the cost of materials, which can be as high as 85% of the operating costs of a commercial-scale production plant (27).

An alternative production approach is community biodiesel. Community biodiesel production is conducted at a much smaller scale, with local plants using waste feedstock (such as recycled cooking oil or animal fat from farming activities) (28). Community biodiesel production is not as efficient or clean as commercial production, which has higher production standards. However, in Thailand community biodiesel can be produced that meets standards for use in agricultural vehicles (such as tractors, combine harvesters and other equipment). These vehicles, which have simpler engines than transport vehicles, can use less refined products and can also use unblended biodiesel (28). Community biodiesel offers an alternative route to the introduction of biodiesel, as well as allowing small-scale production from a recycled feedstock. Thus, it offers a useful complement to commercial biodiesel though it is not a full substitute.

1. The History of Biodiesel

Biodiesel has its early technological origins in the invention of a transesterification process designed for vegetable oil (29). This invention, in 1853, predated the development of the diesel engine. Diesel, a heavy fuel designed for use primarily in commercial vehicles, was invented by German chemist Rudolf Diesel (30). Diesel's first engine, which was premiered at the 1900 Paris World's fair, was initially operated on a biofuel derived from peanut oil. Although a few countries produced biodiesel during World War II because of a shortage of fossil fuels, the process was not generally thought to be economically efficient and as a result, was mainly abandoned for about 40 years (30).

Modern biodiesel production has its roots in the oil crisis of 1973 and 1978, which spurred the European government toward the development of energy self-sufficiency and the exploration of alternative fuel sources (31). Austrian and French research projects improved the efficiency of the refinement process (30). Among the improvements this process made was the development of a methyl ester standard of rapeseed oil, which allowed production to be good enough for use in transport vehicles (30). Another area of the early development of biodiesel was South-Africa, which was suffering from fuel shortage because of trade sanctions placed during Apartheid (31). Development of biodiesel continued through the 1980s, and by the early 1990s, it was efficient enough in Europe for small-scale commercial production (30).

European commercial biodiesel production began during the 1990s, spurred by a 90% tax deduction for biodiesel in the EC. Production in the United States began in the 1990s but became significantly higher following the 2001 terrorist attacks (31). However, biodiesel remains a minority formulation in most countries biofuel industries (32). Bioethanol, which is more easily produced from cheap feedstock such as maize, represents the majority of biofuel production today (32).

2. Origins of biodiesel in Thailand

Thailand was a relatively early adopter of biodiesel production, with the first experimental production programs being introduced by Royal Decree in 1985 (33). In 2005, B5 diesel (a mix of 5% pure biodiesel and 95% fossil diesel) was introduced, and in 2008 the Renewable Energy Development Plan mandated a stepped approach to increase biodiesel use, targeting mandatory B7 mix for diesel stocks by 2013 (33). These government policies have been introduced to increase Thai energy self-sufficiency (34).

Thailand can grow some appropriate feedstocks such as palm, which can be used readily for the transesterification process (33). Thus, it is well positioned to develop a biodiesel industry. PTT, through its subsidiary PTT Green Energy, was one of the first companies to produce commercial biodiesel and continues to provide the product as well as exerting influence on policymaking (34). Thailand's commercial biofuels industry today is focused on new production processes and feedstock sources, such as jatropha and microalgae, as well as the establishment of palm oil plantations to support development using standard palm-based techniques.

The industry is strongly supported by government policies, which are designed to support commercial production (34). Thailand also has some community biodiesel production plants, which produce agricultural fuel from locally recycled feedstock (such as used cooking oil) (23, 28). Community biodiesel is not high-grade fuel and cannot be purchased commercially; instead, it is produced as a community effort to reduce agricultural production costs.

3. Oil Price Deregulation in Thailand

The domestic policy context of biodiesel use in Thailand is based in a gradual oil price deregulation process. Before 1991, the oil industry in Thailand was fully regulated, with the retail oil price fully determined by the government (35). For a

brief period in 1991, the oil market was semi-regulated, as changes were phased into the retail oil industry. The final stage of full deregulation began in August 1991 (36). These periods were marked by different conditions and effects on oil prices.

3.1 Regulation (1979 to March 1991)

Up to 1991, the Thai oil market was fully controlled by the Thai government, with prices fully regulated, along with oil imports and industry participants (36). During this period, the government-controlled ex-refinery and import prices of oil and established a specific marketing margin (or the amount companies were allowed to realize in profits and additional costs). Retail prices were also entirely controlled, and the marketing margins and retail prices were not changed very often. An oil fund levy was used to stabilize retail prices. During this period, prices were consistent throughout years, but there was little competition in the market only four major companies (PTT, Shell, Esso, and Caltex) were retailing oil products in the Thai market. No other licenses were issued for the retail trade, though there were a few other competitors in the wholesale market. The relatively thin coverage meant that many rural areas did not have official retail outlets such as gas stations at all; instead, customers bought gasoline from "drum pumps" at a high and uncontrolled price. This situation also led to market distortion as well as retailer and consumer responses including contamination at the retail stage and a shift to diesel vehicles (36). Thus, while prices were kept low during this period due to government intervention, supply was inadequate, and many users were not able to access adequate or safe supplies.

3.2 Semi-regulation (March to August 1991)

Rather than deregulating the oil market immediately, the Thai government used a six-month transitional strategy to deregulate the market (36). The intention of deregulation was to improve quality and fuel supply by reducing or eliminating import controls and increasing the number of competitors in the market (37). Other goals included improving tax and duty to reduce distortion of prices, improving production and refinery capacity, and reducing regulations involved in establishing new retail channels (gas station) (36, 37) Deregulation included a limited number of consumer petroleum products, including gasoline, diesel, fuel oil and kerosene (37). During the semi-regulated period, the government reduced the oil fund levy and eliminated the maximum retail price, but retailed ex-refinery and import price setting

(though on a more regular basis) (36). Oil companies and gas station had to report prices, but were allowed to vary prices regularly.

Furthermore, the gas station had to post their prices for the first time. During this transitional period, prices trended slightly below the recent maximum price.

3.3 Deregulation (Post – August 1991)

During the final stage of deregulation, the Thai government eliminated controls on ex-refinery and imported wholesale prices and retail prices (36). For the first time, retail prices were allowed to vary entirely with the market (although the government retained control over components of petroleum prices including fuel duty levies) (35). However, this did not result in as much price change as much be expected, since the country was still import-dependent and oil imports continued to use the benchmark Singapore market prices, which were used by the government during the regulatory period (35). Furthermore, the price deregulation was accompanied by additional import restrictions, such as an import levy to encourage the use of domestic refineries (36). By 1997, the retail price had dropped about 1.5 baht/liter, mainly due to a fall in the ex-refinery price, compared to pre-1991 prices.

Deregulation of the oil industry did not immediately result in better conditions for consumers. Failure of some gas station to comply with price-setting requirements and plot (especially in retail areas) had negative effects, and consumers did perceive the marketing margin selected by companies as too high (36). Furthermore, the Thai government has continued to use direct intervention, either through the oil fund or through manipulation of ex-refinery or even retail rates, in the industry (37). This means that despite the deregulation process, the Thai government still plays a significant role in setting oil prices.

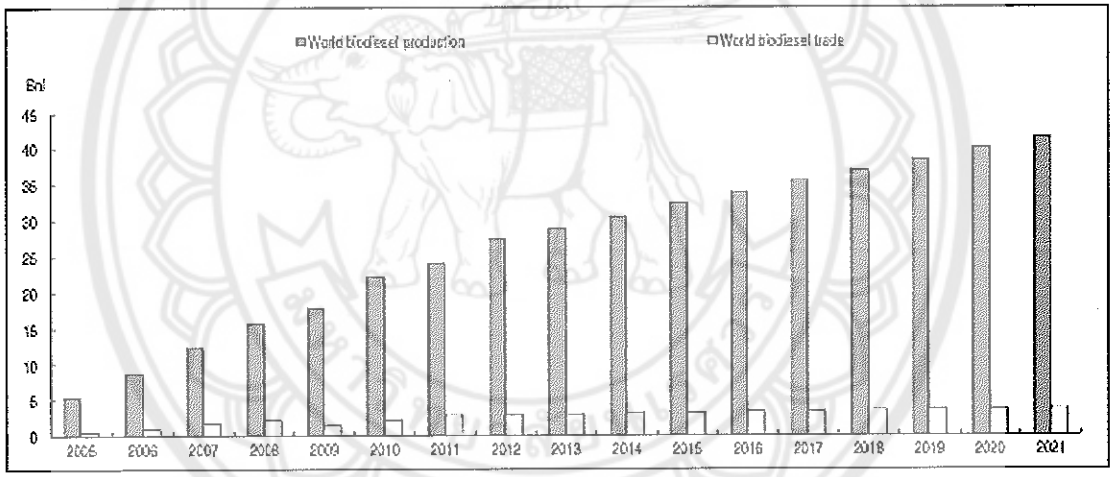
Trend of the biodiesel price in the future

1. Global biodiesel market and prices

The main biodiesel production regions include the EU, US, Argentina, and Brazil, although local biodiesel production takes place around the world (38). However, production is highly volatile; for example, while Malaysia was a major producer in 2010, its output of biodiesel was minimal in 2011 (38). The price of biodiesel is highly volatile and varies by market, because of the use of market subsidies intended

to promote biofuel adoption as well as fluctuations in the underlying price of the feedstocks (38).

Figure 3 shows the estimated biodiesel production and trade through 2021. As this shows, most biodiesel is consumed domestically, which is different from the world petroleum market (where there is much more product trade). However, it should be noted that even at the end of the period, the estimated replacement of fossil diesel will be under 10% in most countries (38). Thus, while biodiesel is expected to increase in importance, it is not likely to be a primary fuel replacement (probably because of the relative rarity of diesel engines in the first place). The estimated global biodiesel production in 2013 was 24.7 million tonnes, the majority of which was produced from soybean oil or palm oil (39).



Figures 3 Estimated global production and trade of biodiesel, 2005 to 2021 (38)

It is difficult to estimate a global price for biodiesel because feedstocks and demand vary widely between the regions that use the product (and because, as shown in the figure above, most biodiesel is not traded on the world market). International trade only accounted for 4% of biodiesel production in 2012, and this is expected to rise to only 7% in 2021 (38). In some production regions, such as the EU, global trade is expected to fall during this period as regulatory requirements for inclusion of biodiesel and other biofuels come online (38). Thus, biodiesel is not a globally traded commodity to any extent, and there is no global market in the commodity as such. However, the

global price of biofuels, including biodiesel, has generally been increasing over the past decade (38). These increases are highly volatile and depend mainly on the price of feedstocks (and also drive up the price of these feedstocks) (38). Thus, biodiesel on the global market is locally produced and traded, and dependent on other markets for pricing.

Thailand's biodiesel production can be compared to the situation in other developing countries to understand factors in biodiesel pricing and trading. Two other countries that have active programs for production and use of biodiesel include China and Brazil. These two countries are the largest producers of biofuels, particularly bioethanol, in the world after the United States (40). No useful information can be identified on the consumer price of biodiesel from the Chinese market. The majority of China's biofuels production has historically been in bioethanol, because of the fragmented supply of oil crops necessary for biodiesel production (40). However, biodiesel production is the subject of development, including the development of algal feedstock and other advanced production techniques (40). The 2013 production of biodiesel in Thailand was estimated to reach 966 million liters (41). According to the USDA-GAIN report on China's biofuel production, China has had difficulty implementing a full-scale biodiesel production program, with trial programs mainly only being conducted in Hainan Province (41). This report indicated that although the Chinese government has identified increased biofuel production and use in its most recent Five Year Plan, it has not yet been able to implement a biodiesel program that has delivered significant amounts of fuel to the consumer market. The main problem with China's biodiesel production is that the feedstock its development program is based on is used cooking oil, which has an inconsistent supply (41). Although China does have substantial grain production, this production is mainly allocated for human or livestock food supplies and has not been made available to biodiesel production (41). Thus, despite China's dominance in the world biofuel market generally, the majority of their production is in bioethanol, and there is no significant consumer availability of biodiesel. Brazil is more similar to Thailand than China, with an active biodiesel industry and government mandated biodiesel blends for consumer use (42). Brazil's mandatory B6 blend has generated consumer demand estimated at 4.4 billion liters in 2014, approximately 20% increased from 2013 (42). Biodiesel is also subject to a 14%

import tariff, which means that the majority of biodiesel is probably produced in Brazil. Biodiesel prices are not market-driven in Brazil but instead are determined by government subsidies and preferences, including subsidies and purchasing preference for farmers from poor areas (42). Biodiesel is purchased based on an auction system.

2. The Thai market for biodiesel

Figure 5 shows the price of biodiesel in the Thai market over the past ten years (2005 to 2015) (23). It should be kept in mind that the national sale of biodiesel products only began in 2005 (23), which explains the flat pricing during 2004. The price appeared to be highly volatile up to the significant spike in 2008. This spike is most likely related to the global commodities boom in 2008, which resulted in a substantially increased cost for both food products and biofuel feedstocks (44). The combination of poor production yields in some countries with subsidy pricing for commodities used for biofuel production (particularly corn for ethanol production in the United States) led to a significant increase in the cost of crops, including those used for biofuel feedstocks as well as substitute crops (44). While ordinarily this may be handled by normal market mechanisms, the introduction of requirements for biofuel use is thought to have caused a market shock that increased the price of both food and biofuels (45). After this initial shock, prices could be expected to even out (45).

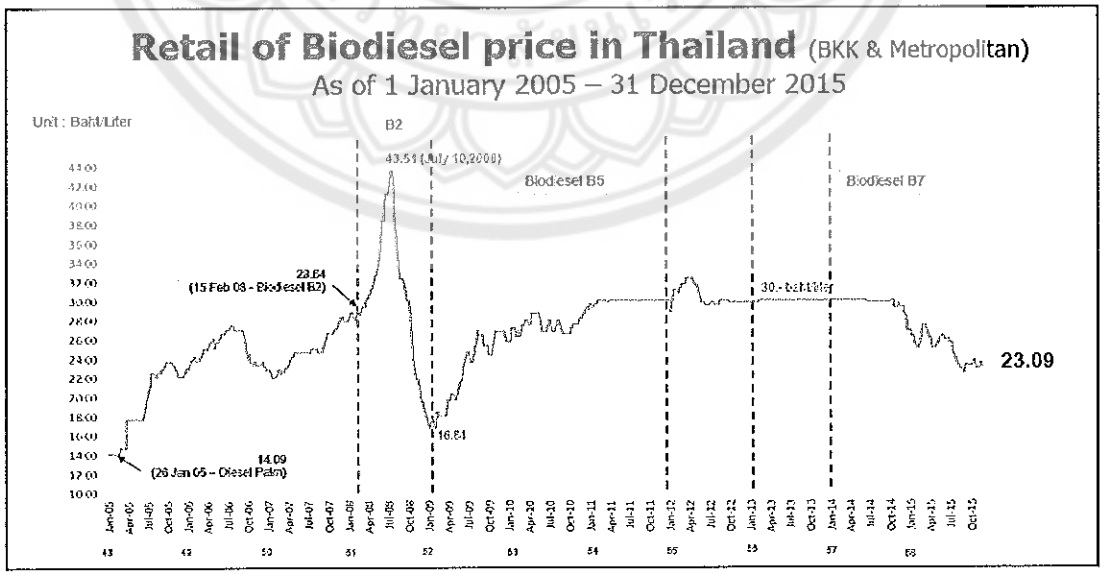


Figure 4 Biodiesel price (baht/liter), 2005 to 2015 (23)

3. The future of biodiesel prices in Thailand

The AEDP2015 proposed by the Thai government, which is scheduled for 2015-2036 will have some impact on the price of biodiesel over this period, particularly by its intention to change the supply and demand structure of the market. The proposed plan call target of 14 ml/day production, compared to a 2012 production of 1.62 million liter/day (46). This amounts to a 369% increase in daily production of biodiesel. Supply-side mechanisms include increasing feedstocks primarily by increasing the number of palm plantations to 5.3 million (848,000 hectares) and increasing the production capacity of palm oil to at least 3.05 million tonnes/year. The plan also proposes demand-side mechanisms, including increasing the blending share of biodiesel to 7% and trialing B10 and B20 (10% and 20% biodiesel blends) in transportation lorries and fishing boats (46). However, this plan also will involve new biodiesel replacements, including ED95, diesohol, and biofuels derived from seaweed and jatropha among others, which could influence prices by introducing new substitute products. Thus, it is clear that the development of the biodiesel plan encompassed in the AEDP plan will influence the price of commercial biodiesel, but it is uncertain to what extent these factors will change the price. However, one problem could be the continued reliance on palm oil as the main feedstock for biodiesel. As already discussed, use of feedstocks for biofuels that share a food use can result in price instability, particularly when the biofuel use is being introduced or expand (44,45). Thus, a rapid increase in the use of palm oil for biodiesel could be problematic. This is particularly true given that palm oil is increasingly used in global food production because it is an inexpensive low trans-fat product (47). Thus, further instability could be encountered because of the reliance on palm products in the AEDP, since substitute feedstocks including jatropha and seaweed are still under development (23). There is also a potential global market in palm oil for biodiesel production in countries that do not have climates appropriate for growing high-oil vegetable feedstocks, like Ireland (48). This could further affect the price.

Government policies regarding oil and gas (especially pricing policies) can also be expected to influence the biodiesel price. Thailand already protects LPG using a price protection program, primarily because of its use in domestic heating, cooking, and transportation (49). Although the use of biodiesel is not likely to overlap with the use of LPG, this could still impact the price of biodiesel, particularly in transportation

(a major commercial use) where LPG could sometimes be a substitute. However, it is very difficult for the government to abandon these policies, because they have a substantial effect for the poorest of Thailand's citizens (who may not otherwise be able to afford such fuels) (50). The Thai government also subsidizes biodiesel prices, although the subsidy rate varies. For example, in 2011 the Thai government increased its subsidies for B3 and B5 biodiesel (3% and 5% biodiesel blends respectively) to reduce the price to below 30 baht/liter (51). In Figure 6 shows that the price of biodiesel has been flat at 30 baht/liter for the last two years, indicating that this is an ongoing subsidy approach. However, this policy may not be retained indefinitely by the Thai government and is associated with its own economic cost.

In summary, the price of biodiesel in Thailand can be seen to be highly reactive to feedstock price changes, as expected, although it has been steady over the past few years. The reliance on palm oil in the AEDP could be particularly problematic since this could bring the production of biodiesel into conflict with food commodity pricing on a global scale. The AEDP introduces some initiatives meant to increase supply, including increased palm plantations, as well as initiatives to increase demand (such as increased blending of biodiesel in various products). However, there is still a lot of uncertainty in the future, including the effect of other fuel policies and subsidies and the potential impact of the development of a global market for Thai palm oil for biodiesel production. To date, no full assessments have been made on the impact of these factors on the future price of biodiesel in Thailand.

Factors effect on the biodiesel price in the oil market

There are some known factors that will influence the price of biodiesel, based on biodiesel markets in other countries and existing models. These can be separated into policy factors and market factors.

1. Policy factors

Government Policies are known to affect the price of biofuels. Some policies that influence the price of biofuels in other markets include government subsidies, blending mandates, and policies that influence production (such as requirements for feedstock cultivation and support for plant construction).

2. Subsidies

Government Subsidies (either directly to the consumer or subsidies for feedstock prices) are one of the most studied types of policies that influence the price of biofuels. Up to 2007, the main biofuel production (bioethanol produced in the United States and Canada) was only cost-effective because of government subsidies for growing corn feedstocks as well as subsidies for bioethanol production itself (52). These subsidies in effect created double policy support for biofuels, but without this support, bioethanol would have been economically infeasible because of the production costs (52). Thus, the influence of government subsidies needs to be considered.

3. Blend mandates and other industry requirements

There are also different kinds of government policies that could influence the price of biofuels. Blend mandates determine the number of biofuels that will need to be included in standard fuel blends (53). Blend mandates manipulate the demand for the biodiesel product by requiring the inclusion of some of the product in all base fuels sold (53). Thailand already has blend mandates in place related to B3 and B5 biodiesel blends and will be implementing B10 and B20 blends as experimental offerings for marine and road logistics fleets, as discussed above. Thus, this is likely to be an essential aspect of the price of biodiesel in the future.

Government policies can also provide direct support for the development of biofuel markets and influence prices, for example by mandating the construction of new processing facilities or requiring land to be used for the production of feedstock crops (54). There are some policies implemented in the AEDP that fall into this category, including policies intended to increase the amount of land under cultivation for palm oil (as well as subsidiary feedstocks like jatropha).

4. Taxes (Excise tax, municipal tax, and VAT)

Government Policies can have direct impacts on the price of biodiesel or other fuels through the application of taxes. Some kinds of tax that may be applied to fuels in Thailand include excise tax, municipal tax, and VAT. Excise taxes are narrow-based taxes that are collected based on a transaction, either ad valorem (per transaction) or per unit (55). Excise taxes are commonly used to support or redistribute benefits (for example, taxing fuel to support roads) or to discourage the purchase of undesirable goods. They may also be used because they are easier to collect than other types of tax.

Excise taxes vary in their economic effects depending on the market and product (55). A value-added tax (VAT) is a broad-based tax levied on a per-item basis, with the same rate applying across a wide category of goods (56). VAT is typically levied generally on a commercial basis and is paid by the retailer based on their total sales. The purpose of VAT is revenue generation, and like excise taxes, the effect varies depending on economic preferences (although VAT is typically regressive because of the fixed rate, which affects lower income people more than higher income people) (56). In Thailand, VAT is paid at each production stage by the importer, producer, wholesaler or retailer, with consumers ultimately paying the excess cost (57). There are some VAT exemptions, including small businesses and goods purchased for religious or charitable purposes, but biofuels do not fall into any of these exemption categories (57). Unlike excise taxes and VAT, the municipal tax is levied by the municipal government, typically based on general purchase categories (58). Revenues from the municipal tax go to the municipality to finance general needs. Although biodiesel in retail diesel blends would ordinarily be subject to the taxes above, in recent years tax rates have been reduced (37). Since December 2010, the Thai government has been using various approaches to combat the rising price of diesel fuel. The initial approach (a subsidy derived from the Oil Fund, which is discussed below) was discontinued relatively soon, and instead, a policy of tax reduction or elimination has taken its place. This policy eliminated the VAT (0.40 baht/liter) and reduced excise taxes (from 5.30 bath/liter to 0.005 baht/liter), resulting in a direct consumer subsidy of 5.695 baht/liter (37). Furthermore, diesel is not currently subject to municipal tax.

Table 2 shows the price structure for diesel in February 2013, showing the effect of taxes, as well as the fund charges, which are discussed below. The IISD's (50) analysis shows that the average retail price for diesel (29.99 baht/liter) is significantly below the average retail price for gasoline (46.45 baht/liter), mainly due to the reduction in VAT, excise tax, and municipal tax as well as a reduction in the oil fund levy charges. As the IISD (50) noted, these subsidies are not supported for gasoline products, producing a distorted effect on the market. Although the specific rates change periodically, this snapshot demonstrates the general rates of tax and their effect on the retail price of diesel.

Table 2 Price structure of diesel (B5 blended diesel) as of February 2013 (37)

Component	Cost (Baht/liter)
Ex-refinery price (Wholesale price)	25.49
Excise tax	0.01
Municipal tax	0.00
Oil fund levy	0.30
Conservation fund levy	0.25
VAT (wholesale)	1.82
VAT (retail)	0.14
Total retail price	29.99

5. Fund Charge (Oil Fund and Energy Conservation Fund)

In addition to taxes and direct subsidies, government funds also affect the price of biodiesel, as well as other petroleum products. Two notable funds include the oil fund and the conservation fund. While the oil fund policy is used to support and subsidize biodiesel products compared to non-biofuel products, the conservation fund has a neutral effect. These funds are used for different purposes and designed in different ways.

The oil fund has its roots in the 1973 oil crisis and the Thai government response (35). The original oil stabilization fund, established in 1973, set rates for contribution for producers; these funds were then used to mitigate price increases. A similar fund was established in response to the 1978-1979 oil crisis, and further policies have been used to support fuel objectives. Vikitset's (35) analysis showed that with the introduction of biofuels and biofuel blends, like biodiesel and gasohol, the government had used the oil fund to encourage uptake of these products. The oil fund was used as a de facto cross price subsidy (subsidizing biodiesel and other biofuel products through increased prices of other products). The use of a negative oil fund component for B2 and B5 biodiesel meant that prices were lowered compared to non-biofuel products (35). However, it should be noted that these subsidies are lower than

the subsidies in neighboring countries, such as Malaysia (37). The oil fund subsidies can be shown to have the effect of increasing stabilization in petroleum product prices (35). These effects occurred in all segments, whether the oil fund contribution increased or decreased the price of individual petroleum products. This is an important point since it demonstrates that the oil fund's stabilization goal is effective even though it does potentially increase the cost of products.

Another fund-based policy of the Thai government is the conservation fund. The conservation fund is a government policy that levies a charge on fossil fuel-based energy products to fund renewable energy projects and promotions (59). The five-year conservation program is the umbrella policy that governs the collection and distribution of revenues under the conservation fund. According to Irwan and Heikens (59), this type of non-revenue policy is common in Thailand, and the conservation fund is one of nearly 100 extra-budget funds that provide special purpose revenues. The levies associated with the conservation fund ranges from 0.07 baht/liter to 0.25 baht/liter (59). As Table 2 shows, the average cost for biodiesel products is 0.25 baht/liter, which is the same as for gasoline and other petroleum products (37). There are several strategic goals the revenues from the Energy Conservation Fund are used for. These include: increasing the rate of alternative and renewable energy provision and utilization, with a goal of 15.6% of energy demand; improving the energy efficiency of commercial installations and reducing energy consumption by 10.8%; and long-term policy development for energy efficiency and reduction of energy use (59). A general assessment of the program shows that it has proved effective at increasing funding for these goals, although the long-term policy implementation is still uncertain.

The Energy Conservation Fund does raise the price of biodiesel but does not distort the market compared to substitute products. The cost increase of the Energy Conservation Fund is minimal but consistent. In the long run, it may reduce the cost of energy, due to the development of energy efficient solutions.

6. Ex-refinery price

The biggest market factor in the price of biodiesel is the ex-refinery or wholesale price of the underlying product (diesel). As Table 2 shows, the biggest part of the price structure of diesel is the ex-refinery price (about 85%) (37). Since biodiesel blends typically contain only 2% to 5% biodiesel, the ex-refinery price of fossil diesel

will remain the most significant part of the price structure. This raises the question of how the ex-refinery price of diesel is established and what factors play a role in this price. Before oil price deregulation, the Thai government mandated an ex-refinery price based on the Singapore wholesale spot price (35). The Singapore oil price is the price agreed upon by oil traders in Asia that conduct energy trading in (the) Singapore market. It is not the price indicated by Singapore or the refineries in Singapore (60). This price was selected by the government because, as the closest major market to Thailand, it generally most accurately reflected the spot price for suppliers. According to Vikitset (35), although producers were allowed to alter their ex-refinery prices following deregulation, most producers continued to use the Singapore spot price. Producers continued to use the Singapore spot price because it was relatively high compared to other available prices (36). Today, the Singapore ex-refinery market price continues to be used by major producers including PTT (Thailand's state oil company) (60). There are several reasons given by PTT for the continued use of the Singapore price. The first reason is Singapore is the central role of Singapore in the Asian market, which is based in high refining and exporting capacity compared to other countries in the region (about 1.5 times that of Thailand), Singapore's role as Asian port of entry, and strong management systems and infrastructure. Singapore's central role in Asian oil trading means that the Singapore market price represents a regional average of prices. Singapore's close geographic relationship to Thailand also means that Singapore's prices are the least high prices that could be realistically achieved for export to Thailand. Since the Singapore price is generally used in Asia for establishing trade policies and trade deals, it is most appropriate for use as a market or wholesale price. Furthermore, the Singapore price floats with global price changes, which offers the best possible price (60). These reasons are all logical regarding encouraging the use of Singapore prices. However, it is also important to note that Singapore prices have consistently been higher than in other world markets (35). Since suppliers use the Singapore price regardless of where they purchase the petroleum products distributed in Thailand, there is the opportunity for arbitraging the higher price of the Singapore market but supplying cheaper products. Regardless of reasons, most suppliers (including producers and importers) use the Singapore ex-refinery price for wholesale pricing of their products in

Thailand. This makes it reasonable to assume the Singapore price represents the wholesale fraction in the Thai market.

7. Market factors

There are also market factors that can influence biofuel prices. These include supply, demand, price of substitute products, and the price of inputs. One factor is supply, which in the case of biofuels (including biodiesel) comes from farmers (61). Farmers determine what crops to grow based on the market price for the products; in the case of an increase in biofuel prices (and subsequently increased demand for feedstocks), farmers will increase supply, which will bring prices back down(61). However, the agricultural supply base also means that supplies are limited based on the demand for other agricultural products, agricultural capacity, and weather patterns. In the case of Thailand, the crop concerned for biodiesel will mainly be palm oil, since jatropha is still experimental.

Demand for biodiesel will also affect the price, particularly about supply. Demand is influenced by the price of the biofuel product compared to substitute products (discussed below) as well as the fleet structure (which determines the extent to which biofuels can be used) (62). These authors compared Brazilian and US demand for biofuels, finding that vehicle fleet composition determined the potential demand for biofuel. In this case, the demand will be determined by the commercial and passenger fleets as well as fishing fleet, which all use diesel fuels and which have been targeted for replacement of fossil diesel with biodiesel (46). Demand may also be driven by export demand for Thai biodiesel and biodiesel feedstocks (63). In practice, however, there is very little international trade in biodiesel, and this is not expected to grow much over the period in question (38).

The price of substitute products (in this case, fossil diesel) will also be a factor in the price of biodiesel. It is known that to encourage biofuel use, the price must be similar to the price of the substitute fossil fuels (64). This can be overcome somewhat by using government policies (for example, mandating biodiesel mixing in all products), but it will still help to determine the total price of biodiesel as well as consumer willingness to adopt it (62).

The fourth factor that should be considered is the price of inputs. The underlying feedstock is one of the major costs associated with the production of biofuels and is known to influence the price of the completed product (65). There is likely to be significant covariance in this relationship, however, since the demand for biofuels is also known to influence the price of feedstocks (44). The price of other energy sources (including oil and electricity) also need to be considered, because the production of biofuels requires significant inputs from other sources (66). While the main feedstock will be palm oil, there will need to be some research done to determine the main source of energy inputs for production of biofuels in Thailand. Marketing costs are also a significant cost associated with the retail price of biodiesel products. The relevant costs are typically combined into a marketing margin, the percentage of the per-unit price of the product that is spent on marketing activities (67). Some of the marketing activities associated with the petroleum industry include direct consumer advertising (for example, television and outdoor advertising), public relations, sponsorships, and incentive and promotional activities. These activities are required to increase consumer awareness of the brand and differentiate one supplier from another (68). The effectiveness of consumer marketing for commodity products such as gasoline and diesel are debatable since consumers often view these products as essentially substitutable (68). However, this does not prevent companies from spending money on marketing activities. For oil producers, marketing margin also includes downstream marketing logistics and distribution costs, such as packaging and transportation (69). These costs are incurred along with the promotional costs as described above.

Before deregulation in 1991, the Thai government mixed the marketing margin (36). Following deregulation, the marketing margin could vary depending on the firm's preferences. However, firms still kept this rate relatively low. An evaluation of diesel prices in 1997 showed that the marketing margin amounted to 0.8920 baht/liter (or about 10.1% of the total price of 8.81 baht/liter)(36). This was more than double the pre-deregulation marketing margin, although a reduction in the refining margin meant that the consumer's cost did not change much. In 1999, the marketing margin dropped rapidly but then stabilized (36).

The way in which individual producers calculate their marketing margin is opaque. One authors' analysis of natural gas production for energy supply in Thailand explained how PTT calculated its marketing margins for natural gas (70). This analysis showed that PTT's marketing margin for gas was calculated as a percent of the gas pool price, and varied depending on the product customers. The marketing margin ranged from 1.75% of the power pool price (for Independent Power Producer customers) to 9.33% of the power pool price (for Small Power Producers) (70). This variation means that marketing margins can affect the retail price of products in a significant and potentially unpredictable fashion. This makes the marketing margin worth considering in price relationships for oil industry products, including biodiesel and biodiesel-fossil fuel blends.

Scenario planning

1. **Definition of Scenario Planning**

The word "Scenario planning" has been defined by many researchers are as follows:

Porter (71) define a scenario as: "the perspective of the possible occurring situation which may whether happen as expected."

Schwartz (72) define a scenario as: "as a tool to see the future and make a decision by the administrator which depend on content, story, trend, and environment."

Ringland (73) define scenario planning as: "as a part of Strategic plan of tool and technology for unclear future management.".

Schoemaker (74) offers "a method for future imagination which is possible to help the organization make a better decision."

Van der Heijden (75) stated that scenario helped the company to understand the changeable both internal and external competitive market regarding technology and other information

Lindgren, & Bandhold (76) stated that scenario is a method to manage changeable business environment in the future.

Selin (77) defines scenarios as a situation to differentiate the future, but they should have equal reasons for development by gathering information orderly which lead the organization to understand the unclear future

Wack (78) claimed that scenario is a plan to search for the ability of the old entrepreneurs who have a creative vision regarding fast-changing which is more complicated changeability.

JISC (79) concludes that scenario means a tool for a strategic plan which helps develop a flexible plan.

Peterson et al. (80) define a scenario planning is a plan for strategic tools can be adapted to decide scientific development which is used to face changeability

Blomgren Jonsson, & Lagergren (81) offer a scenario planning scenario is a general method which is used to analyze complicated energy system to prepare for work processing.

Star et al. (82) conclude that a scenario planning is a technique which use to make a decision of uncertain situation and apply for environmental adaptation.

Maier et al. (83) indicated that the scenario is a situation. However, it is not predictable, and this process cannot set possibility in the future, especially extension planning of conversation to cover all of the possible responds in order to motivate organizations continuing working due to a changeable situation which has been prepared for an uncertain future.

Ringland (84) indicated that scenario is the normal aspects of the future situation that can occur; it is not the forecasting, but it is the possibility of the future situation.

Therefore, from all definitions of a scenario planning in this above can be concluded that is not a forecast, but the scenario planning means the art of creating a future scenario to make a decision or the process of strategic administration to make the manager be able to handle with the possible situation in the future.

2. Benefits of Scenario Planning Applied to renewable energy

Scenario planning initiated as a tool which was improved to help support public policy. However, we consider these processes in the present's evidence which is highly influenced by two factors. The first one is the approach expansion in the associated world where democratic pillars do not demand emphasis. The second one is the shift in public policy development which is away from the top and down of supremacy of the specialists, pre-eminent in Berger period, and further the intention of central citizen world of policy generation evidence at present. On the other hand, this

shift has not turned upside down to this main culture, or it has not even been paired to a corresponding epistemological orientation of this policy founder or even experts (85).

Moreover, Using the technique of original scenario planning may not help to forecast the change in external factors. Also, since there is the change occurs rapidly or when we have limited information; these things may make the organization overlook the opportunities and the detrimental effects that may affect the growth or development of people in the organization. The scenario planning is the tool that creates for handling with the change in the uncertain environment (86). Therefore, we can say that the scenario planning is the powerful implement regarding forecasting and managing the change in the industry and the surrounding. Also, forecasting the future situation which is an crucial tactic to use when there is the fluctuation in business. Also, scenario planning is the clear way to show the connection between thinking about the future and strategic plan, creative thinking about the future and strategic plan that can use in a real situation (87).

The main point of scenario planning is that we can imagine in the current situation, what we can see, and the tendency that create that scenario. Moreover, that scenario cover not only the vision, but also the challenge of the organization. All in all, scenario planning is not the forecasting, but reflecting the future scenario that is imagined; and even the alternative of a possible scenario that related to the future (88, 89). The scenario planning is the description of the potential of a future situation that has more than one aspect. According to Cornelius and his working group (89), scenario planning has much importance. Firstly, it shows the first plan and selecting the appropriate strategies with the organization. Next, it helps the manager to realize about the change and uncertainty of the operation in organizations. Thirdly, the scenario planning shows the tools to identify the future scenario and the ways to respond with that scenario. Fourthly, it shows the possibility of the combination between quantitative and qualitative research, so it makes the person who draws the scenario plan be able to append the result from others forecast; and also be able to consider from various elements. Lastly, it helps to develop the aspects of the manager that may difficult to change. In conclusion, currently, there are much organization that tries to apply this strategy (scenario planning) to create the strategic planning of budgeting,

and forecasting seems to be the effective way to make the hypothesis of the future scenario (90).

Scenario planning has become more popular because of two main factors. Firstly, the effects of the uncertain situation that occurs rapidly such as the September 11 attacks, epidemic, bird flu, pig flu, Ebola virus, and MERS. The second factor is that the fast growth of the economy in China and India, social media, and technological devices (90).

2.1 Scenario planning and the businesses

During the time, scenario planning has become more popular as it is an implement that use to support the strategic management and technology to handle with uncertain situation. Moreover, it is still popular because of its ability that can assess the aspect of possibility, while the quantitative forecast cannot (91). Using scenario planning in the business started since the 1970s, when the Royal Dutch/Shell company succeed to forecast the factors that may affect the company. Even though, they may not be able to avoid all of the problems due to the economic and political issues, for the overall picture the company is still successful (92). We can say that the scenario planning helps the company handle with the oil shock situation at the beginning of 1970s better than their competitors. Also, the scenario planning also helps the manager to understand the current situation that the oil price is lower than 2 USD/Barrel, and it affected the business; since the main competitor in this industry has the potential to bring the change and difference in this industry (93). The example of Shell company shows that looking towards the change in business and technology makes them successful.

All in all, the real challenge of creating a successful strategy is to rely on continuously following and tracking the business that may affect the organization in the future (92). Even though, using the scenario planning in the first stage is focusing on strategic planning, these days many organization tries to use the future scenario to apply with the operational planning, budgeting, and forecasting by focusing on the effectiveness of those hypothesis (90).

2.2 The appropriate way to apply scenario planning

Managing the risk is the important part for uncertainty from rapidly changing; therefore, using scenario planning will help the organization be able to make a strategic decision and see the uncertain situation that may occur in the future (91).

Moreover, the scholar defines that the scenario planning is the process that use to forecast the uncertainty in the future that may be various (94). Scenario planning is the tool for strategic planning use for setting the flexible long term plan and studying the future by understanding the effects of critical driving factors and uncertainty of organization (92). Usually, for the development of organizational strategies, people believe that our world and society in the next ten years (approximately 2020) will not be that much different from current time. However, scenario planning will make people see that there will be a lot different from these days because it depends on the fundamental of each scenario plan that has the demographics, politics, economics, social, technology, laws, and environment which are the main driving factors.

According to Schoemaker (74), the organization will gain the benefits from using the scenario planning when they are facing the situation as following:

1. High uncertainty rate and the ability of the manager to forecast and change the organization.
2. In the past, there is any unexpected situation that detrimentally affect the organization.
3. The organization do not try to acknowledge or create their opportunity
4. Low quality of strategic thinking such as being a stereotype.
5. The industry facing with the significant change.
6. When there are a different point of view.
7. When the competitors using the scenario planning.

3. Scenario planning process

The focus of the scenarios depends upon the organization developing them. For example, this study is looking for its future, including the following:

1. Identify focal issue or decision

Regarding creating a future scenario within 10 to 50 years, it has to have a clear and appropriate objective to create this scenario regarding size as worldwide, local or an organization in the area such as Thailand's province, Samut Songkhram, etc.

2. Identify driving forces

Comments from the public are included in determining the driving force also to accurately analyze trends in both qualitative and quantitative terms to produce analysis from the document review and forecasting from the public's comments

3. Rank importance driving forces and uncertainty

To prioritize the Driving force to be identified and to determine on its certainty or uncertainty we must theorize 2 driving forces that are of prime importance and uncertainty or that can change the ongoing trends, this may be even a desirable event, which is a key part of the prioritization process. While Negative factors can be defined as the most different to ongoing trends yet most relevant conditions in the future.

4. Select scenario logics

By creating a Future scenario via defining the main points of trends and uncertainty of the future can often lead to bring two major uncertainties that make up the core of the future image of the organization, (Figure 6). We must then Analyze the future image in the form of a summary of short texts that can rightfully and adequately represent the image. The summary may identify related effects and potential events in a certain period. Creating the Future image, it must also be reviewed by the surveyors as it must include existing evidence to refine the appropriate image further.

5. To create a prosperous future, we must relate the future image to the plan that has been devised such as for scenarios of assessing the strategies and

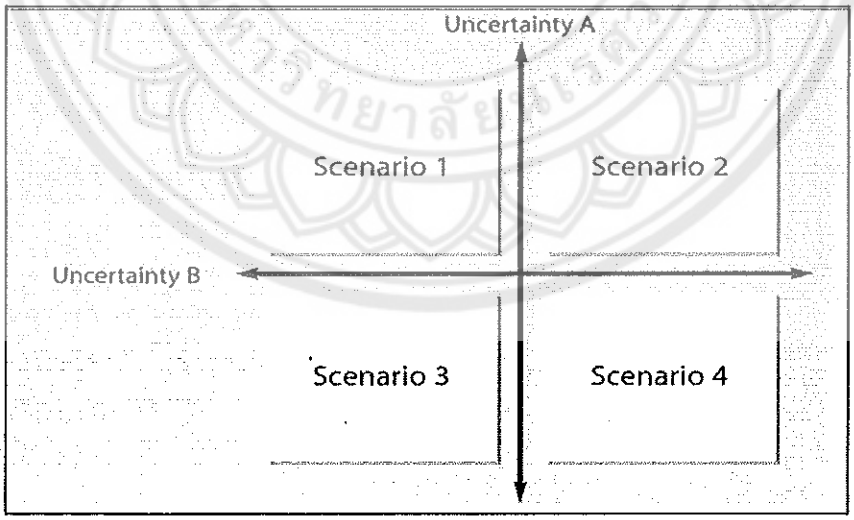


Figure 5 Scenario cross that constitutes four different scenarios based on two uncertainties (95)

Relevant Study

Vaccaro et al. (96) considered this situation which is about Biodiesel situation chain of the government of Brazil. They have the main objective which specifies driving factors or important components which related to chain situation of Biodiesel of the government of Brazil. From research, the process of creating a future scenario which indicates that chain situation of Biodiesel of the government of Brazil having two main factors which are the keys for sustainability and ability of competition of chain of Biodiesel of the government of Brazil. Firstly, "Effectiveness of public policies for the biodiesel chain'' and ''Price of raw materials for the production of biodiesel" by ''Effectiveness of public policies for the biodiesel chain'' can be divided into quality policy or ineffective policy. Regarding price, they have low price and high price. Also, research indicates that the important consideration relying on the main ingredient to produce Biodiesel from the Brazilian government, especially soya bean and developed ingredient to respond to the need of secure foundation of Biodiesel production.

Szarka et al. (97) said that the analysis of long term energy and the role of Bio-energy in Germany. This research has an objective to research and creating an understanding of this situation of energy and analyzes the expectation of-of the role Bio-energy in 2050. From this research found that Germany still has unstable future energy development in 2050 such as the potential of producing stable Biomass in the country.

De Paula Dias et al. (98) claimed that stably possible situation. There was research about industries of Brazil in 2030, and the results show that structure in industries in Brazil are passed on factors regarding society, environment, and economy and they gained a lot of support from others such as territory and politics.

Mofijur et al. (99) showed that the research of this situation of energy and policy and objective of bio-fuel in ASEAN countries. This research has a purpose of presenting the unstable situation of energy in the world due to unstable of the environment through the conflict of politics and economy. This research concluded that the use of energy and release of CO2 in ASEAN countries had been increased daily. To reduce the use of energy and CO2 that could be dangerous to the environment. The govèrnment in ASEAN countries set a goal which uses biofuel in diesel motor thanks to reducing fossil fuel and pollution.

Cremonez et al. (100) Regarding Biodiesel production in Brazil: current situations and the public's future perspective indicates that the Brazilian Biodiesel is a renewable source of energy. The objective of the Biodiesel production is to enhance the country's energy performance and to stabilize the country's impact on the volatility of the petroleum products in the export market. Even though of the fact that the soybean plants are the primary source for the biodiesel production, The country has a larger expanded area that can be compatible to cultivations of other crops that can replace soybean as another source to meet the supply and demand. If Brazil has enough capacity to be a large production base, then Brazil can become a reference point for biofuel production also with other sources such as biogenosene and aviation biofuel.

Singh (101) said that energy sufficiency aspirations of India and the role of renewable resources: scenarios for the future. The objective of the paper is to examine and discuss the perennial problems plaguing the Indian electricity scenario, for example, energy inequity, energy deficit, and energy insecurity. The analysis done in the present paper shows that in the most desirable electricity demand-renewable growth scenario, the percentage share of renewable electricity in the overall electricity mix of India rises steadily from the current 6% to around 43–44% by 2031–32. Then decays gradually to saturate at about 26–27% by 2063–2065; whereas, in the most likely scenario it rises steadily to approximately 29% by 2030–2031 and then decays gradually to settle at about 21% by 2064–2065. It leaves policymakers with a lot of thinking to do regarding the viability of other alternatives in long-term power planning and underscores the need for path-breaking R & D in the sector.

Wangjiraniran et al. (102) showed the research of this scenario analysis of disruptive technology penetration on the energy system in Thailand. This research has an objective to understand how the energy sector in these countries would change under this trend, Thailand was selected as a case study to analyze changes in its energy sector. This research concluded that the high penetration of disruptive technologies—EV, ESS, and solar PV—will have an impact on Thailand energy system in Thailand, particularly in the transportation and power sector. In the transportation sector, oil products remain the major fuels; however, EVs can reduce the fuel economy demand and improve the energy efficiency by 13%, and will decrease GHG emission by 7 million tCO2eq by 2036. In the power sector, EV will raise electricity demand at night depending on the

charging pattern of EVs, and EV will increase GHG emission by 4 million tCO_2eq by 2036.

Zhang, & Wenying (103) said that the role of biofuels in China's transport sector in carbon mitigation scenarios and the results show that bioethanol will be more influenced by the electrification than biodiesel and bio jet fuels due to its easier substitution by electricity. Biofuels will be indispensable in China's transport decarbonization, and relevant and coherent policies will be needed to propel the sustainable development of biofuels.

From the revision that relates with the Scenario Planning of the alternative energy in many countries, this makes the researchers conclude that the future situation of biodiesel price depends on many factors as following:

1. The effectiveness of government's policies
2. The price of the material for the production of biodiesel.
3. The stable potential of the production of biomass in the country
4. Politics and economy
5. The policy of reducing carbon dioxide emissions.
6. Cultivated area of planting palm oil and soybean.
7. Disruptive technology

According to the all previous statement, the researcher found that that the factors that is most influenced and related with the future situation of alternative energy in Thailand are the disruptive energy and the future situation of biodiesel price

CHAPTER III

RESEARCH METHODOLOGY

The methodology of this study concerns in determining the factors which influences the biodiesel price in oil market of Thailand during January, 2008 to December, 2017 and forecasting the biodiesel price of Thailand in next 19 years, during 2018 to 2036 along with the development in scenario planning for alternate futures in situation of biodiesel price to change. This chapter emphasized the essential issues as follow:

Research Instrument

This study was designed as a mixed method research approach to scenario planning. It also describes the terms of factors influenced the biodiesel price in oil market of Thailand during January 2008 to December 2017, and forecasts the biodiesel price of Thailand in next 19 years, during 2018 to 2036.

The research instrument of this study is an in-depth interview. It was designed by using open-ended question to show the attitude of the participants on the future situation about the biodiesel scenario planning and also the expertise in order to consider their perception toward the current status of biodiesel price focused on explaining the biodiesel pricing situation and identifying risk factors that could affect the price changed over the next 19 years.

The items of the in-depth interview were divided into three main categories.

First is an attitude toward the current situation of biodiesel price focuses on explaining the biodiesel pricing situation. Second is to identify risk factors that could result in changes in pricing over the next ten years. The last one is an attitude toward the effect of Alternative Energy Development Plan (AEDP: 2015–2036) on the biodiesel price situation with a particular focus on production mandate for biodiesel, tax and non-tax incentives.

Moreover, The interviewer should have prepared for the interview starts by reviewing the literature on the research or content about in scenario planning, the factors influence the biodiesel price in oil market of Thailand and forecasting the biodiesel price of Thailand in next 19 years which also one part of the preparation for the interview.

Data Collection

The data collection is divided into two parts:

1. **Secondary data for Phase 1 (Quantitative research)**

This section describes the data used to estimate our forecasting model and determines the factors that influenced the biodiesel price in oil market of Thailand. This study uses secondary data from Energy Policy and Planning Office, Ministry of Energy of Thailand. This data is a monthly average retail price of regular grade biodiesel that consists of 1) Ex-refinery price, 2) Foreign Exchange, 3) Tax (excise tax and municipal tax), and 4) Fund (oil fund and conservation fund). Prices are expressed in baht per liter. The sample period runs from January 2008 to December 2017.

2. **Primary data for Phase 2 (Qualitative research)**

The total of 8 interviews consists government Sector, private sector and education sector etc. These people will help regarding checking and identifying the possible plan of the future situation of biodiesel price.

The in-depth interview consists of 3 main questions which are 1. What do you think about the current situation of biodiesel price? 2. From your perspective, what are the factors that may affect the change of biodiesel price in the next 19 years? 3. Do you think that AEDP: 2015-2036 will have any effect on biodiesel price?, and How?. This field works were conducted from February 2017– March 2017.

Four steps of interviews are as follow:

1. Making an appointment for interviewing with 8 participants

2. The interviewer should make a friendly atmosphere to make the participants feel safe and free to express their opinion. Moreover, we need to clarify the objective of this research, and inform the participants that we will record the audio file, and translate every word that they say.

3. The data collection took place under control all of the interviewers. Each interview was conducted in 60-90 minutes per person.

4. After the interview is complete, the interviewers should conclude by using mapping in important topics together with writing a note in each interview.

Data Analysis

Data obtained from secondary data for Phase 1 (Energy Policy and Planning Office, Ministry of the energy of Thailand) was analyzed by using statistical software for windows program. There were composed of two parts which use statistical data analysis as follows:

1. Quantitative analysis

1.1 The assessed of the factors influenced the biodiesel price in oil market of Thailand during January 2008 to December 2017 using Multiple Linear regression analysis with stepwise regression procedure for selecting the independent variables include 1) Ex-refinery price, 2) Foreign Exchange, 3) Tax (excise tax and municipal tax) and 4) Fund (oil fund and conservation fund) into the regression equation. This study uses the secondary data from Energy Policy and Planning Office, Ministry of the energy of Thailand to analyze by using the ordinary least square (OLS). It will help determine how the independent variable influences retail biodiesel price. The result will show by R^2, adjusted R^2, t-statistics, f-statistics, tolerance, and Durbin-Watson statistic; the level of significance in this analysis is 0.05.

1.2 This study constructs the statistical forecasting model of the biodiesel price of Thailand in the next 19 years, from 2018 to 2036 by time series decomposition method. The data set is the secondary data collecting from Energy Policy and Planning Office, Ministry of Energy of Thailand from January 2008 to December 2017. The time series analysis focus on separating each component of the time series. For each element that has already separated, it will have different movement of time series, so it will help regarding creating the new forecasting method (104). The components of time series that influences the forecast are the trend, seasonal, cyclical, and irregular (104).

The trend of a time series decomposition method (T) indicates the variability of the data during a long-time that it increases, decreases or remains stable, and which irregular changes occur. Generally, the trend is considered by the least square method, which consists of estimators that minimize the sum of squared residual regression. The example of the trend formula is explained by Justiniano (105).

$$\hat{Y} = a + b\,(t) \qquad (1)$$

where a is the intercept.

b is the slop.

t is amounts (initial)

Seasonal variation is repeatedly the variation of time that occurs year after year with a duration less than one year. The Seasonal variation in a series corresponding to the increase and drop fluctuations that are repeated in a certain period of the year, month, week or day.

Cyclical variation is used notation "C" that has the characteristic of similarly as seasonal variation, but the cyclical variation is fluctuations in the values of variables longer than a year.

Irregular variation is the variation of time that not a trend, seasonal and cyclical, which is the one that does not follow a pattern, its fluctuations are not explained.

Therefore, The following are details of the procedures used in this study.

1. The time series decomposition analysis was to make a plot graph using Microsoft Excel and analyze whether it had a trend to increases, decreases or remains stable, and which irregular changes.

2. Step two is to calculate the seasonal change by using the ratio to moving average which averages one moving per 12 months (k = 12). This method eliminates the seasonal influential (S) and the irregular variation (I) from the data.

3. Next, to find the appropriate trend equation

4. Step four is to calculate the cyclical change index; this is conducted by eliminating the trend (T) out of the moving average (MA) by $\hat{C} = (T \times C) / \hat{T}$

5. Step five is to calculate irregular index ($\hat{I}$) by $\hat{I} = (S \times I) / \hat{S}$

For this kind of forecast, the formula will be multiplication or addition, so it depends on the distribution of the time series model. To demonstrate, if the distribution is constant, we will use the addition formula; however, if it is not, we will use the multiplication form as a first and second equation. Therefore, the final step of

creating forecasts by the multiplicative decomposition model consists of estimating the four components of the model.

For the time series forecasting, the element that is the most influence on the forecast is the change of season, trend rate, and the shift in cycle. For the abnormal change, we cannot forecast because of the random variable is uncertain, so we cannot assume the future situation that what is going to happen, when it is going to happen, and how strong it will be. Therefore, we selected three components were trend ($\hat{T}$), cyclical ($\hat{C}$) and seasonal index $\hat{S}$ for forecast th,e biodiesel price of Thailand in the future are given as

$$\hat{Y} = \hat{T} \times \hat{C} \times \hat{S}$$

Furthermore, we have to find the difference between the real information and the forecast (Error) to calculate the mean absolute percentage error (MAPE) (105). The forecast that has the lowest rate of MAPE is the most accurate one (106). The mean absolute percentage error (MAPE) as shown in below equation.

$$\text{MAPE} = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{Ft - At}{At}\right| \times 100\%$$

In Equation above, Ft is the forecasted value at the year t, At denotes the actual value at year t. N stands for the number of observations.

2. Qualitative analysis

Data obtained from primary data of phase 2 was analyzed by using contents analysis, the contents analysis consist two steps are as follow;

For the qualitative data in the second phase, we use content analysis which is the idea of Johnson and LaMontagne (107). It consists of 6 steps which are 1) preparing the necessary information to analyze and adjust the tools for collecting the information (Data preparation) 2) Familiar with the data 3) Identified unit of analysis 4) Tentative categories 5) Refined categories 6) Category integrity

Reliability and Validity

We follow the work of the mixing method. Thus, the Assessment of research tools can be classified as two groups include

1. Assessment of research tools for quantitative research

In part of evaluation of research tools for quantitative research is consistent validity. It is mandatory for the overall quality of an assessment to ensure that its secondary data would be sufficient in quality. An error data refers to data riddled with inconsistencies, because of poorly designed recording systems which are incomplete control. Therefore, before analysing the secondary data, cleaning data is an initial use that can test sufficient quality of data. It is more efficient to detect errors by actively searching for them in the planning. Data cleaning involves repeated cycles of screening, diagnosing, and treatment.

2. Assessment of research tools for qualitative research

The Assessment of research tools of content analysis determines whether the conclusions are accurate or not. The research quality ensures the validity and reliability of this study. The validity and reliability are described as followings

2.1 Internal consistency

Internal validity is usually important for the explanatory or causal study to establish validity in a causal relationship, as the distinct from spurious relationships. In this study, the researchers set the stages distinctly by using research design, and the research instrument for collecting data along within each question which was thematically arranged in relevance to the objectives of the research.

Moreover, the purposive sampling was applied to recruit individual into this study with staring by key persons including leaders of the former of energy policy, planning office, private sector, transportation sector and other experts who volunteers in-depth interview in point of positive or negative attitude toward the current situation of biodiesel price focused on explaining the biodiesel pricing situation and identifying risk factors that could result in changes in price over the next ten years.

2.2 External validity

External validity is the ability to use the result of the interview to conclude the generalization between the sample and the population effectively (103). In this study, Interviewers are chosen from whom experienced in the leader position of

the from energy policy and planning office, private sector, transportation sector and amplified or enhanced concepts of the Alternative Energy Development (AEDP: 2012–2021) for production of scenario planning helped generating the leaders exploring ways in forward and make a better decision.

3. Validity

In this study, content validity is the most concerned. Major advisor and co-advisor are both persons who validate for such validity.

4. Reliability

Different protocols were used to collect data, including secondary data, in-depth interview, Tap record, voice-data, and documents preserved for further verification.

5. Construct validity

Reviewed with literature reported in the main document about biodiesel scenario planning, journals, then established a chain of evidence by building a literature review and consolidating existing knowledge of researchers.

Ethical Considerations

Research ethics is an important thing in every research situation to make sure that researchers would not harm participants and provide benefits, as well as conduct research in a proper way. In this research, the main concern was confidentiality of interview respondents, credibility and trustworthiness of external data. Data were not collected from interview participants but mainly came from public sources, which was identified. This helps to protect the credibility and trustworthiness of the underlying data, even though interpretations of this data may vary widely. This leaves the main concern of protecting interview participants. Interview participants could face some risks by participating in this research, particularly if they inadvertently disclose non-public information. To protect participants, the following steps were taken. Firstly, the participants were offered confidentiality to themselves and their organizations if they desired, the organization they work for, it will not be disclosed. No personal identities were disclosed in this process. The second concern was sensitive information. The researcher would submit interview transcripts to participants following with the preparation and giving them the chance to reject any information they feel that it should not be disclosed.

Methodology Flow Chart

The mixed method research of this study is presented in the flowchart below.

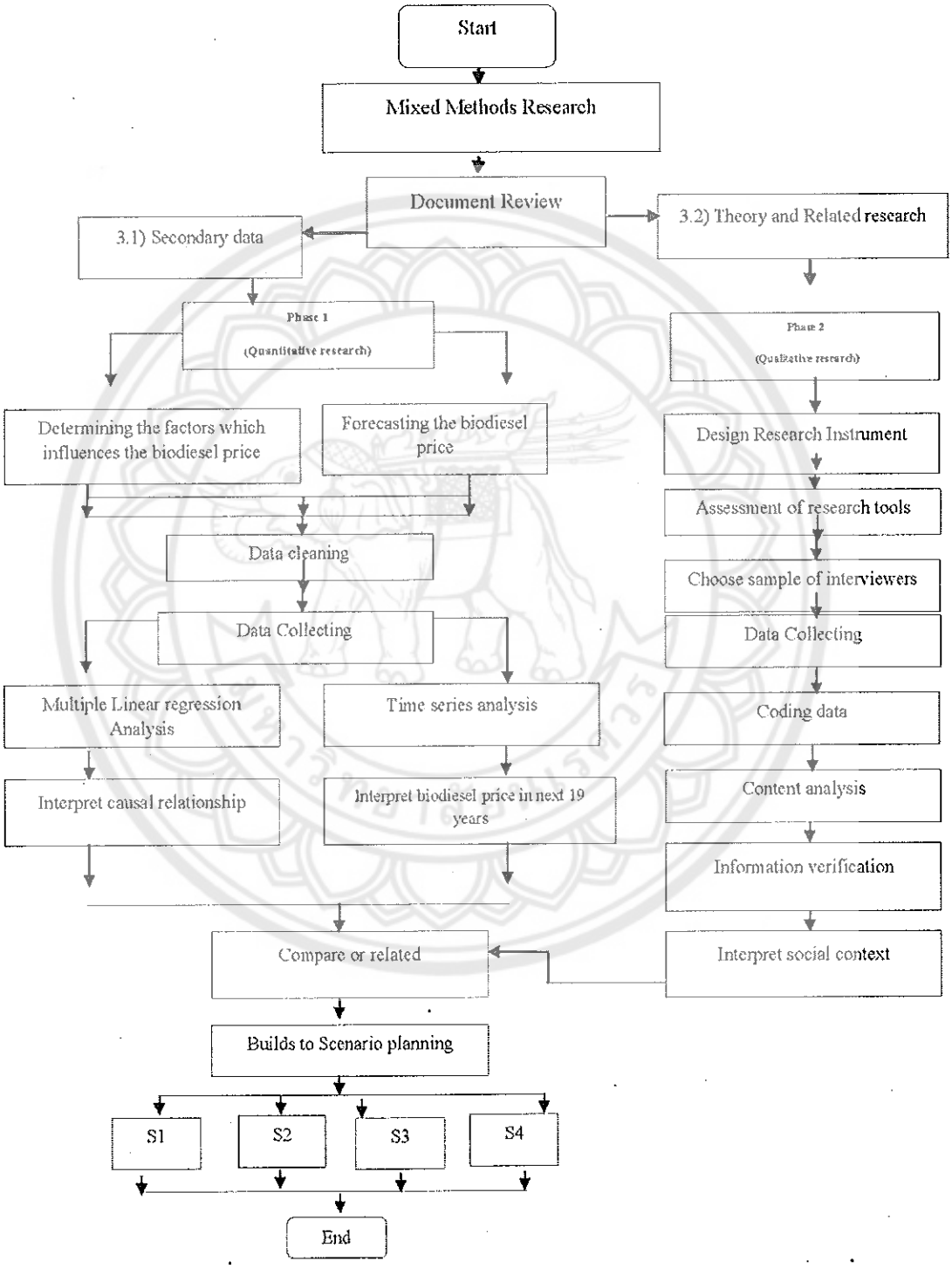


Figure 6 Methodology Flow Chart

CHAPTER IV

RESULTS

The main issues in this phase 1 of the study show the results of quantitative research for determining the factors which influence the biodiesel price in oil market of Thailand during January 2008 to December 2017 and forecasting the biodiesel price of Thailand in next 19 years, during 2018 to 2036 along with the development in scenario planning for alternate futures in situation of biodiesel price to change. This study use monthly average retail price of regular grade biodiesel, ex-refinery price, foreign exchange, tax (excise tax and municipal tax), fund (oil fund and conservation fund) and retail price, obtained price from Energy Policy and Planning Office (EPPO), Ministry of Energy of Thailand. Prices are expressed in baht per liter. The sample period runs from January, 2008 to December, 2017 overall 120 samples.

While, the phase 2 in this study shows the result of qualitative research to accomplish their attitude toward the current situation of biodiesel price focused on explaining the biodiesel pricing situation and identifying risk factors that could result in changes in pricing over the 19 years. The research instrument of qualitative research was designed by using open ended questions and then collection by in-dept interview with expert from government sector, private sector, and education sector and other experts overall 8 persons. The results are classified as follows

The results of Quantitative research

1. General characteristics of ex-refinery price, foreign exchange, tax (excise tax and municipal tax), fund (oil fund and conservation fund) and retail price.

Considering in the details of all situations of ex-refinery price, foreign exchange, tax (excise tax and municipal tax), fund (oil fund and conservation fund) and retail price from The Energy Policy and Planning Office (EPPO), Ministry of Energy of Thailand between January, 2008 to December, 2017 found that

Ex-refinery price

The average of ex-refinery price from 2008 to 2017 was around 20.50 baht/liter (Table 3) while the Figure 7 shows the trend in the past of ex-refinery price between 2008 and 2017, for in year 2008, ex-refinery price peaked at highest 35.76 baht/liter in July 2008 and fell sharply in the January of 2009. While April of 2011, the ex-refinery price increased rapidly reaching around 26.69 baht/liter and in January of 2011, the ex-refinery price is reached the lowest of 10.79 baht/liter.

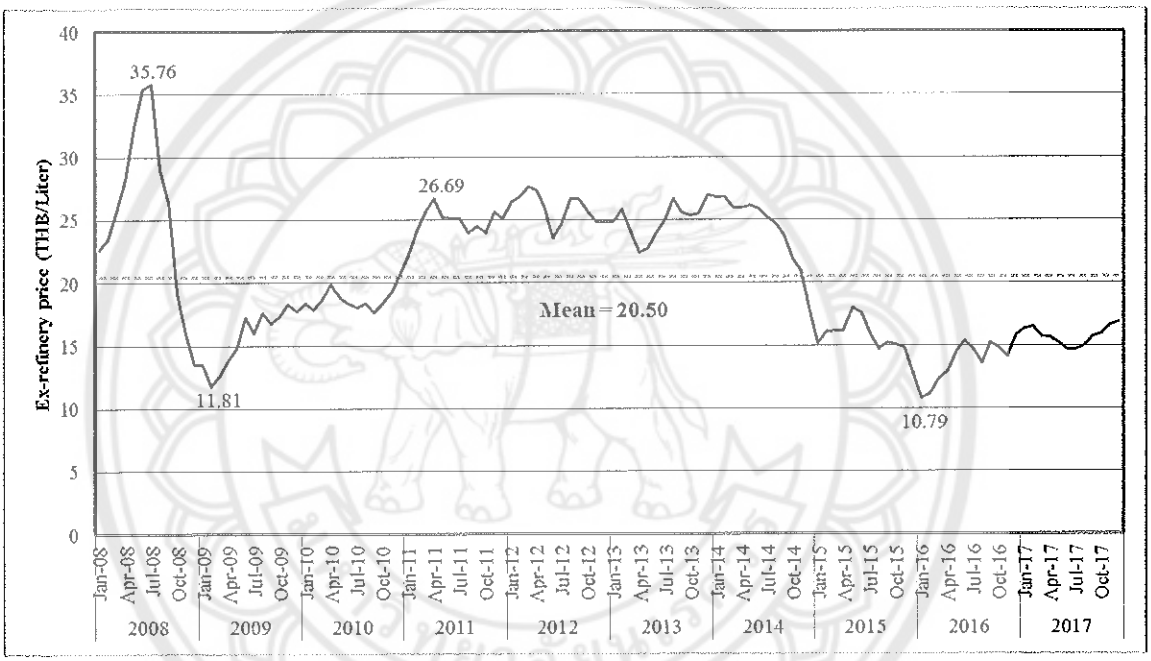


Figure 7 Ex-refinery price between 2008 and 2017 (baht/liter)

Foreign Exchange

The average of the foreign exchange from 2008 to 2017 was around 32.91 baht/dollar (Table 3) and the Figure 7 indicates that the foreign exchange in the March of 2009 will increase to the highest 35.92 baht/dollar, meanwhile the foreign exchange fell slightly in the October of 2010 to 30.11 baht/dollar. After between from January, 2012 to December, 2014 found that the foreign exchange is below the average value (32.91 baht/dollar). In contrast, the foreign exchange fell down in the April of 2013 at 29.22 baht/dollar. (See more detail in Figure 8).

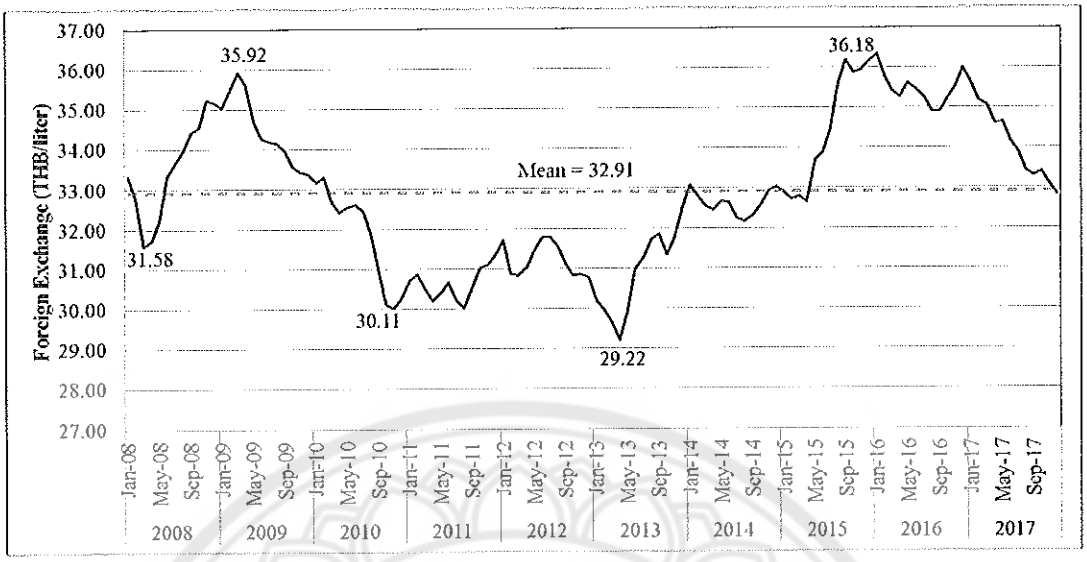


Figure 8 Foreign Exchange between 2008 and 2017 (baht/dollar)

TAX (Excise tax and Municipal tax)

The average of tax including excise tax and municipal tax from 2008 to 2017 was around 3.04 baht/liter (Table 3). Moreover, the Figure 8 showed that the tax (excise tax and municipal tax) is stable at 5.84 baht/liter in between the April of 2009 to October of 2010. In contrast, the tax (excise tax and municipal tax) fell down of April in 2011 to 0.10 baht/liter from 5.84 baht/liter. Meanwhile, the tax in the February of 2017 onwards is stable at 6.44 baht/liter (See more detail in Figure 9).

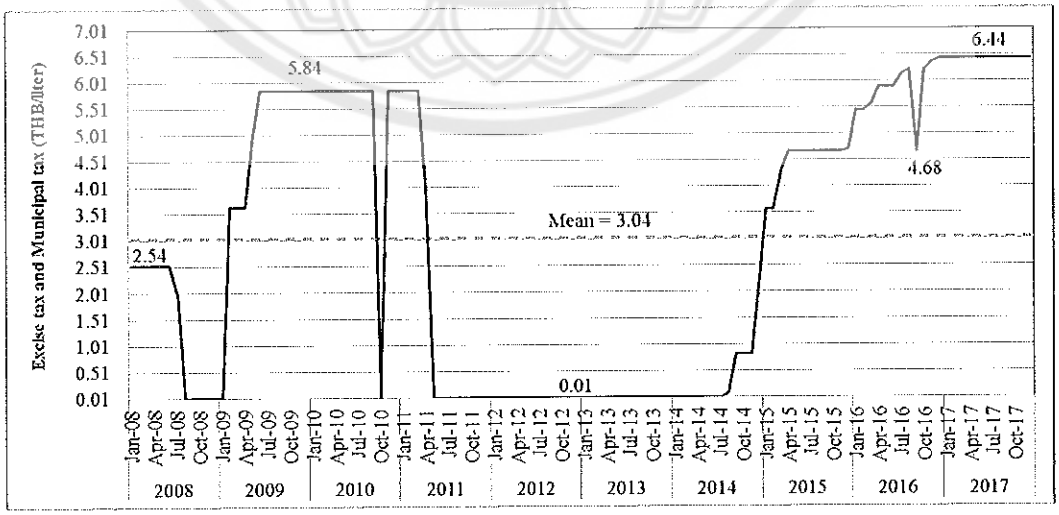


Figure 9 Excise tax and Municipal tax between 2008 and 2017 (baht/liter)

FUND (Oil fund and Conservation fund)

The average of fund (Oil fund and Conservation fund) from 2008 to 2017 was around 0.88 baht/liter (Table 3). The highest recorded fund (oil fund and conservation fund) was reached maximum of 6.74 baht/liter on October, 2010. After falling below -4.67 (baht/liter) in the March of 2011. During January in 2012 to October in 2014, funds (oil fund and conservation fund) are fluctuating from the average value (0.88 baht/liter). But during October in 2016 to December in 2017 the fund (oil fund and conservation fund) is stable at 0.26 baht/liter. (See more detail in the Figure 10)

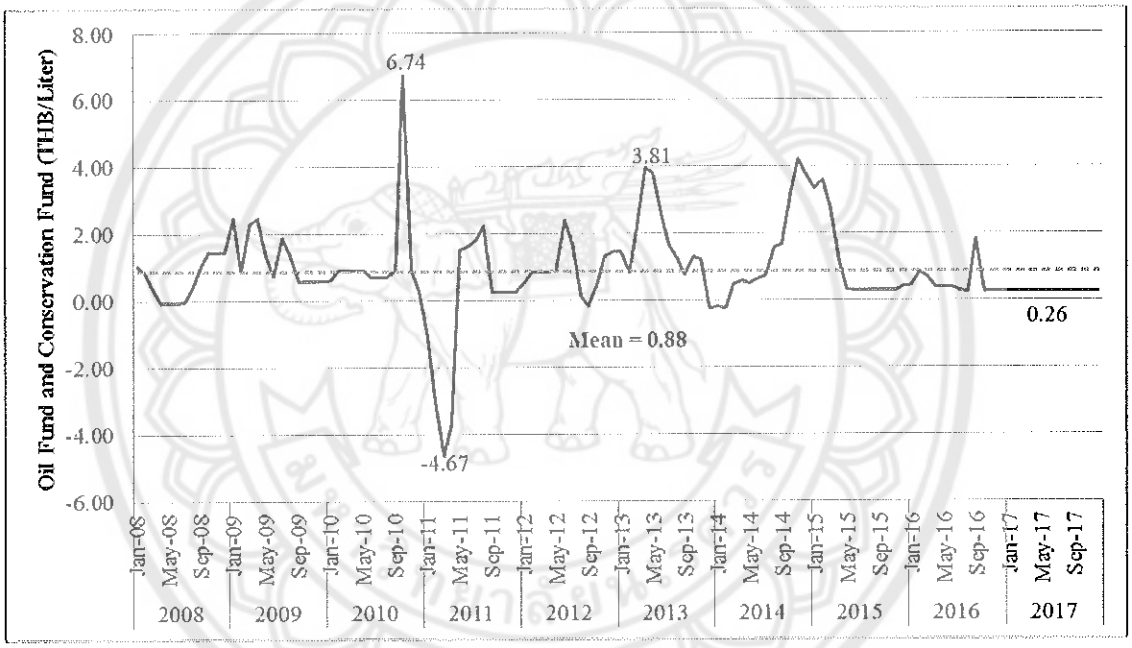


Figure 10 Oil fund and Conservation fund between 2008 and 2017 (baht/liter)

Retail Biodiesel Price

The average of fund (oil fund and conservation fund) from 2008 to 2017 was around 26.96 baht/liter (Table 3). The Figure 10 showed that in the June of 2008 the retail price has fluctuated rapidly at 42.40 baht/liter. After, January 2009 the retail price have fallen to the lowest price 18.63 baht/liter. In year 2010 to 2014, the retail price had fallen again around above 26.96 baht/liter. (See more detail in the Figure 11)

From the Figure 11 shown as the situation of biodiesel price will depend on the volatility of oil prices in the world energy market. For example, in the first year (2008) on July, the biodiesel prices are highest at 42.40 baht/liter because the world energy crisis occurred in the year 2008, crude oil prices rose above 140 usd/bbl and this increase demand of oil for the Olympic Games held in China. On the other hand, the trend of biodiesel prices has been continuously decreasing, on January of 2009 the retail price has fallen to the lowest price 18.63 baht/liter because the global economic crisis or subprime. After that, during the years 2009 to 2010, the biodiesel price will continuously rise because Organization of the Petroleum Exporting Countries (OPEC) has set oil production cuts to bring oil prices back to equilibrium.

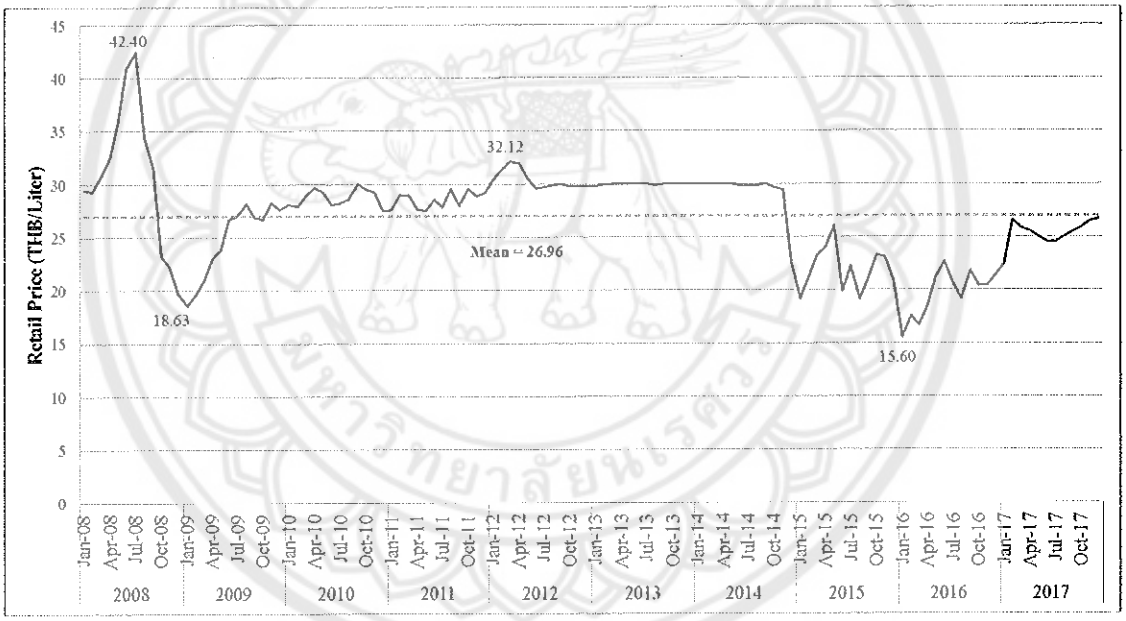


Figure 11 Retail Price between 2007 and 2016 (baht/liter)

Table 3 Mean and Standard deviation of Ex-refinery price, Foreign Exchange, Tax (excise tax and municipal tax), Fund (oil fund and conservation fund) and retail price

Factors	Mean (baht/liter)	Standard deviation (S.D.)
Ex-refinery price	20.50	5.453
Foreign Exchange	32.91	2.403
Tax (excise tax and municipal tax)	3.04	2.225
Fumd (oil fund and conservation fund)	0.88	1.361
Retail Price	26.96	4.549

2. The results of correlation between ex-refinery price, foreign exchange, tax (excise tax and municipal tax), fund (oil fund and conservation fund) and retail price

The findings of estimate correlation matrix in the Table 4 show that there is satisfactory degree of relationship among the variables. Five variables included ex-refinery price, foreign exchange, tax (excise tax and municipal tax), fund (oil fund and conservation fund) and retail price. Each outcome variable was significantly correlated with each other outcome variable. For example, the ex-refinery price is positively correlated with fund (oil fund and conservation fund) ($r = 0.469$). Moreover, the foreign exchange is positively correlated with fund (oil fund and conservation fund) ($r = 0.319$). Meanwhile, the ex-refinery price is positively correlated with retail price ($r = 0.887$). (See more detail in Table 4).

Table 4 Correlation between Ex-refinery price, Foreign Exchange, Tax (excise tax and municipal tax), Fund (oil fund and conservation fund) and retail price

Variables	1	2	3	4	5
1) Ex-refinery price	1	0.199*	0.092	0.469*	0.887*
2) Foreign Exchange		1	0.042	0.319*	0.267*
3) TAX			1	0 .038	0.226*
4) FUND				1	0.504*
5) Retail Price					1

Note: TAX denote Excise tax and Municipal tax, * Significant at p-value < 0.05
FUND denote Oil fund and Conservation fund.

3. The results of the factors influences the biodiesel price in oil market of Thailand during January, 2008 to December, 2017

Table 5 The Multiple linear regression analysis using Stepwise method

Independent variables	b	S.E.	Beta	t-test	Sig.
(Constant)	6.425	2.626		2.446	0.016*
1) EX	0.673	0.037	0.806	18.139	0.000*
2) FX	0.151	0.078	0.080	1.939	0.050*
3) Tax	0.326	0.080	0.160	4.066	0.000*
4) Fund	0.357	0.153	0.107	2.336	0.021*
$R = 0.909$, $R^2 = 0.826$, $F = 136.690$, p-value=0.000					

Note: EX denote Ex-refinery price, FX denote Foreign Exchange, TAX denote excise tax and municipal tax, Fund denote oil fund and conservation fund,
* Significant at p-value <0.05

Multiple linear regression analysis was used to develop a model for predicting the retail price and determining the factors influences the biodiesel price in oil market of Thailand from January, 2008 to December, 2017. Four variables included ex-refinery price, foreign exchange, tax (excise tax and municipal tax), fund (oil fund and conservation fund). From the Table 5 found that the four variables was very high positively correlated with the retail price ($r = 0.909$) which the R^2 is 0.826, means that variation in the ex-refinery price, tax (excise tax and municipal tax), foreign exchange, fund (oil fund and conservation fund) explains 82.6 % of the sample variation in the retail price.

In part of the result of significant for R^2 found that there is always at least one independent variable affecting the retail price in oil Thailand market from January, 2008 to December, 2017, a significant level of 0.05 ($F = 136.690$, P-value = 0.000).

Controlling for other variables in the model found that

Ex-refinery price: The correlation coefficient ($b = 0.673$) indicates that as the ex-refinery price increases, the retail price in oil market of Thailand increases 0.673 THB/liter. However, the relationship is very strong.

Foreign Exchange: The correlation coefficient ($b = 0.151$) indicates that as the foreign exchange increases, the retail price in oil market of Thailand increases 0.151 THB/liter.

Tax (excise tax and municipal tax): The correlation coefficient ($b = 0.326$) indicating that as the tax (excise tax and municipal tax) increases, the retail price in oil market of Thailand increases 0.326 THB/liter .

Fund (oil fund and conservation fund): The correlation coefficient ($b = 0.357$) indicating that as the fund (oil fund and conservation fund) increases, the retail price in oil market of Thailand increases 0.357 THB/liter

The predictive unstandardized equation from our model is

$$Y_{\text{Retail price}} = 6.425 + 0.673\ (\text{Ex-refinery price}) + 0.151\ (\text{FX}) + 0.326\ (\text{Tax}) + 0.357\ (\text{Fund})$$

4. The results of forecasting the biodiesel price of Thailand in next 19 years, during 2018 to 2036.

The time series forecasting method by using decomposition Method, it is possible to observe that a time series data can be influenced by four main components

Trend, which is the product demand behavior for a long period of time;

Cyclical variations, which are fluctuations in the values of variable longer than a year that can follow the business cycle;

Seasonal variation, which is the variation that occurs year after year with a duration less than one year, often in the same period and almost the same magnitude;

Irregular variation, which is the one that does not follow a pattern, fluctuations not explained. The results four main components are as follow:

4.1 The results of trend component

The trend of a time series indicates the behavior of the data during a long-term (i.e., if it increases, decreases or remains stable, and which speed changes occur). Identify the trend allows the removal of this component of the study series, so it can get a better view of the other components that can interfere in the demand. Therefore, using the data to plot the graph to see the trend of the graph like in the Figure 12

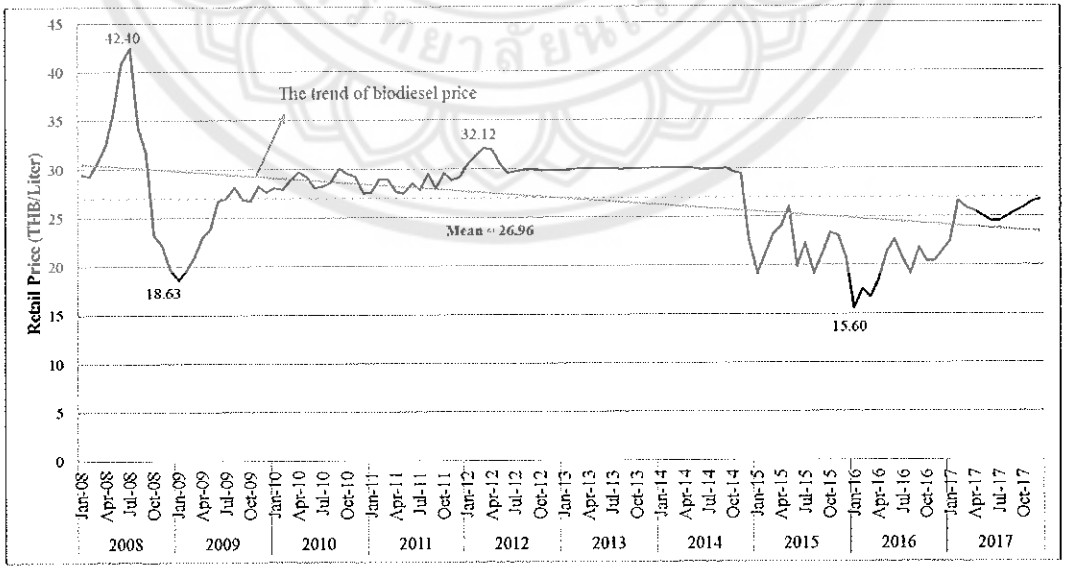


Figure 12 The trend of biodiesel price in oil market of Thailand from January, 2008 to December, 2017

4.2 The results of seasonal index

Analyzing the seasonal change by using the ratio to Moving Average which averages one moving per 12 months (k=12). This method eliminates the seasonal influential (S) and the irregular variation (I) from the data. Finally, you will get the seasonal index in the Table 6

Table 6 Seasonal Index

Month	Seasonal index (%)
Jan	97.8
Feb	98.8
Mar	100.6
Apr	100.6
May	101.2
Jun	101.5
Jul	101.7
Aug	101.1
Sep	99.3
Oct	99.0
Nov	99.6
Dec	98.7

The computation of seasonal data on the percentage, if the number of accident has the seasonal data which equals to 100, there is no influential of the season change effect of the occurrence of the biodiesel price. However, if the seasonal index is more than 100, the influence of the season in that month affects the higher than average in occurring of a biodiesel price. Moreover, the less than 100 seasonal indices that affects on the way that the biodiesel price in that year will less than the average.

From the seasonal index in the Table 6, the influence of the season in the month Jan, Feb, Sep, Oct, Nov and Dec leads to the biodiesel price decrease that below the average 2.2%, 1.2%, 0.7%, 1.0%, 0.4% and 1.3% consecutively. In the dominant part of season in month Mar, Apr, May, Jun, Jul, and Aug it would lead the

biodiesel price increase that's higher than the average number of 0.6%, 0.6%, 1.2%, 1.5%, 1.7% and 1.1%, respectively.

4.3 To find the appropriate trend equation

This research uses three equations: Linear, Exponential., Quadratic as it is shows in Table 7.

Table 7 The format of trend equation that is appropriate for the biodiesel price from January, 2008 to December, 2017

Equation model	The trend equation	R^2	RMSE
.1. Linear	$\hat{Y} = 30.265 - 0.041(t)$	0.248	3.445
2. Exponential	$\hat{Y} = 29.936 - 0.001(t)$	0.127	4.528
3. Quadratic	$\hat{Y} = 28.153 + 0.063(t) - 0.001(t^2)$	0.210	4.229

Note: R^2 and RMSE values come from statistics analysis program that shown as appendix A

From the results in Table 7, When the comparing three model equations of trend were founded that the linear equation has the highest R^2 value ($R^2 = 0.248$) and the root mean squared error (RMSE) is minimum (3.445). Therefore, we select used as a Linear equation that describes the trend value of the biodiesel price followed the theory of time series analysis in economics of Phumthan Rangkhakunnuwat in 2013.

The linear trend function as

$$\hat{Y} = a + b\,(t)$$

Where

$a = 30.265$, $b = -0.041$

t = mounts (initial on Jan,2008)

Therefore, the linear trend equation is

$$\hat{Y} = 30.265 - 0.041\,(t)$$

4.4 Calculate the cyclical variation

The cyclical change index is conducted by eliminating the trend (T) out of the moving average (MA) by $\hat{C} = (T \times C)/\hat{T}$ and $\hat{C}$ that was computed from the Table 4 will be in the range of 0.70 to 1.30 which is nearly 1.00 and when put C value to plot the graph. It will be shown in the Figure 13.

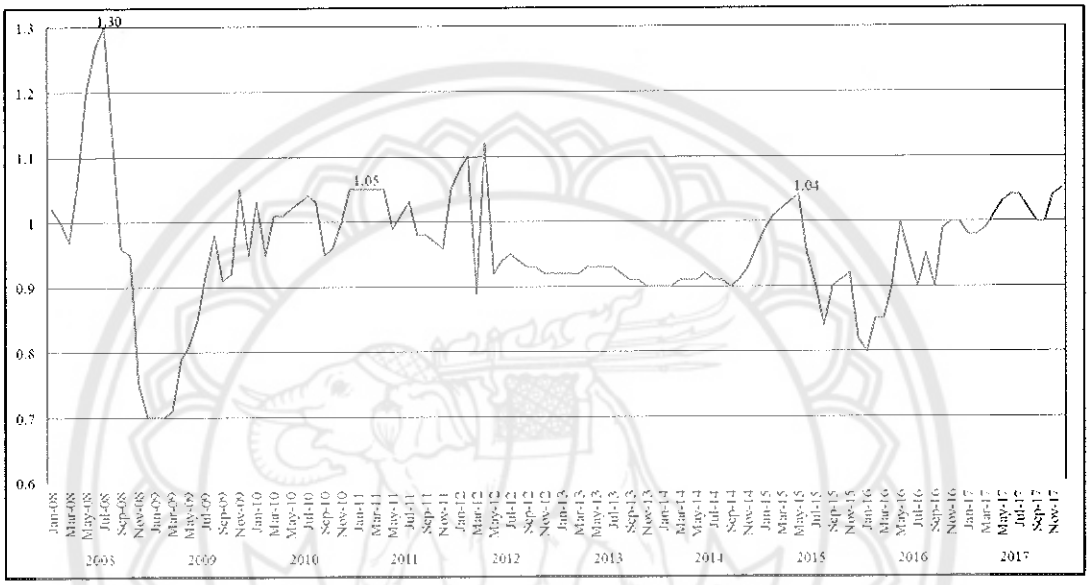


Figure 13 The cyclical change index of biodiesel price in oil market of Thailand from January, 2008 to December, 2017

While, irregular index computation ($\hat{I}$) by $\hat{I} = (S \times I)/\hat{S}$ and we get the change of irregularity index in the range of 0.9507 to 1.10011 which equals around 1. Therefore, the component of all 120 data set that we computed. Shown in Appendix B

4.5 Forecasting the biodiesel price of Thailand in next 5 years, during 2018 to 2022.

Before forecasting the biodiesel price of Thailand in next 5 years, during 2018 to 2022, we can consider accuracy of the predictive value is close to the true value between 2008 to 2017 in the Table 8.

Table 8 Comparison of the predictive value and true value in the biodiesel price of Thailand, during 2008 to 2017

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	Seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2008	Jan	29.43	30.22397	1.02	0.97815	30.15
	Feb	29.29	30.18280	100.	0.98814	29.82
	Mar	30.71	30.14164	0.97	1.00641	29.42
	Apr	32.49	30.10047	1.07	1.00647	32.42
	May	36.02	30.05931	1.20	1.01210	36.51
	Jun	40.92	30.01814	1.27	1.01534	38.71
	Jul	42.40	29.97697	1.30	1.01672	39.62
	Aug	34.37	29.93581	1.12	1.01108	33.90
	Sep	31.65	29.89464	0.96	0.99273	28.49
	Oct	26.22	29.85347	0.95	0.98985	28.07
	Nov	22.22	29.81231	0.75	0.99609	22.27
	Dec	19.69	29.77114	0.70	0.98690	20.57
2009	Jan	18.63	29.72998	0.70	0.97815	20.36
	Feb	19.59	29.68881	0.70	0.98814	20.54
	Mar	20.99	29.64764	0.71	1.00641	21.18
	Apr	23.05	29.60648	0.79	1.00647	23.54
	May	23.84	29.56531	0.81	1.01210	24.24
	Jun	26.68	29.52415	0.85	1.01534	25.48
	Jul	26.96	29.48298	0.92	1.01672	27.58
	Aug	28.17	29.44181	0.98	1.01108	29.17
	Sep	26.83	29.40065	0.91	0.99273	26.56
	Oct	26.7	29.35948	0.92	0.98985	26.74
	Nov	28.19	29.31831	1.05	0.99609	30.66
	Dec	27.63	29.27715	0.95	0.98690	27.45

Table 8 (cont.)

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2010	Jan	28.09	29.23598	1.03	0.97815	29.46
	Feb	27.93	29.19482	0.95	0.98814	27.41
	Mar	28.94	29.15365	1.01	1.00641	29.63
	Apr	29.64	29.11248	1.01	1.00647	29.59
	May	29.2	29.07132	1.02	1.01210	30.01
	Jun	28.07	29.03015	1.03	1.01534	30.36
	Jul	28.24	28.98898	1.04	1.01672	30.65
	Aug	28.58	28.94782	1.03	1.01108	30.15
	Sep	27.79	28.90665	0.95	0.99273	27.26
	Oct	27.83	28.86549	0.96	0.98985	27.43
	Nov	29.26	28.82432	1.00	0.99609	28.71
	Dec	29.89	28.78315	1.05	0.98690	29.83
2011	Jan	29.99	28.74199	1.05	0.97815	29.52
	Feb	29.99	28.70082	1.05	0.98814	29.78
	Mar	29.96	28.65966	1.05	1.00641	30.29
	Apr	29.99	28.61849	1.05	1.00647	30.24
	May	29.99	28.57732	0.99	1.01210	28.63
	Jun	29.99	28.53616	1.01	1.01534	29.26
	Jul	29.99	28.49499	1.03	1.01672	29.84
	Aug	29.51	28.45382	0.98	1.01108	28.19
	Sep	27.99	28.41266	0.98	0.99273	27.64
	Oct	29.51	28.37149	0.97	0.98985	27.24
	Nov	28.88	28.33033	0.96	0.99609	27.09
	Dec	29.12	28.28916	1.05	0.98690	29.31

Table 8 (cont.)

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2012	Jan	30.45	28.24799	1.08	0.97815	29.84
	Feb	31.31	28.20683	1.10	0.98814	30.66
	Mar	32.12	28.16566	0.89	1.00641	25.23
	Apr	31.99	28.12450	1.12	1.00647	31.70
	May	30.51	28.08333	0.92	1.01210	26.15
	Jun	29.58	28.04216	0.94	1.01534	26.76
	Jul	29.74	28.00100	0.95	1.01672	27.05
	Aug	29.89	27.95983	0.94	1.01108	26.57
	Sep	29.93	27.91866	0.93	0.99273	25.78
	Oct	29.79	27.87750	0.93	0.98985	25.66
	Nov	29.79	27.83633	0.92	0.99609	25.51
	Dec	29.79	27.79517	0.92	0.98690	25.24
2013	Jan	29.79	27.75400	0.92	0.97815	24.98
	Feb	29.95	27.71283	0.92	0.98814	25.19
	Mar	29.99	27.67167	0.92	1.00641	25.62
	Apr	29.99	27.63050	0.93	1.00647	25.86
	May	29.99	27.58934	0.93	1.01210	25.97
	Jun	29.99	27.54817	0.93	1.01534	26.01
	Jul	29.99	27.50700	0.93	1.01672	26.01
	Aug	29.89	27.46584	0.92	1.01108	25.55
	Sep	29.99	27.42467	0.91	0.99273	24.78
	Oct	29.99	27.38350	0.91	0.98985	24.67
	Nov	29.99	27.34234	0.90	0.99609	24.51
	Dec	29.99	27.30117	0.90	0.98690	24.25

Table 8 (cont.)

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2014	Jan	29.99	27.26001	0.90	0.97815	24.00
	Feb	29.99	27.21884	0.90	0.98814	24.21
	Mar	29.99	27.17767	0.91	1.00641	24.89
	Apr	29.99	27.13651	0.91	1.00647	24.85
	May	29.99	27.09534	0.91	1.01210	24.96
	Jun	29.91	27.05418	0.92	1.01534	25.27
	Jul	29.85	27.01301	0.91	1.01672	24.99
	Aug	29.86	26.97184	0.91	1.01108	24.82
	Sep	29.99	26.93068	0.90	0.99273	24.06
	Oct	29.66	26.88951	0.91	0.98985	24.22
	Nov	29.42	26.84834	0.93	0.99609	24.87
	Dec	27.60	26.80718	0.96	0.98690	25.40
2015	Jan	25.83	26.76601	0.99	0.97815	25.92
	Feb	26.22	26.72485	1.01	0.98814	26.67
	Mar	26.76	26.68368	1.02	1.00641	27.39
	Apr	25.26	26.64251	1.03	1.00647	27.62
	May	26.07	26.60135	1.04	1.01210	28.00
	Jun	25.90	26.56018	0.95	1.01534	25.62
	Jul	24.53	26.51902	0.90	1.01672	24.27
	Aug	22.90	26.47785	0.84	1.01108	22.49
	Sep	23.21	26.43668	0.90	0.99273	23.62
	Oct	23.31	26.39552	0.91	0.98985	23.78
	Nov	23.06	26.35435	0.92	0.99609	24.15
	Dec	21.37	26.31318	0.82	0.98690	21.29

Table 8 (cont.)

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
	Jan	19.84	26.27202	0.80	0.97815	20.56
	Feb	20.31	26.23085	0.85	0.98814	22.03
	Mar	21.86	26.18969	0.85	1.00641	22.40
	Apr	22.32	26.14852	0.90	1.00647	23.69
2016	May	24.15	26.10735	1.00	1.01210	26.42
	Jun	25.04	26.06619	0.95	1.01534	25.14
	Jul	24.55	26.02502	0.90	1.01672	23.81
	Aug	23.38	25.98386	0.95	1.01108	24.96
	Sep	23.21	25.94269	0.90	0.99273	23.18
	Oct	24.38	25.90152	0.99	0.98985	25.38
	Nov	24.20	25.86036	1.00	0.99609	25.76
	Dec	25.61	25.81919	1.00	0.98690	25.48
	Jan	26.43	25.77802	0.98	0.97815	24.71
	Feb	26.57	25.73686	0.98	0.98814	24.92
	Mar	25.80	25.69569	0.99	1.00641	25.60
	Apr	25.57	25.65453	1.01	1.00647	26.08
2017	May	25.02	25.61336	1.03	1.01210	26.70
	Jun	24.52	25.57219	1.04	1.01534	27.00
	Jul	24.52	25.53103	1.04	1.01672	27.00
	Aug	24.99	25.48986	1.02	1.01108	26.29
	Sep	25.46	25.44870	1.00	0.99273	25.26
	Oct	25.93	25.40753	1.00	0.98985	25.15
	Nov	26.46	25.36636	1.04	0.99609	26.28
	Dec	26.70	25.32520	1.05	0.98690	26.24

Moreover, when considering the error evaluation showed that the time series decomposition is well suited for biodiesel price data in matter of forecasting as the errors obtained are small (MAPE = 3.469) which it shows in Table 9.

But, This study the data not more than 10 years and the value of cyclical change was low between of 0.70 to 1.30, we selected three components were trend ($\hat{T}$), cyclical ($\hat{C}$)and seasonal index $\hat{S}$ for forecast the biodiesel price of Thailand in next 5 years, during 2018 to 2022 are given as

$$\hat{Y} = \hat{T} \times \hat{S} \times \hat{C}$$

When

$\hat{T}$ is estimates of trend components of time units (t).

$\hat{S}$ is estimates of seasonal change components of time units (t).

$\hat{C}$ is estimates cyclical of components of time units (t).

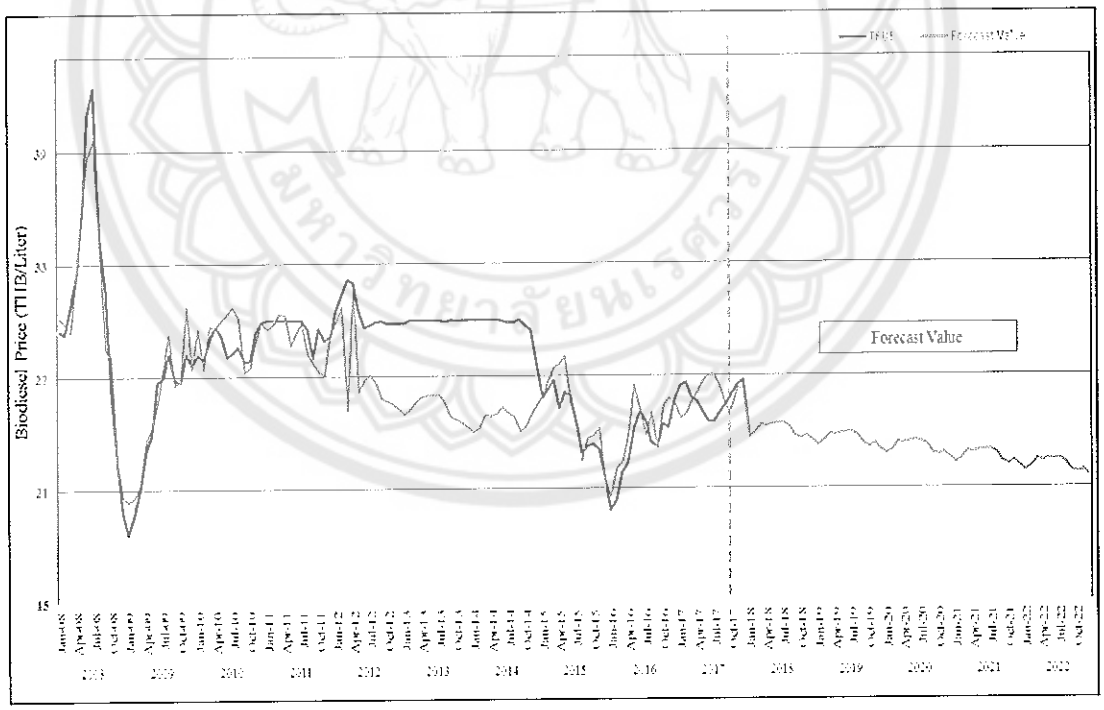


Figure 14 Comparison of predicting value and true value of the retail price from January, 2007 to December, 2016 and Forecasting the biodiesel price of Thailand in next 5 years, during 2018 to 2022

From the results of forecasting the biodiesel price of Thailand in next 5 years in the Figure 13 indicate that the biodiesel price of Thailand between in year 2018 to 2022 has been continuously decreased. In the first year (2018), the biodiesel price will be around 23.50 to 23.72 baht/liter. In the final year (2022), on December the retail price has fallen to the lowest price 21.63 baht/liter. See more detail of forecasting the biodiesel price of Thailand in next 5 years, during 2018 to 2022 in the appendix C.

4.6 Forecasting the biodiesel price of Thailand in next 5 years, during 2023 to 2027

This Section used 12 for a monthly series. While, decomposition time series data on biodiesel prices totaling 180 months between January, 2008 to December, 2022 and split to four parts are trend seasonality, cycles, irregular index. The results show in the appendix D. Before forecasting the biodiesel price of Thailand in next 5 years, during 2023 to 2027, we consider the accuracy of the predictive value is close to the true value between 2008 to 2022 (Figure 15). The Table 9 show that MAPE in overall was 3.141.

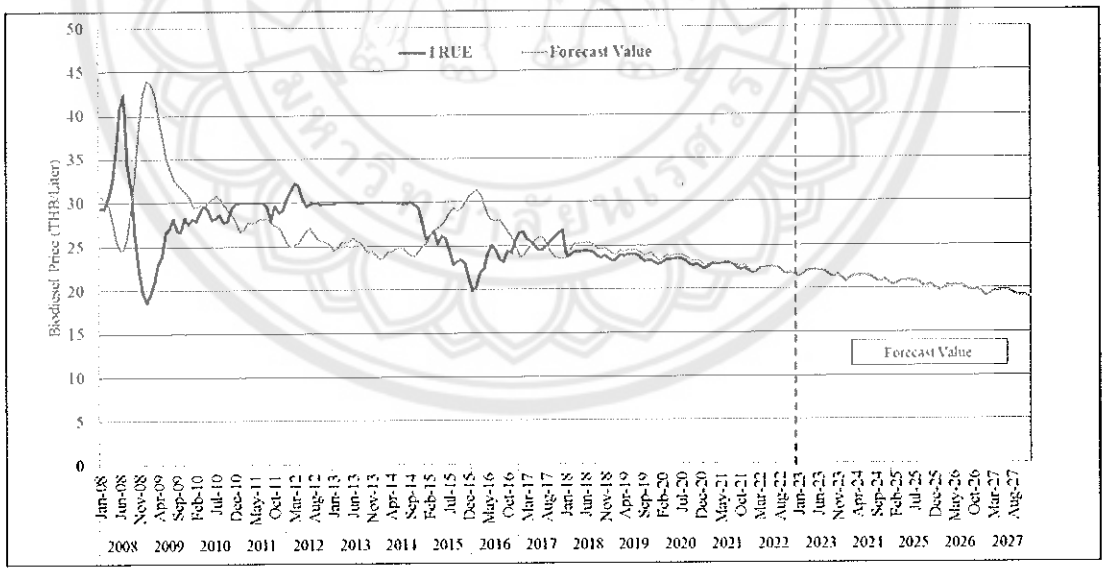


Figure 15 Comparison of predicting value and true value of the retail price from January, 2007 to December, 2022 and Forecasting the biodiesel price of Thailand in next 5 years, during 2023 to 2027

From Figure 15 found that the biodiesel prices in Thailand for long term from 2023 to 2027 has been continuously decreasing over the last 5th years. In the first year (2023) ,the biodiesel prices around 21.50 to 21.28 baht/liter. By December 2027 the retail price has fallen to the lowest price 18.96 baht/liter. (See more detail of the results of forecasting the biodiesel price of Thailand in next 5 years between 2023-2027 in the appendix D)

4.7 Forecasting the biodiesel price of Thailand in next 5 years, during 2028 to 2032.

This section used 12 for a monthly series. While, decomposition time series data on biodiesel prices totaling 240 months between January, 2008 to December, 2022 and can found the four parts are trend seasonality, cycles, irregular index. The results show in the appendix E. Before forecasting the biodiesel price of Thailand in next 5 years, during 2028 to 2032, we consider the accuracy of the predictive value is close to the true value between 2008 to 2027 (Figure 15). The Table 9 show that MAPE in overall was 2.414.

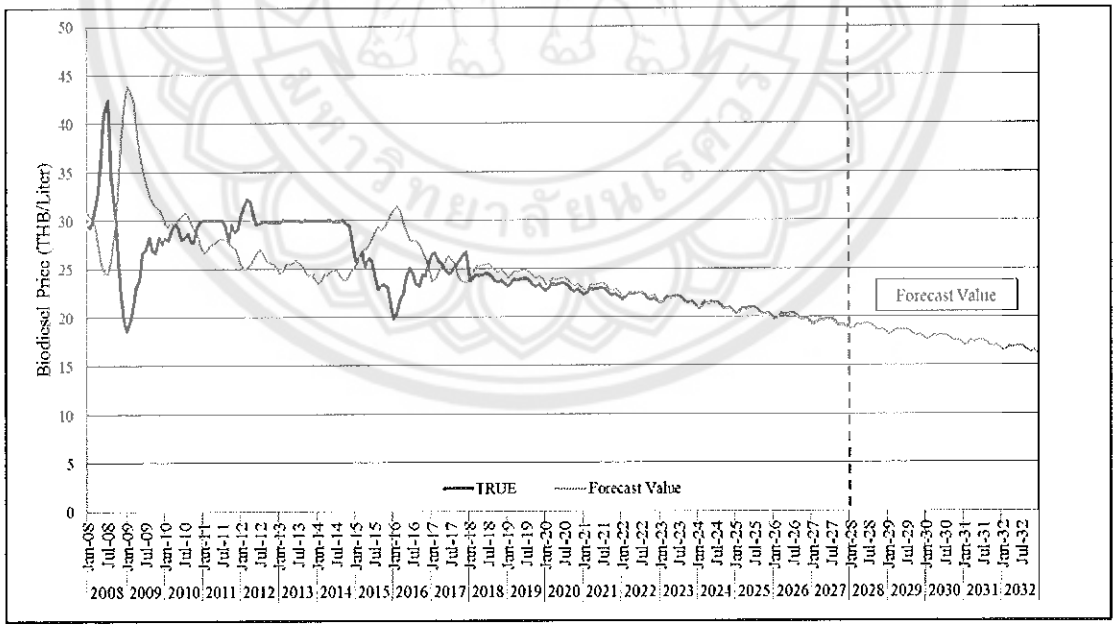


Figure 16 Comparison of predicting value and true value of the retail price from January, 2008 to December, 2027 and Forecasting the biodiesel price of Thailand in next 5 years, during 2028 to 2032

From Figure 16 found that the biodiesel prices in Thailand for long term from 2028 to 2032 are similar to above Figure 15. In the first year (2028) ,the biodiesel prices around 18.76 to 18.50 baht/liter.In the last year (2032), the biodiesel price around 16.52 to 16.23 baht/liter. (See more detail of the results of forecasting the biodiesel price of Thailand in next 5 years between 2028-2032 in the appendix E)

4.8 Forecasting the biodiesel price of Thailand in next 4 years, during 2033 to 2036

This section used 12 for a monthly series. While, decomposition time series data on biodiesel prices totaling 300 months between January, 2008 to December, 2032 and can found the four parts are trend seasonality, cycles, irregular index. The results show in the appendix F. Before forecasting the biodiesel price of Thailand in next 5 years, during 2033 to 2036, we consider the accuracy of the predictive value is close to the true value between 2008 to 2027 (Figure 17). The error evaluation showed that the classical time series decomposition is well suited for biodiesel price data in a matter of forecasting as the errors obtained are small (MAPE = 0.065) (Table 9).

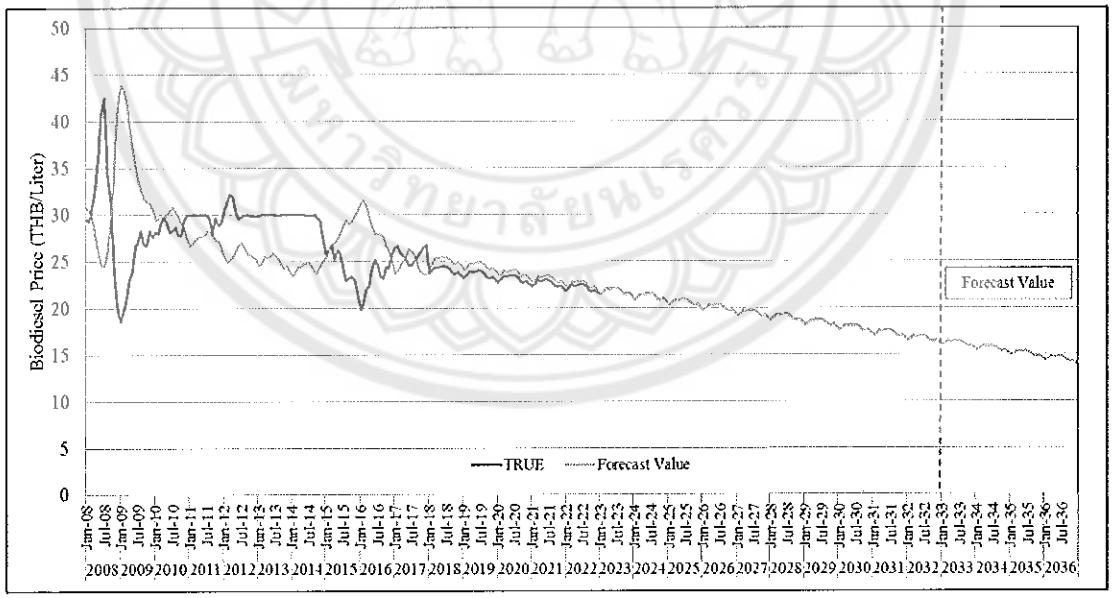


Figure 17 Comparison of predicting value and true value of the retail price from January, 2008 to December, 2032 and Forecasting the biodiesel price of Thailand in next 4 years, during 2033 to 2036

From Figure 17 found that the biodiesel prices in Thailand for long term from 2028 to 2032 are similar to above Figure 15 and Figure 16. In the first year (2033) ,the biodiesel prices around 16.03 to 15.74 baht/liter. In the last year (2036), the biodiesel price around 14.37 to 14.05 baht/liter. (See more detail of the results of forecasting the biodiesel price of Thailand in next 4 years between 2033-2036 in the appendix F)

4.9 The difference between the real information and the forecast (Error)

Table 9 percent of mean absolute percentage error (MAPE%)

Forecast Model	Range	MAPE (%)
1	2018-2022	3.469
2	2023-2027	3.141
3	2028-2032	2.414
4	2033-2036	0.065

From the table above found that the error evaluation in model 4 the classical time series decomposition is well suited for biodiesel price data in the matter of forecasting as the errors obtained are small (MAPE = 0.065), followed by model 3 and model 2.

The results of Qualitative research

The in depth interview is the part of the qualitative research in order to accomplish the attitude toward the current situation of biodiesel price by focusing on the explanation of the biodiesel pricing situation , identifying risk factors that may affect the change in price over the next ten years, and the attitude toward the effect of Alternative Energy Development (AEDP: 2015–2036) on the biodiesel price situation with particular focus on production mandate for biodiesel, incentive tax and non-tax with the leaders of the former energy policy and planning office, private sector, transportation sector and other experts. The qualitative results were presented in below as the following:

1. The current situation of biodiesel price focuses on explaining the biodiesel pricing situation

From the in depth interview, we found that there are eight participants who gave the information that related to the overall production of biodiesel in Thailand. Nowadays, the number of biodiesel has increased rapidly because of the support from government in order to make it become another source of energy instead of using diesel; this is one of good campaigns because it can decrease the importation of diesel. There are also some problems during this project such as the expansion of area to grow the oil palm that the price of it is unstable, and the output per each area as they have to consider which one is the best. However, the usage of biodiesel (B100) in Thailand is keeping increasing as the government supports Thai people to use biodiesel by regulating the law since February 2008 that diesel should have 2 percent of biodiesel as a component. In addition, the government also maintain promoting the sales of B5 by setting the price below B2 approximately 0.50 to 1.00 baht/liter. Moreover, if the needs of biodiesel reach the set up goal, it will allow the government to expand the oil palm farm; if this becomes true, future price of biodiesel will be decreased as well. The main factors that lead people to use more biodiesel are the price, and the standard of biodiesel that qualified by each car's company. Since the car companies qualify that biodiesel can use with various type of car, the needs of biodiesel will be increased.

> ...For the first, third, and seventh participants mentioned that "As the production and sales of biodiesel in Thailand has increased, it will increase the price of energy crops as well; therefore, this causes negative effect to Thai economy. On the other hand, there are also the benefit from this situation that the price of energy crops increase. Since the demand is higher, so the supply will be increased too".
>
> (1st, Personal communication, December, 1, 2018; 3rd, Personal communication, December, 3, 2018; 7th, Personal communication, December, 7, 2018)

...Next, the fourth participant said that " There are various time that the government need to decrease the biofuel during the process due to the fluctuation of price and quantity of the agriculture goods"

(4th, Personal communication, December, 4, 2018; 8th, Personal communication, December, 8, 2018)

...Sometimes, when there are any problems such as the shortage of oil palm or drought; the government has to decrease B100 in diesel

(2nd, Personal communication, December, 2, 2018)

...The fifth participant also said, "There will be higher competition between Thailand and other countries, so it may affect upstream industry, especially oil palm farmers and the suppliers of B100. Therefore, they need to adapt in order to increase the efficiency"

(5th, Personal communication, December, 5, 2018)

...Lastly, "From my understand, nowadays, there is the policy that government try to promote and support the production and usage of biodiesel seriously. For instance, they create the aggressive measure to increase the demand of biofuel like controlling the gap difference between the price of gasoline and common ethanol fuel mixture, and steadily increase B100 in diesel. These processes provide more energy security and increase the value of agriculture products. Nevertheless, waiting the government to stimulate the demand is unsustainable for the business. The investors in biofuel business should have ability to connect between upstream and downstream in the process, and maintain stocking the inventory to reduce the cost per unit by using the economy scale in order to increase the ability to compete with other type of fuel."

(6th, Personal communication, December, 6, 2018)

2. The risk factors that could result in changing in pricing over the next 19 years

For this in depth interview in section 2, we have found that all of the eight participants acknowledge that the factors that have influence on the change of biodiesel price in next 19 years are consist of following:

1. The First factor, is fundamental factor which is the demand or consumption of biodiesel in Thailand. This consists of the demand of biodiesel in the transportation sector, family or community sector, industry sector and economic sector. Therefore, when the demand of using biodiesel in each sector increase, the price of biodiesel in the future will reach the highest rate.

2. Secondly, the production cost factor is the ex- refinery price. Ex-refinery price is the price that the refinery sold to the oil traders. Generally, the method of calculation of the ex-refinery price value come from the principle of the Thai government, which refined prices followed with the Singapore market, and adding the transportation value, insurance value and lost costs.

3. Thirdly, tax factor, is assigned by Thai government, which consist of excise tax, VAT, and municipal tax in different rate followed the objective in each tax, For example, the excise tax is a tax that Thai government charges from the luxury goods. Moreover, Thai government also considers that biodiesel is a luxury product, so they charge at a fixed rate as it has declared by the excise department. However, for the municipal tax, it is local taxes that collect in local area where the refinery is located, etc.

4. Fourthly, funds which include oil fund and conservation fund. The oil fund will be collected by the Ministry of Energy in order to decrease the change of domestic oil price, and maintain the price when the price in global market is changing. Because if the price in global market is high, the government have to use the oil fund to help the maintain the domestic price by making the price lower. In addition, for the conservation fund, it is the compensation part that collected by Ministry of Energy; and this fund will be used for supporting the research and development of alternative energy that related with energy conservation.

5. Next, the price of agricultural products, especially the crude palm oil price which is a factor that affects the change of the biodiesel price. Because of the seasonal fluctuations sometimes crude palm oil price increases, it affects the biodiesel

price in the domestic markets; the price will increase as well.

6. Lastly, the foreign exchange rate; normally, we use US Dollar in terms of exchange. When the US Dollar depreciate, the price of crude oil will be decreased. Also, if the US Dollar appreciate, the price of crude oil will be increased as well. As mentioned below,

> ...The major factors that lead to the change of biodiesel price is because of the fluctuation of the price in global market, or some events that cause detrimental effects such as nature disasters, terrorize; these things can lead higher biodiesel price. However, if it does not has this kind of events, the supply and demand will be at the equilibrium point; the price will be at the normal level.
>
> (1st, Personal communication, December, 1, 2018; 2nd, Personal communication, December, 2, 2018)

> ...Thai Baht is able to depreciate or appreciate all the time; for example, when Thai Baht is appreciate, the oil price will be increase.
>
> (4th, Personal communication, December, 4, 2018; 3nd, Personal communication, December, 3, 2018)

> ...In terms of setting the standard of the retail price of biodiesel, there are various factors that we need to concern. First thing is the cost or the ex-refinery price; we have to set the ex-refinery price. Next, we need to calculate the tax such as municipal tax, excise tax, and VAT. Lastly, the most important factor is the oil fund and conservation fund. If the government need to collect more taxes and funds, the oil price will be increased at the same time.
>
> (5th, Personal communication, December, 5, 2018; 6th, Personal communication, December, 6, 2018;)

> ...Normally, the standard of Biodiesel price is setting by the demand of consumers from all community, industry, transportation, and economic factor. As a result, in the future if Thailand has higher demand of biodiesel, the price will be increased. Therefore, we need to rely on industrial crops such as crude oil palm, and if the price increase, the oil price will increase too.
>
> (7th, Personal communication, December, 7, 2018; 8th, Personal communication, December, 8, 2018)

The attitude toward that the effect of Alternative Energy Development (AEDP: 2015–2036) on the biodiesel price situation

From part 3 of in depth interview, we have found that the attitude of eight participants towards the effect of alternative energy development plan(AEDP: 2015–2036) on the biodiesel price situation. We can conclude based on the goal of Alternative Energy Development Plan (AEDP: 2015–2036) that they want to increase the proportion of renewable energy in the form of biodiesel for 14.00 mml/d by 2036. For the alternative energy development, even though, biodiesel need higher cost of production than other types of oil, the ministry of energy still want to support and develop biodiesel; the reason is that they want to generate the revenue to the farmers by using agricultural product. In addition, this also one of the plans to deal with the oil price that may increase in the future. The government also has the plan to motivate people to use biodiesel; although, currently we still use B7, but soon it will be develop into B10. Moreover, in the future, they have plan to develop until B100.

Nevertheless, there are some reasons that affect the production of biodiesel which are the uncertainty of government that they are going to support the usage of biodiesel. The entrepreneurs are also affected by the oil companies as in the past, they were start making biodiesel by themselves; they increased biodiesel as a component of diesel more than 10 percent or we also known as "B10". However, when car companies do not cooperate with them, the government will be unable to help as well. In addition, in terms of managing the crude palm oil, it is somewhat difficult because we need to look on the level of consumption as well. Since there is the shortage of crude palm oil, they may need to decrease the ratio of biodiesel such as form B7 to B3.5; so, this is one of the factors that reduce the possibility to use B100. Therefore, in the next 3-5 years, if

the government does not try to deal with this problem, this will affect the farmers because of the low price of crude palm oil.

In conclusion, the participants believe that alternative energy development plan 2015 (AEDP 2015) can help stimulating the usage of biodiesel, but for the future price it depends on many factors. For instance, if the government has better way to manage such as using better material and technology, and creating effective output as it said

> ...The lower price of oil is not the factor that can destroy this industry, but the bad policy. Nowadays, the government does not want to support because there are approximately 5 million liter of B100 produces per day. However, the use of B100 is less than 4 million liter per day, so this directly affect the crude palm oil's farmers because of the change in price.
>
> (5th, Personal communication, December, 5, 2018; 4th, Personal communication, December, 4, 2018; 6th, Personal communication, December, 6, 2018)

> ...For AEDP 2015, it will help reduce energy import, but the government must try to support the usage of biodiesel as well. So, the gross domestic product will be increased, and the farmers will have better life.
>
> (1st, Personal communication, December, 1, 2018; 2nd, Personal communication, December, 2, 2018; 8th, Personal communication, December, 1, 2018)

> ...Currently, the ministry of energy has the policy to support the usage of alternative energy or alternative energy development plan 2015. Nevertheless, if the entrepreneurs do not try to develop the production method, this plan may not be accomplished.
>
> (3nd, Personal communication, December, 3, 2018; 7th, Personal communication, December, 7, 2018)

Table 10 summary of the results of biodiesel price classified by topic

Biodiesel price		
Topic	**Quantitative results**	**Qualitative results**
1. The risk factors that could result in changing in pricing over the next 19 years	1. Ex-refinery price 2. Taxes (excise tax and municipal tax) 3. Funds (oil fund and conservation fund) 4. Taxes (excise tax and municipal tax)	**1. Demand of biodiesel** 2. Ex-refinery price 3. Taxes 4. Funds **5. Price of agricultural** **6. The Foreign exchange**
2. The biodiesel price in the future	The trend of biodiesel prices has been continuously decreasing over the last 20th century. In the first year (2018), the biodiesel prices around 23.50 to 23.72 baht/liter between January to December. In the final year (2036), on December the retail price has fallen to the lowest price 14.05 baht/liter.	"if the needs of biodiesel reach the set up goal, it will allow the government to expand the oil palm farm; if this becomes true, future price of biodiesel will be decreased as well ".

CHAPTER V

DISCUSSION AND SCENARIO PLANNING

This scenario planning of biodiesel price in Thailand is selected to use with the mix research method as a tool to find the framework of the possibility of the future situation for biodiesel price in the next 19 years (2018 to 2036). From the results from two phases (quantitative and qualitative research), this study can create the new alternative of scenario planning about the certainly and uncertainty of the situation of biodiesel price on the decision making of Ministry of Energy to design renewable energy policy for energy security in Thailand. Chapter 5 is presented in three parts like the following:

Conclusion

1. Quantitative results

According to the general characteristic results in quantitative phase from secondary data of Energy Policy and Planning Office, Ministry of Energy of Thailand found that the Ex-refinery price grew up in 2008 and down up in 2015, on average 20.50 baht/liter between 2008 to 2017. Meanwhile, the foreign exchange rate reached the highest rate which was 35.92 baht/dollar in the March of 2009 and fell to the lowest 29.22 baht/dollar in the April of 2013, in average from 2008 to 2017 the foreign exchange rate was around 32.91 baht/dollar. In the part of taxes (excise tax and municipal tax) from Thai government, from a peak of 6.44 baht/liter in 2017 and falling 0.01 THB/liter in the April of 2011 until July 2014. Moreover, the highest funds (Oil fund and Conservation fund) was reached maximum of 6.74 baht/liter in October 2010. After that it was falling below -4.67 (baht/liter) in March 2011 which is in the average around 0.88 baht/liter. Lastly, the average retail price from 2008 to 2017 was around 26.96 baht/liter while the retail price has fluctuated rapidly at 42.40 baht/liter on July 2008. However, in January 2009 the retail price has fallen to the lowest price of 18.63 baht/liter.

As a result, the research for finding the factors influences the biodiesel price in oil market of Thailand from January 2008 to December 2017. The results indicate that the model is significance (F= 136.690, p-value = 0.000). The model's goodness of fit is extreme ($R^2 = 0.909$), which means that variation in ex-refinery price, taxes (excise tax and municipal tax), funds (oil fund and conservation fund) explains 90.9% of the sample variation in the retail price, leaving 9.1% of variance unaccounted. For the four independent variables which are Ex-refinery price, Tax (excise tax and Municipal tax), Foreign Exchange and Fund (Oil fund and Conservation fund) are significant ($p < 0.05$). All three independent variables could be considered to have a high efficiency, with the correlation coefficient (b) more than 0.300. Variables with an effect on the biodiesel price in oil market of Thailand, the Ex-refinery price has the highest effect, followed by Fund (oil fund and conservation fund) Tax (excise tax and municipal tax) and, respectively. While the foreign exchange has the correlation coefficient (b) less than 0.300 that means a few effects on biodiesel price.

The unstandardized regression equation is:

$$Y_{\text{Biodiesel price}} = 6.425 + 0.673\,(Ex) + 0.151\,(FX) + 0.326\,(TAX) + 0.357\,(FUND)$$

The standardized regression equation is:

$$Z_{\text{Biodiesel price}} = 0.806X1_{(EX)} + 0.080X2_{(FX)} + 0.160X3_{(TAX)} + 0.170_{(FUND)}$$

Lastly, the results of forecasting of biodiesel prices in Thailand using time series decomposition Method for Long Term From 2018 to 2036 in this above found that the trend of biodiesel prices has been continuously decreasing over the last 19th years. In the first year (2018), the biodiesel prices around 23.50 to 23.72 baht/liter. In the final year (2036), on December the retail price has fallen to the lowest price 14.05 baht/liter. The error evaluation in model 4 the classical time series decomposition is well suited for biodiesel price data in the matter of forecasting as the errors obtained are small (MAPE = 0.065), followed by model 3 (MAPE = 2.414) and model 2 (MAPE=3.141), respectively.

2. Qualitative results

For the qualitative research of the scenario planning of biodiesel price in Thailand, the researcher chose to study the crucial factors that related to the change of biodiesel price. For the purposive sampling, we selected eight samples from the leaders of government sector, private sector and education sector. The researchers collected the result by gathering the information from the in-depth interview. Regarding assessing the information, in this part, we use qualitative research to consider the critical issues and interpret the important information that is related to the attitude towards the current situation of biodiesel price. The qualitative research is focused on the explanation of the biodiesel pricing situation, identification of risk factors that may affect the change in price over the next ten years and the attitude toward the effect of Alternative Energy Development Plan (AEDP: 2015–2036) on the biodiesel price situation. The result of qualitative research can be summarized from the interview as following:

2.1 The current situation of biodiesel price focuses on explaining the biodiesel pricing situation

The current situation of the number of people who use biodiesel tends to increase because of government support. However, the government did not use their full potential. To demonstrate, the government try to help the farmers by expanding the area for growing oil palm, but they still use the policies that not support the production of biodiesel. Also, the government needs to assure the standard of biodiesel that all car can use it. As a result, all of the producer, supplier, and the consumer will be able to obtain the benefits.

2.2 The risk factors that could result in changes in pricing over the next 20 years

The risk factors that may cause a change in pricing over the next 20 years. There are various factors that may affect the change in the price of biodiesel in Thailand. There are three main factors which are as follow:

2.2.1 The fundamental factor is the needs of consumers to use biodiesel, or regarding the economy, is called demand and supply as same as other products. The demand and supply of each type of oil are changing along the situation during that time. When the demand and supply are non-equilibrium, it will affect the price. For instance, if the demand is lower than the supply, the price will be higher.

Moreover, the seasonal factor is also affecting the material price. To demonstrate, if oil palm price increase or decrease, it will affect the production cost of biodiesel.

2.2.2 Cost of production factor is the fuel price that oil refinery sells to the small group of oil users; it consists of the ex-refinery price, excise tax, municipal tax, oil funds, conservation funds, and value-added tax. These things are the factors that indicate the fluctuation of biodiesel price.

2.2.3 Economic factors

The oil price is relying on economic growth because when there is a high growth rate, the foreign exchange rate will change as well. Therefore, when the US Dollar is depreciated, the price of crude oil will be decreased. Also, if the US Dollar is appreciated, the price of crude oil will be increased.

3. The attitude toward that the effect of Alternative Energy Development (AEDP: 2015–2036) on the biodiesel price situation

The Alternative Energy Development Plan (AEDP: 2015–2036) is the factor that stimulates the change of biodiesel price in Thailand. The main goals of The Alternative Energy Development Plan (AEDP) is to increase the proportion of alternative energy by using biodiesel for 14.00 million litres/days within 2036. The production costs of biodiesel are somewhat higher than another type of petrol, so the ministry of energy still need support to develop biodiesel. The reason is that we still need to create the income for farmers by using the agricultural products. Moreover, AEDP is created to fulfill the oil price, when there is the fluctuation in the world market. However, the biodiesel price does not only rely on AEDP, but it needs government help such as allocating the material, providing high-quality production, and using better equipment and technology; therefore, we will have effective biodiesel that is able to use with all vehicles, and that leads the equilibrium price

In conclusion, the result of in-depth interview from 8 participants show the different aspects of each person on the change of biodiesel price on key issues which are in Figure 17

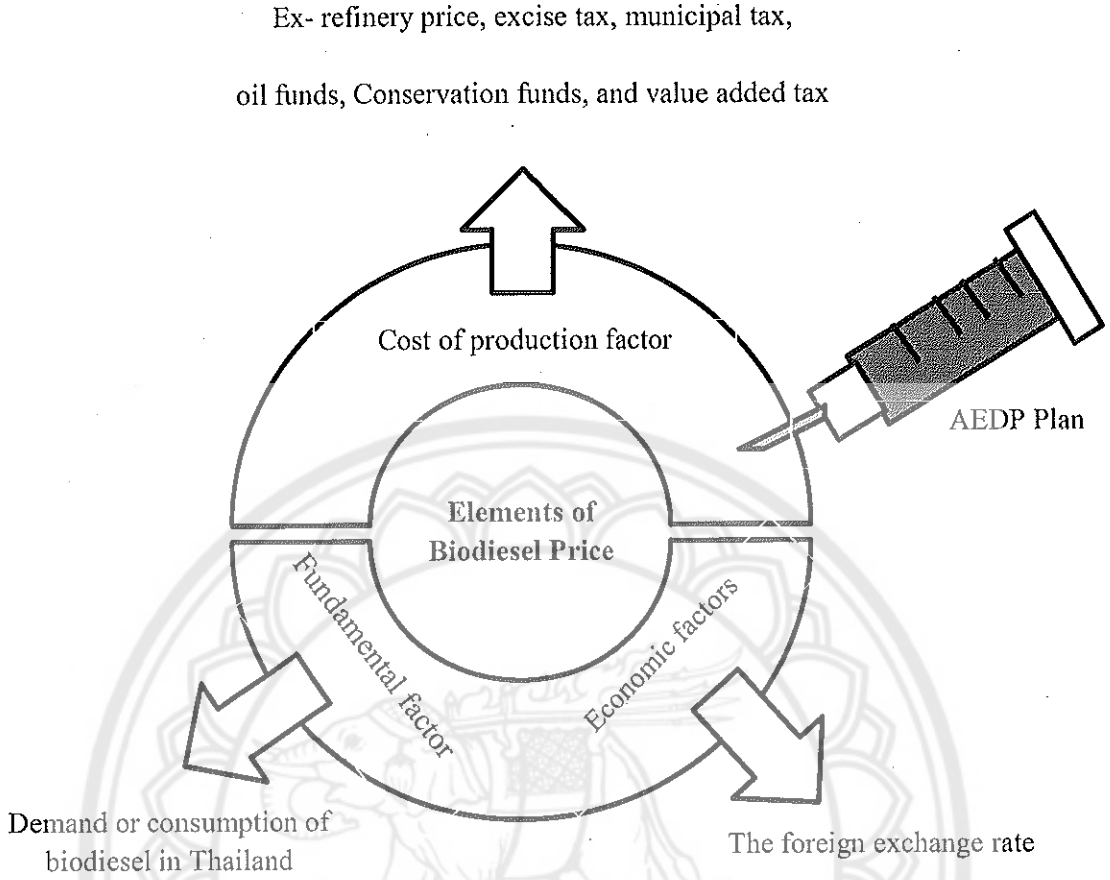


Figure 18 Summary the qualitative results

Discussion

1. The factors which influence the biodiesel price in oil market of Thailand during January 2008 to December 2017

The results from chapter 4 showed that the model is significance ($F = 136.690$, p-value = 0.000). The R^2 is equal 0.909, which mean that the variation in ex-refinery price, foreign exchange rate, taxes (excise tax and municipal tax), funds (oil fund and conservation fund) showed that 90.9 % of the sample is variation in the retail price, and left 9.10% of variance unaccounted. For the four independent variables which are ex-refinery price, taxes (excise tax and municipal tax), and funds (oil fund and conservation fund) are significant ($p < 0.05$). We can consider that all of the three independent variables have high efficiency with the correlation coefficient (b) more than

0.300. For the variables that affect the biodiesel price in oil market of Thailand, the ex-refinery price has the highest effect because the price from ex-refinery price is the cost that is accounted on the commercial biodiesel supplier. It is the benefits of oil suppliers because mostly the price will be similar to Singapore which refers to the standard cost of production in each region. The price from the ex-refinery price is the cost that is accounted on the commercial biodiesel supplier (35).

From the seller's perspective, the ex-refinery price is the cost set by the commercial refineries. Even though nowadays, Thailand already has some commercial refineries, we still use the standard that same as Singapore. Which similar to the qualitative research that the contributor expected to predict the ex-refinery price which is the price that the refineries sell to the oil traders. Generally, the method to calculate the ex-refinery price value comes from the Thai government. The refined prices follow Singapore market and add the transportation value, insurance value and lost costs. Also, according to the study of Vikitset (35), this was advantageous to the producers because most of them are using almost the same price will be similar to Singapore which refers to the standard cost of production in each region.

Next, other factors affect biodiesel price which depends on the Thai government. The government needs to impose the taxes and funds such as excise tax, oil fund tax, and energy conservation fund. According to the study of International Institute for Sustainable Development (6), the government supports ethanol and biodiesel usage to expand the fuel catering, support the energy products in the countries, and reduce the excise tax of biodiesel with ethanol mixture. While the oil fund and the reduction biodiesel b5 tax is continuing, this affects the retail price because it is lower than diesel and biodiesel 2 percent. The government adjusts the mandatory biodiesel-blending requirement, depending on the supply and stocks of palm oil which vary with the season and the harvest yield (5). As well as the qualitative result, the funds will be collected by the ministry of energy to decrease the change of domestic oil price, and maintain the price when the price in the global market is changing. Because if the price in the global market is high, the government have to use the oil fund to help the maintain of domestic price by making the price lower. Therefore, the qualitative research shows that the taxes and funds have a positive influence on the price of biodiesel; this research

is somewhat similar to the study of Vikiset (35), it stated that the oil fund component has a potential on every product which is including B5.

On the other hand, the researcher expected that the foreign exchange rate has a few effects on the retail price of biodiesel ($p < 0.05$) when we control the other independent variables. The fluctuation of the Dollars exchange rate is not only directly affected the world economy and oil price in this industry but also affects the oil policy in exporting countries that using fuel (108). Thus, in some situation, the Thai government may buy the oil in the futures, have the price intervention. Therefore, although, the exchange rate or Thai Baht may appreciate, the biodiesel price still cannot be higher than the standard. This evidence shows that the relationship between foreign exchange rate and biodiesel price are a few related. Same as the other studies such as the studies of Obadi Saleh and Othmanová (109) indicated that the reduction of the dollar is similar to the increasing number of oil price between the countries which is the dollar depreciation or Euro, as well as the study of Maples (110), found that the main factor is the exchange rate especially, the US dollar exchange rate which is the main currency of the petroleum industry that tends to have a potential on the cost of production.

However, it is somewhat interesting for this study because of the four independent variables still cannot explain the dependent variable which is biodiesel price that is not available to show up in a petrol station for 100 percent. It shows that some of the retail biodiesel prices in Thailand depend on other factors. From the qualitative research, we found that there are two main factors that different from quantitative research which are the palm oil and the demand for biodiesel in Thailand. The result from this research is somewhat similar to other research such as Ming and Chandramohan (111) stated that palm oil would be used as the main ingredient regarding producing biodiesel. Therefore, if there is any change in price, it will certainly affect biodiesel price at the petrol station. Also, if we look at the need of biodiesel in Thailand, We have found that these days Thailand has the campaign to support the production of biodiesel in 2005. However, the primary production of biodiesel has no significant until 1st February 2008. The government has the policy to compensate the biodiesel which is diesel mixed with 2 percent of biodiesel (112); due to the usage of biodiesel B100 (pure biodiesel) regarding the production of biodiesel B2, and the needs of biodiesel B5 has

increased in 2009 and 2010 (113). Therefore, in terms of understanding the price structure, we need to do more research on other factors such as basic necessity, government, agriculture, etc. This may help explaining the structure clearer.

2. Forecasting the biodiesel price of Thailand in the next ninteen years, from 2018 to 2036

The results from the forecasting of biodiesel prices in Thailand by using time series decomposition method for the long term from 2018 to 2036, we found that the trend of biodiesel prices has been continuously decreased over the last 19th years. In the first year (2018), the biodiesel prices around 23.50 to 23.72 baht/liter. In the final year (2036), on December the retail price has fallen to the lowest price 14.05 baht/liter. The qualitative research shows that the use of biodiesel (B100) in Thailand is keeping the increase as the government supports Thai people to use biodiesel and expand the oil palm area. So, if the goal of government is successful, the future retail price of biodiesel trend will be decreased; as there is a balance between the main component and area to grow the crude oil palm. However, the most interesting thing in this research is that the result is somewhat similar to the alternative energy development plan 2015 as they want to increase the usage of alternative energy up to 30 percent. As the policy of The Minister of Energy has promoted biofuels as concrete since 2004 by licensing biofuel factories, expanding more biofuel stations, and promoting public relations to make people become more confident to use biofuels. Until the world energy crisis occurred in the year 2008, crude oil prices rose above 140 USD a barrel; this increase demand of biofuels to replace and reduce the import of crude oil. The goal of this plan includes the consideration of potential of renewable energy sources that can be developed, and it uses to formulate the target of AEDP 2015 to replace 30 percent of final energy consumption and consistent. From this study, the trend of biodiesel prices has been continuously decreased over the last 20th century until the demand of biodiesel energy is in a significant proportion of the energy consumption of the country, which has increased steadily.

Therefore, the main factor that can make people using more alternative energy is the lower price and higher quality energy. Moreover, from many literature reviews, we have found the increasing number of people that need biodiesel in many countries. For instance, according to Melikoglu (114), the biodiesel demand in Turkey

may drastically rise to 3.4 million m3, in 2023. Same as the study of Indrawan et al. (115) found that there is a target to replace 23 percent of biofuel will replace fossil fuels with the renewable energy in 2025. While, Thai government (AEDP 2015) (6) want to increase and support the use of renewable energy, and this conforms with the results from the forecast of this study; it shows that during the years 2017 to 2036, the biodiesel price will continuously decrease in next 20 years. In the first year (2017), the biodiesel prices will be around 27.504 to 25.842 baht/liter. By December 2036 the retail price will fall to the lowest price which is 22.361 baht/liter. Same as, the aim of AEDP 2015 (6) for biofuel development with the focus on the lower cost of biofuel, to increase the biofuel demand. Moreover, the study of Chanthawong and Dhakal (116) stated that there are four strategies for developing the biofuels in Thailand as follows; (1) Improving farm management and promoting contract farming (average=4.77), (2)Promoting biodiesel research and development in the long-term (average = 4.62), (3) Encouraging free trade in the domestic ethanol market (average = 4.55), and (4) Improving farm management and expanding the cultivation area (average = 4.50) At the same time, the Thai government must predict the biodiesel scenario to identify the use of palm oil biodiesel on a massive scale, and consider the aspects of biodiesel production and prospective resources for biodiesel production systems with consistency. However, in the past worldwide, more than 90% of the transport sector is powered by fuels derived from oil (117). But in the future, the Thai government to reduce dependence on oil in the transport sector, alternatives like biofuels and more electric cars are used in increasing the volume and numbers. Therefore, the growth rate of electric vehicle technology in Thailand is a major key driving force of demand for biodiesel. However, from the assessment of electric vehicle technology development and its implication in Thailand found that the trend growth rate of electric vehicle technology is s-shape (118). When considering the factor that directly affects the biodiesel price is the growth rates of the electric vehicle. Nowadays, most vehicles are driven by fossil fuels or oil. But in the future, Finance (119) indicated that fossil fuel demand would be displaced by the growing fleet of electric vehicles (EVs) while 34% of cars on the road will be electric vehicles (EVs) by 2040. While, Wang and DeLuchi (120) found that the magnitude of petroleum displacement by EVs depends mainly on the amount of petroleum used for electricity generation, for example, in part of the U.S. EVs will reduce per-mile

petroleum use by over 90% because the vast majority of electricity is generated from non-petroleum fuels. And, Gomez Vilchez Jochem and Fichtner (121) indicated that the crude oil prices had been high volatility, which high oil prices affect the car fuel demand. In another study, Johansson and Schipper (122) found that the alternative, substitute vehicle fuel – e.g.electricity – can contribute to reducing to some extent this inelasticity. For example, the road transport sector can significantly influence oil prices under two possible cases. If there are a higher number of people who use an electric vehicle, the demand for petroleum in the transportation sector will be decreased as well.

On the other hand, If the transportation still needs fuel to satisfy the needs of people continuously, the fuel vehicles will continually increase. Therefore, in the future, this will leads to a higher oil price in the world market. From this research, the researcher obtains much information, and this allows us to create scenario planning for future biodiesel price.

3. Scenario planning

This scenario planning study aims to create an in-depth discussion about the probability of biodiesel price situation in the future. When uncontrollable driving forces (critical uncertainties) assumes the predefined levels and develop the frame in the price of renewable energy that clearness, this scenario plan will help the study of factors that affect the price of biodiesel in next 19 years to the next level. Also, the prediction of biodiesel price (phase 1) and the information from the in-depth interview(phase 2); these things may help accomplish the attitude toward the current situation of biodiesel price by focusing on the explanation of the biodiesel pricing situation. As well as identifying risk factors that may affect the change in price over the next ten years, and the attitude toward the effect of Alternative Energy Development Plan (AEDP: 2015–2036) (6) on the biodiesel price situation with a particular focus on production mandate for biodiesel, incentive tax, and nontax. The scenario planning was presented in below as the following:

3.1 The situation of biodiesel price in Thailand in the future

From the forecasting of biodiesel prices in Thailand by using time series decomposition method for the long term from 2018 to 2036, it indicated that trend of biodiesel price continuously decreases from around 23.50 to 23.72 baht/liter in 2018 to 14.05 baht/liter in December of 2036. It shows that the trend of biodiesel prices in

Thailand will decrease about 9.67-9.45 baht/liter. In 2036, the average biodiesel price is around 14.45 baht/liter. (As shown in Figure 18)

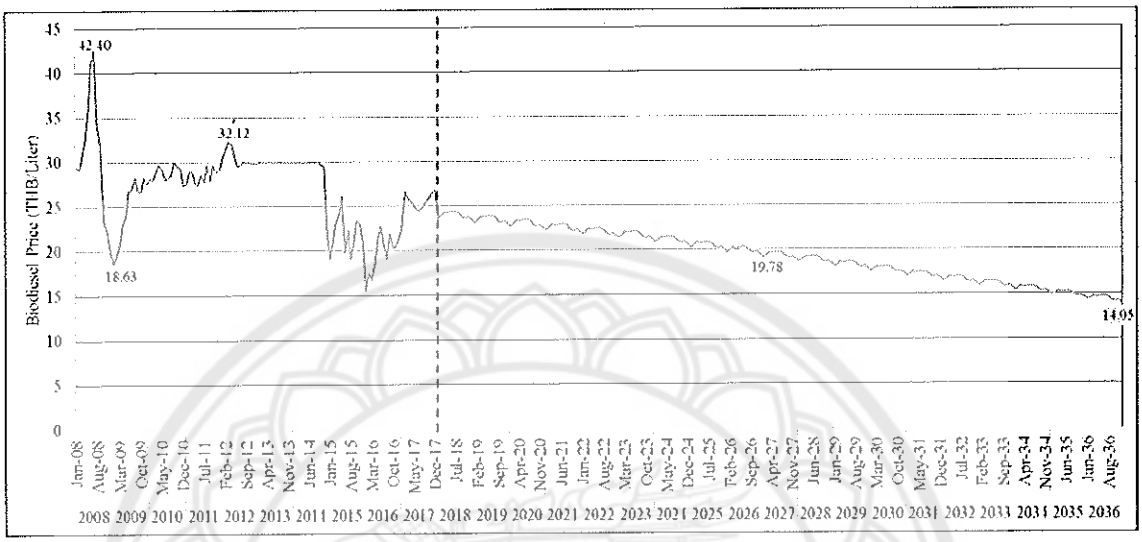


Figure 19 Forecasting the biodiesel price of Thailand, during 2018 to 2036

However, the values of the forecast of biodiesel price in chapter 4 are the past data from the Energy Policy and Planning Office, Ministry of Energy of Thailand monthly average retail price of regular grade biodiesel, during 2008 – 2017. In the future, the price may change because it depends on the situation during that time.

3.2 The goal of various energy plans in Thailand

The situation of energy in Thailand will be taking into a mission which are energy security, economy, and ecology in the next 20 years. Therefore, if we look at the goals from various plans to consider in scenario planning, you will quickly see the result from each plan. The main plans that have effects on the price of biodiesel are shown in Appendix G

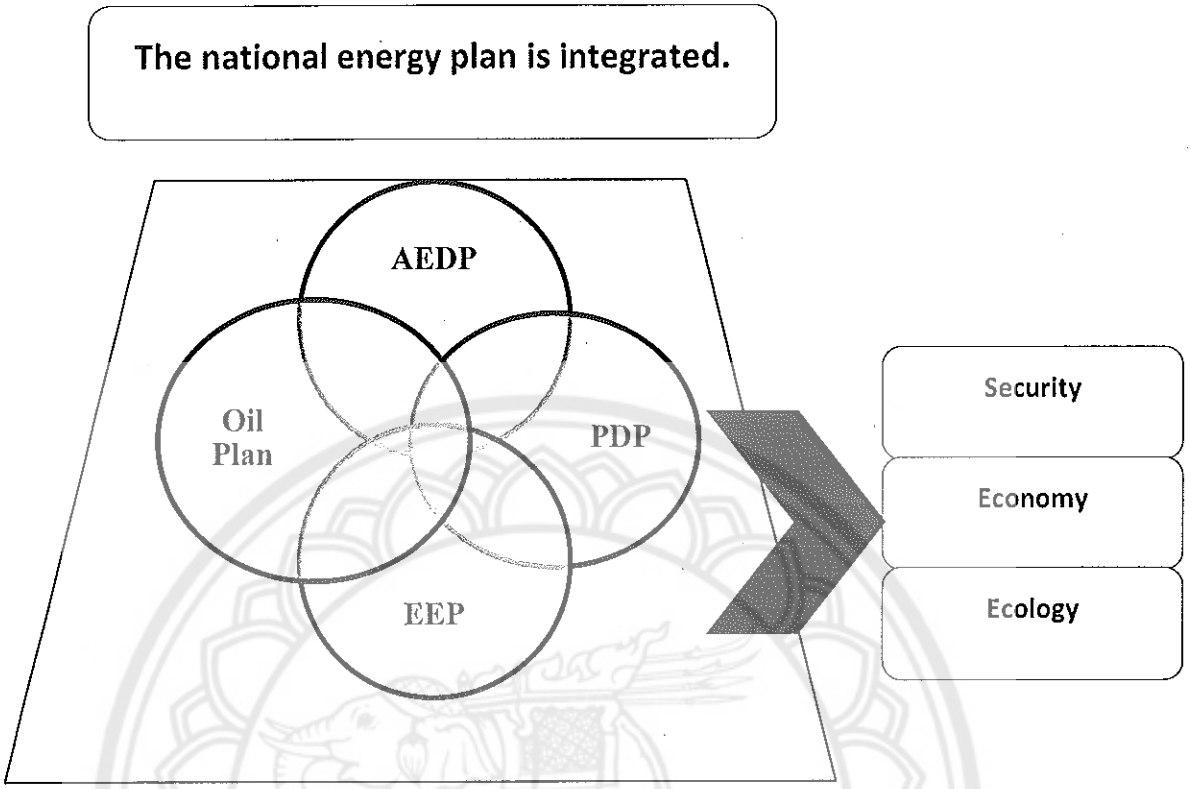


Figure 20 Integrating of the national energy plan

Vehicle Technology of Development in Thailand

The automobile industry in Thailand has overgrown in a shorter time. In 2012, Thailand produced approximately 2.5 million cars, which make Thailand ranked top 10 of automobile manufacturers, and produced the most automobile in ASEAN. The reason is Thailand has a strong supply chain, especially the automobile industry. Also, the development of technology makes Thailand changed from using an internal combustion engine (ICE) to natural fuels car, and now we have an electric car. So, this is one of the choices to adopt this innovation with land transport; this technology may expand shortly from the advantages of using efficient energy, and chemical emission. From the economic analysis, there is a possibility to set the proportion of electric car in the future as follows:

Table 11 Proportion of electric vehicles classified by the type of vehicles in 2030

Year	Motorcycle	Light duty vehicle (LDV)		
		Hybrid electric vehicle	Plug-in hybrid electric vehicle	Battery electric vehicle
2030	35%	18%	12%	4%

Source: Follow on Assessment of Electric Vehicle Technology Development and Its Implication in Thailand (123)

However, the change of weather, economy, environment, political conflicts, and the oil market price. Somehow, all of these factors are related to each other; so it is unavoidable. Many factors are not qualitative variables such as political factor, conflicts in other countries, and the economy. We have to consider as it is an indirect factor that's an affect the development plans like energy conservation and development plan. Therefore, in order to clarify this study, we have set the patterns of the change in future in two mains scenario logics as follows:

1. Development of vehicle technology
2. The situation of biodiesel price in the future

Therefore, the storylines of the scenarios are as follows

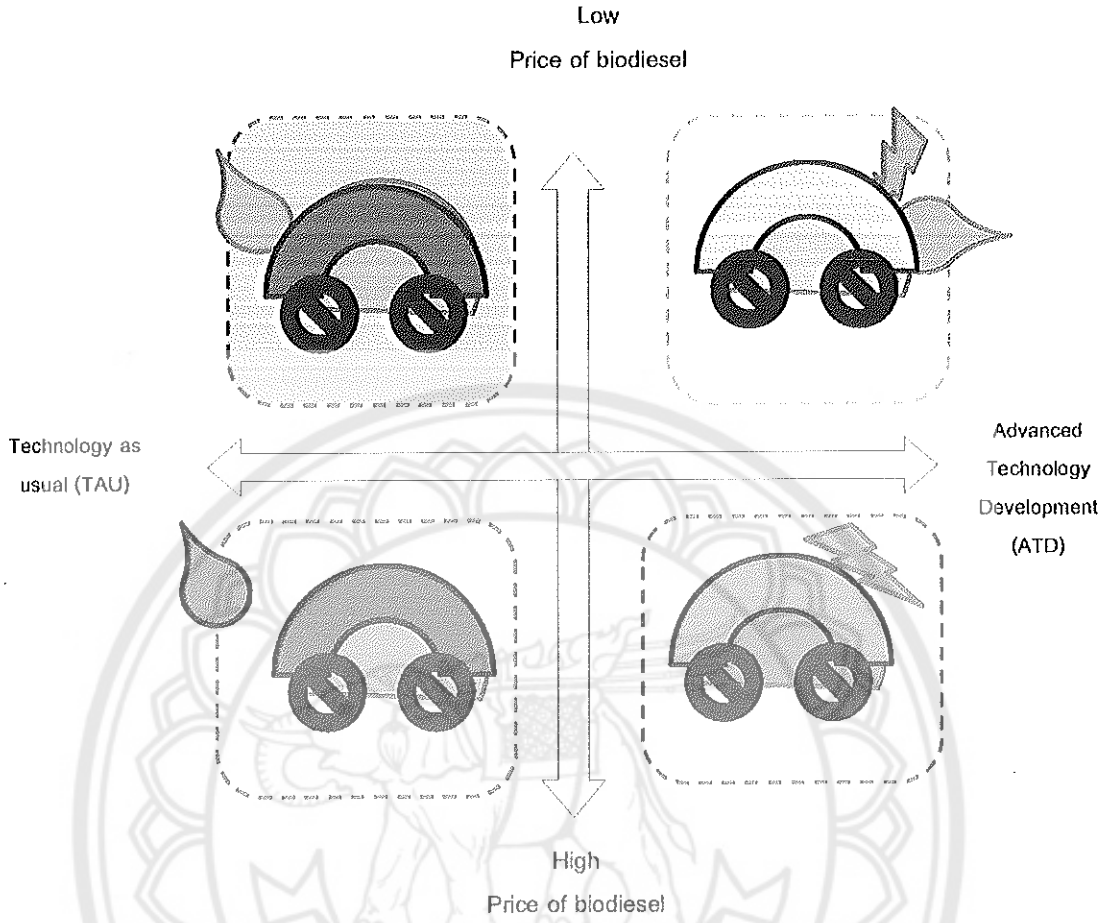


Figure 21 Scenarios planning on affecting biodiesel price and technology in Thailand

1. Scenario 1: Green energy generation

The name ''Green energy generation'' indicates a scenario which is biodiesel price. It is obtained low costs because the Thai government's energy development plans in various sections which are likely to achieve their goals. Regarding green energy generation scenario, the final maximum energy consumption of using biofuel is 20-25 percent in 2036, and the biodiesel consumption increased by 14.0 million liters/day within the period. According to the government's support, the agricultural producers are still deciding palm. Moreover, the potential was determined by the palm and palm oil strategy in 2015-2036, and the assumption that the palm oil is remaining from domestic consumption was expected to produce more biodiesel

following the agricultural areas which supported by the Thai government. Also, the change in weather, economy, environment, political issues, conflicts, and market price can support the development of alternative energy. Currently, the automobile industry in Thailand still uses an internal combustion engine, and adapts the engine to use with other types of alternative energy; however, we need better technology to produce biodiesel.

2. Scenario 2: Combined green and electrical energy generation

The name "Combined green and electrical energy generation" shows a scenario which is low biodiesel price because the government gives full support to accomplish the goal. Firstly, they expand the cultivated area and separate palm oil for consumption and biodiesel production. However, during that time, it may have innovation like green energy that produces less carbon. Electric is still not acceptable because biodiesel has better ability and stability. Moreover, they also have a better situation regarding the weather, economy, environment, politics, conflicts, and the price in the world market. If there is nothing wrong with these factors, the development of alternative energy may move to the next level. In terms of the technology of automobile, it tends to have more electric cars, and people are more interested in it. For the situation of biodiesel price, the price is lower than the past and becomes more interesting, but the market share of electric and fuel vehicle will be risen about 34 percent in 2036.

3. Scenario 3: Fuel energy generation

The name "Fuel energy generation" displays a scenario which is high biodiesel price. As the government cannot fully support those plans, the plan is changed and not accomplished. The main reason is that the agricultural output is lower than the expectation, so there is a shortage of crude palm oil. Also, there are some problems regarding energy manufacturers in countries, so the price of crude oil may be higher than the expectation. Also, the technology for producing biodiesel has low quality; therefore, the consumers may choose to use conventional fuels rather than biodiesel. As a result of scenario 3, in 2036, if biodiesel price is getting higher and the quality is not high as the price, about 70 percent of people will choose to use fuel vehicle, but the consumers will choose to use electric car decrease 20 percent.

4. Scenario 4: electrical energy generation

This shows that the government plan is unsuccessful; they cannot develop the technology to produce biodiesel, and they do not have the potential to develop alternative energy. Moreover, the price in the world market tends to increase, and also has more political problems. There will be other factors that may affect the production of crude palm oil such as the change in weather like a flood, so there will be a shortage of crude palm oil. However, Thailand has a strategy to produce enough electricity that supports vehicle batteries. Also, there is more import and development of electric cars like the lower price of the battery and more convenience. Therefore, this may be a good choice that will be potential for land transport. In the future, it may have the expansion of electric cars because of the efficiency of energy consumption, and less pollution. Also, the electric car is appropriate for transporting in the city center. From scenario 4, in the future, biodiesel price will be higher, but we still have a good structure of electricity includes that convenience and price of the electric car. Therefore, there is approximately 50 percent that the consumers will choose to use an electric car in 2036. Therefore, from the scenario logics that consist of four topics, we can conclude that the main driving forces that affect the biodiesel price in Thailand in the future are including:

1. The growth rates of electric vehicle technology. The overall of the growth rates of electric vehicle technology in Thailand is a major key that affects the demand for biodiesel. However, from the assessment of electric vehicle technology development and its implication in Thailand, the growth rates of electric vehicle technology are s-shape. Therefore, from this study, we can determine that the overall electric vehicle technology growth rates in each future scenario have a different perspective. Moreover, the value of electric vehicle technology growth rates in all future scenario follows the model that uses for forecasting of some electric vehicles (EV) in Thailand. The source of the number of electric vehicles (EV) comes from the National Energy Information Center (NEIC) and the Energy Policy and Planning Office (EPPO) (123) in 2013 that based on the models of forecasting and exploration of energy consumption in the transportation sector. Therefore, we have set the scenario situation of the growth rates of electric vehicle; all scenario are claimed by the forecasting of the National Energy Information Center (NEIC) and the Energy Policy and Planning Office (EPPO) in 2013(124); they expect that the growth rates will be increased due to the increasing

number of market share approximately one percent annually as it shows in Figure 21

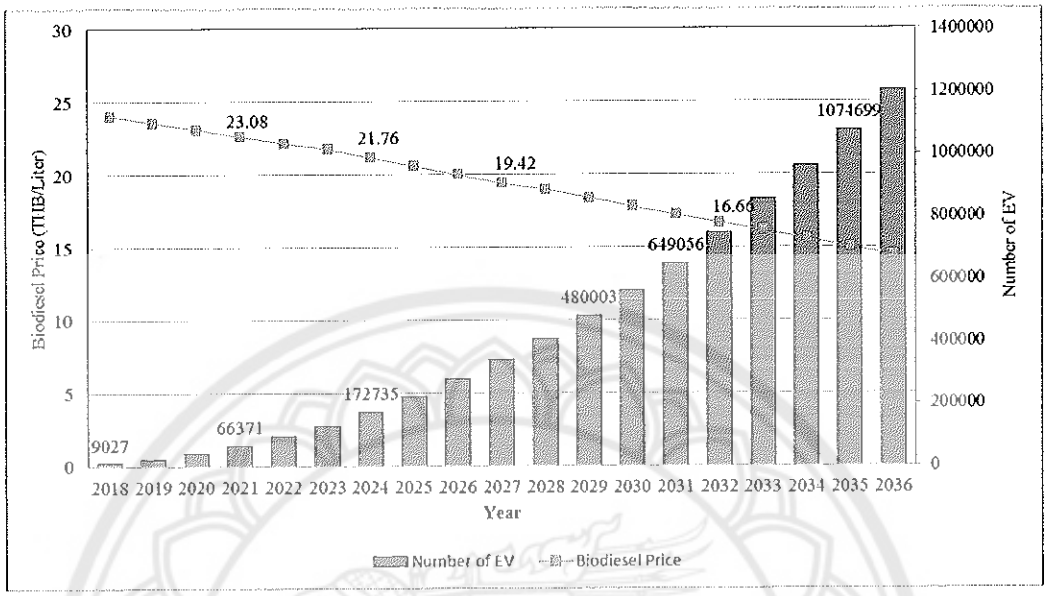


Figure 22 The growth rate of electric vehicle technology and Forecasting of Biodiesel Prices in Thailand from 2018 to 2036

When considering the factor that directly affects the biodiesel price is the growth rates of the electric vehicle. Nowadays, the most vehicle is driven by fossil fuels or oil. If there are a higher number of people who use an electric vehicle, the demand for petroleum in the transportation sector will decrease as well. Also, the demand for an electric vehicle will be increased as it shows in scenario 1 (green energy generation) and scenario 2 (combined green and electrical energy generation). The price of biodiesel has set approximately 14.45 baht/liter, and it is somewhat cheap as same as the quantitative research; however, there are some differences in each scenario. For scenario 1 (Green Energy Generation), there are a higher number of the sales of the electric vehicle in the normal situation, and the normal growth rates are one percent. Moreover, the vehicle that uses fuel will remain, but it will use the alternative energy due to the success of AEDP 2015.

While scenario 2 (Combined Green and Electrical Energy Generation) shows that the electric vehicle will become more popular, and its sales will increase approximately 34 percent (Hybrid electric vehicle, Plug-in hybrid electric vehicle and

Battery electric vehicle) followed by the assessment of Electric Vehicle Technology Development and Its Implication in Thailand. The government still focus on the Energy Efficiency Development Plan (EEDP 2015)

In part of Scenario 3 (Fuel Energy Generation) and Scenario 4 (Electrical Energy Generation) found that the biodiesel price will be increased, so this scenario is different from the quantitative research. The reason for the higher price of biodiesel is because the government may not focus on the social and environment sufficiently. Therefore, people will be still interested in fossil fuel, and it will keep increasing due to the world economy. Also, the oil price may increase to 140 USD/bbl in 2535 or 42.40 Baht/Litre. We can say that the price will increase approximately even up to 70 %. In scenario 3, the growth rates of the electric vehicle are not a normal situation which the consumers will choose to use electric car decrease 20 percent; the reason is that there is an insufficient electricity. Therefore, it makes people prefer using the gasoline vehicle even though; the fuel price is high.

Lastly, scenario 4 (Electrical Energy Generation) shows that there will be huge growth for the electric vehicle; the growth rate will be about 50 percent. Moreover, the government has a plan to produce a sufficient amount of electricity to serve the needs of consumers. Therefore, it makes the electric vehicle more popular than the gasoline vehicle. The hypothesis of each scenario shows in a Figure 22

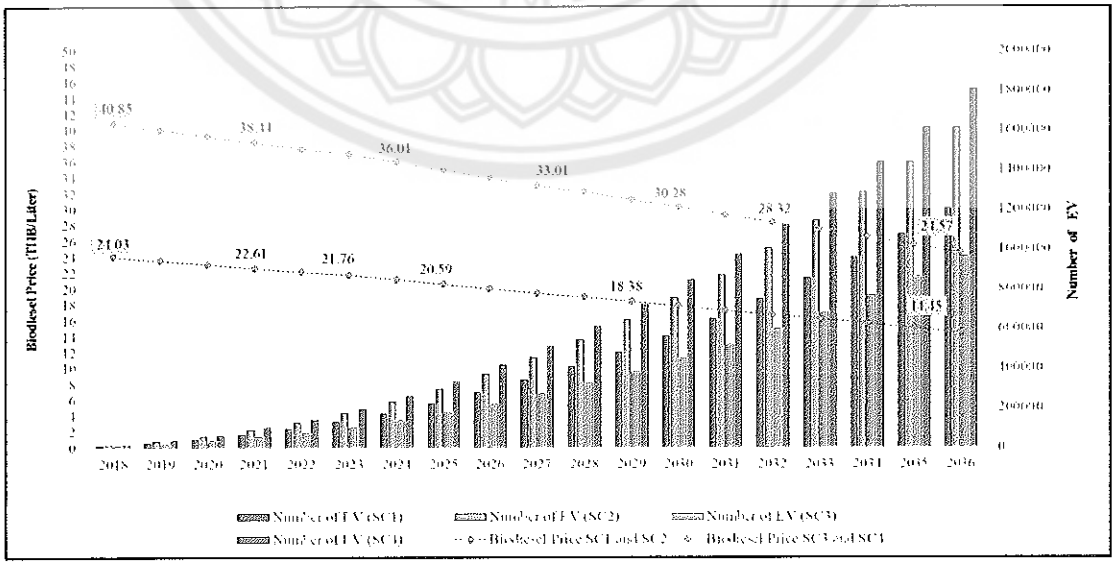


Figure 23 Summary of Scenario 1-4

So we can conclude that the scenarios developed for analysis which aims is to have an in-depth discussion about the future, and also discuss the uncertainty about of biodiesel price that we cannot control. There are two driving forces in this study which are Development of vehicle technology (Technology as usual (TAU) or Advanced technology development (ATD) and the situation of biodiesel price in the future which are low price and high price.

For the scenario planning, it shows that it is somewhat important to consider the electric vehicle because it might be the main factor that will affect the biodiesel price in Thailand. Electric vehicles (EVs) is a new technology which, if electric vehicle efficiency is likely to develop substantially over the next 19 years mitigating the extent to which oil consumption will increase. While charging system or the electricity powering of the EVs are likely to be largely generated using fuels other than oil. However, if it is more convenient to use electric vehicles, the consumers of electric vehicles in Thailand may tend to increase. To demonstrate, when the electric vehicles are cheaper, safe, using a shorter time to charge, able to run longer for a one-time charge, and easy to find the spares and charging station. Therefore, there will be a few numbers of vehicle fuel in the future

Recommendation

1. This study is the future scenario of biodiesel price in Thailand. There is both negative and positive result from this scenario; every scenario shows the tendency of the usage, production, importation of electric vehicles, and the effects on the price that tends to increase. However, since we have known the uncertainty and the ways to solve this problem, we may need to study more regarding managing "Thailand Policy Forum" to specify the way to solve the problems in the future.

2. For the different situation of Thailand in each region, this may affect the overall change of biodiesel price. Therefore, if we study more about the factors that may affect the price in each area, it may make the future scenario clearer. Lastly, for the next study, we should divide the study into the different regions

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APPENDIX

APPENDIX A OUT-PUT OF TREND EQUATION FROM STATISTICS ANALYSIS

Case Processing Summary

	N
Total Cases	120
Excluded Cases[a]	0
Forecasted Cases	0
Newly Created Cases	0

a. Cases with a missing value in any variable are excluded from the analysis.

Variable Processing Summary

		Variables
		Dependent
		Price
Number of Positive Values		120
Number of Zeros		0
Number of Negative Values		0
Number of Missing Values	User-Missing	0
	System-Missing	0

Linear

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.385	.248	.201	4.255

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	244.013	1	244.013	20.552	.000
Residual	1401.016	118	11.873		
Total	1645.029	119			

Coefficients

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Case Sequence	-.041	.009	-.385	-4.533	.000
(Constant)	30.265	.633		47.808	.000

Quadratic

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.459	.210	.197	3.332

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	345.887	2	172.943	8.434	.000
Residual	2399.143	117	20.505		
Total	2745.030	119			

Coefficients

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Case Sequence	.063	.035	.587	1.772	.079
Case Sequence ** 2	-.001	.000	-1.003	-3.029	.003
(Constant)	28.153	.928		30.337	.000

Exponential

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.356	.127	.119	.127

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	325.257	1	325.257	17.092	.000
Residual	2110.913	118	17.889		
Total	2436.170	119			

Coefficients

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Case Sequence	-.001	.000	-.356	-4.134	.000
(Constant)	29.936	.700		42.754	.000

The dependent variable is ln(Price).

The Root Mean Square Error is given as RMSE = $\sqrt{MSE}$

Model	MSE	RMSE
1. Linear	11.873	3.445
2. Exponential	20.505	4.528
3. Quadratic	17.889	4.229

APPENDIX B IRREGULAR INDEX FROM JANUARY 2008 TO DECEMBER 2017

	Year									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Jan	1.01 968	0.95 308	1.01 066	1.01 301	1.01 261	1.00 749	1.00 943	0.97 264	0.96 01	1.02 753
Feb	0.98 538	0.97 964	0.98 911	1.00 425	1.00 967	1.00 503	1.00 366	1.00 063	0.97 617	1.01 966
Mar	0.97 71	0.98 47	0.99 821	0.99 27	1.01 154	0.99 442	0.99 336	1.01 746	1.00 37	0.98 921
Apr	0.97 169	1.01 221	1.02 148	1.00 035	1.02 057	1.00 028	1.00 043	0.97 348	0.98 363	1.00 299
May	0.98 813	0.97 966	1.00 926	0.99 945	0.99 221	0.99 934	1.00 045	1.01 144	1.01 717	0.99 759
Jun	1.06 131	1.02 941	0.97 994	0.99 993	0.98 004	0.99 852	0.99 788	1.02 471	1.03 091	0.98 684
Jul	1.10 011	1.00 101	0.99 2	1.00 647	0.99 179	0.99 603	0.99 373	0.99 681	1.00 959	0.98 458
Aug	0.96 835	1.02 800	1.00 913	1.00 147	0.99 755	0.99 301	0.99 49	0.96 144	0.97 379	0.99 297
Sep	1.02 251	0.99 052	0.99 231	0.97 197	1.00 900	1.00 716	1.01 255	1.00 289	0.98 286	1.00 599
Oct	0.98 598	0.98 113	0.98 215	1.02 211	1.00 264	1.00 442	1.01 047	1.01 889	1.01 537	1.00 419
Nov	0.95 271	1.01 644	1.00 3	0.98 489	0.99 363	0.99 415	1.01 814	1.02 376	0.97 42	0.99 846
Dec	0.95 07	0.99 489	1.01 183	0.98 259	0.99 994	1.00 053	0.99 768	0.99 465	1.00 668	1.00 71

APPENDIX C FORECASTING THE BIODIESEL PRICE OF THAILAND IN THE NEXT FIVE YEARS, FROM 2018 TO 2022

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2018	Jan	.	25.28403	0.959	0.97815	23.72
	Feb	.	25.24286	0.959	0.98814	23.92
	Mar	.	25.20170	0.959	1.00641	24.32
	Apr	.	25.16053	0.959	1.00647	24.29
	May	.	25.11937	0.959	1.0121	24.38
	Jun	.	25.07820	0.959	1.01534	24.42
	Jul	.	25.03703	0.959	1.01672	24.41
	Aug	.	24.99587	0.959	1.01108	24.24
	Sep	.	24.95470	0.959	0.99273	23.76
	Oct	.	24.91354	0.959	0.98985	23.65
	Nov	.	24.87237	0.959	0.99609	23.76
	Dec	.	24.83120	0.959	0.9869	23.50
2019	Jan	.	24.79004	0.959	0.97815	23.25
	Feb	.	24.74887	0.959	0.98814	23.45
	Mar	.	24.70770	0.959	1.00641	23.85
	Apr	.	24.66654	0.959	1.00647	23.81
	May	.	24.62537	0.959	1.0121	23.90
	Jun	.	24.58421	0.959	1.01534	23.94
	Jul	.	24.54304	0.959	1.01672	23.93
	Aug	.	24.50187	0.959	1.01108	23.76
	Sep	.	24.46071	0.959	0.99273	23.29
	Oct	.	24.41954	0.959	0.98985	23.18
	Nov	.	24.37838	0.959	0.99609	23.29
	Dec	.	24.33721	0.959	0.98690	23.03

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2020	Jan	.	24.29604	0.959	0.97815	22.79
	Feb	.	24.25488	0.959	0.98814	22.98
	Mar	.	24.21371	0.959	1.00641	23.37
	Apr	.	24.17254	0.959	1.00647	23.33
	May	.	24.13138	0.959	1.0121	23.42
	Jun	.	24.09021	0.959	1.01534	23.46
	Jul	.	24.04905	0.959	1.01672	23.45
	Aug	.	24.00788	0.959	1.01108	23.28
	Sep	.	23.96671	0.959	0.99273	22.82
	Oct	.	23.92555	0.959	0.98985	22.71
	Nov	.	23.88438	0.959	0.99609	22.82
	Dec	.	23.84322	0.959	0.9869	22.57
2021	Jan	.	23.80205	0.959	0.97815	22.33
	Feb	.	23.76088	0.959	0.98814	22.52
	Mar	.	23.71972	0.959	1.00641	22.89
	Apr	.	23.67855	0.959	1.00647	22.85
	May	.	23.63738	0.959	1.0121	22.94
	Jun	.	23.59622	0.959	1.01534	22.98
	Jul	.	23.55505	0.959	1.01672	22.97
	Aug	.	23:51389	0.959	1.01108	22.80
	Sep	.	23.47272	0.959	0.99273	22.35
	Oct	.	23.43155	0.959	0.98985	22.24
	Nov	.	23.39039	0.959	0.99609	22.34
	Dec	.	23.34922	0.959	0.98690	22.10

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2022	Jan	.	23.30806	0.959	0.97815	21.86
	Feb	.	23.26689	0.959	0.98814	22.05
	Mar	.	23.22572	0.959	1.00641	22.42
	Apr	.	23.18456	0.959	1.00647	22.38
	May	.	23.14339	0.959	1.0121	22.46
	Jun	.	23.10222	0.959	1.01534	22.49
	Jul	.	23.06106	0.959	1.01672	22.49
	Aug	.	23.01989	0.959	1.01108	22.32
	Sep	.	22.97873	0.959	0.99273	21.88
	Oct	.	22.93756	0.959	0.98985	21.77
	Nov	.	22.89639	0.959	0.99609	21.87
	Dec	.	22.85523	0.959	0.98690	21.63

APPENDIX D TO FIND THE FOUR PARTS ARE TREND SEASONALITY, CYCLES, IRREGULAR INDEX AND FORECASTING THE BIODIESEL PRICE OF THAILAND IN THE NEXT FIVE YEARS, FROM 2023 TO 2027

1. The results of the trend component

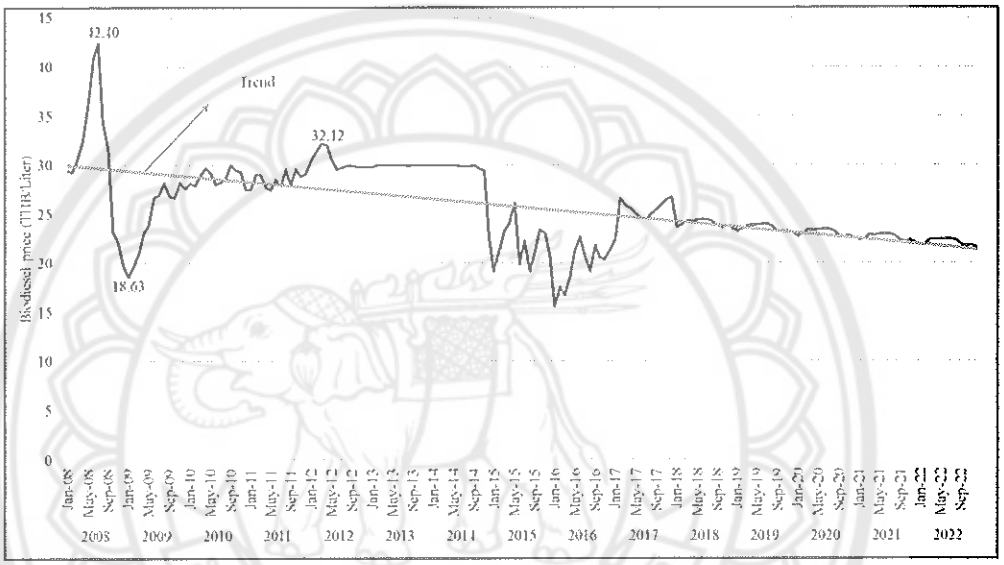

Figure 24 Results of the trend component

The trend of biodiesel price in oil market of Thailand from January 2008 to December 2022

2. The results of a seasonal index

Month	Seasonal index (%)
Jan	97.6
Feb	98.6
Mar	100.4
Apr	100.5
May	101.1
Jun	101.5

Month	Seasonal index (%)
Jul	101.7
Aug	100.9
Sep	99.4
Oct	99.3
Nov	100.1
Dec	99.0

From the seasonal index in the above, the influence of the season in the month Jan, Feb, Sep, Oct, and Dec leads to the biodiesel price decrease that below the average 2.4%, 1.4%, 0.6%, 0.7% and 1.0% consecutively. In the dominant part of the season in month Mar, Apr, May, Jun, Jul, Aug, and Nov it would lead the biodiesel price increase that's higher than the average number of 0.4%, 0.5%, 1.1%, 1.5%, 1.7% 1.9% and 1.1%, respectively.

3. To find the appropriate trend equation

The format of trend equation that is appropriate for the biodiesel price from January 2008 to December 2017.

Equation model	The trend equation	R^2
1. Linear	$\hat{Y} = 30.592 - 0.048(t)$	0.458
2. Exponential	$\hat{Y} = 30.495 - 0.002(t)$	0.444
3. Quadratic	$\hat{Y} = 29.618 - 0.016(t) + 0.00(t^2)$	0.445

As we can see in the above table, the most appropriate trend equation is the linear equation because it has the highest R^2.

Therefore, the linear trend function as

$$\hat{Y} = a + b\,(t)$$

Where

$a = 30.592$, $b = -0.048$

t = mounts (initial on Jan,2008)

Therefore, the linear trend equation is

$$\hat{Y} = 30.592 - 0.048\,(t)$$

4. Calculate the cyclical variation

The cyclical change index is conducted by eliminating the trend (T) out of the moving average (MA) by $\hat{C} = (T \times C)/\hat{T}$ and $\hat{C}$ that was computed from the Figure 23 will be in the range of 0.80 to 1.50. It will be shown in the figure

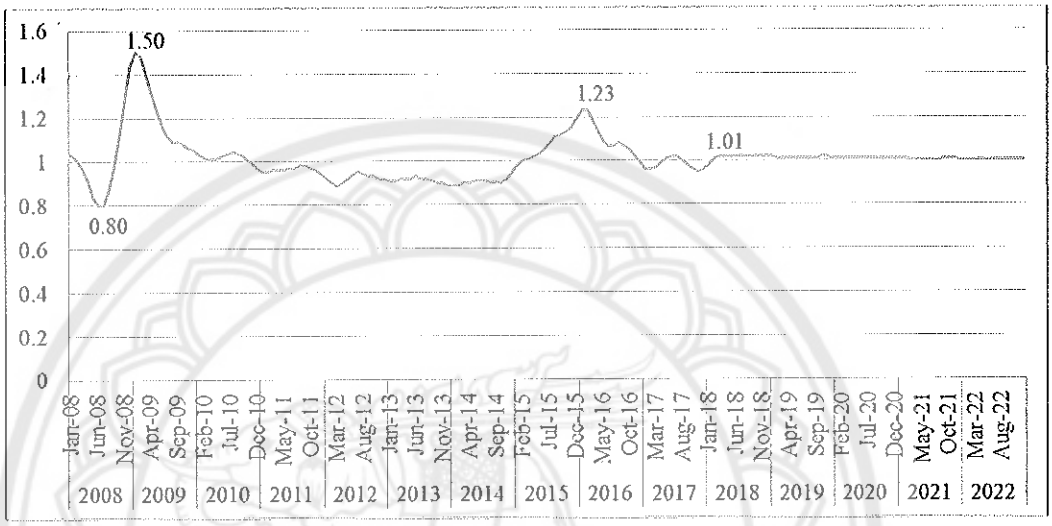

Figure 25 The cyclical change index of biodiesel price in oil market of Thailand from January 2008 to December 2022

5. Irregular index from January 2008 to December 2022

	Year									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Jan	1.01 955	0.95 491	1.01 251	1.01 487	1.01 44	1.00 935	1.01 13	0.97 454	0.96 197	1.02 936
Feb	0.98 545	0.98 034	0.98 98	1.00 497	1.01 036	1.00 575	1.00 438	1.00 138	0.97 689	1.02 038
Mar	0.97 725	0.98 485	0.99 835	0.99 284	1.01 168	0.99 455	0.99 35	1.01 76	1.00 385	0.98 934
Apr	0.97 184	1.01 235	1.02 158	1.00 046	1.02 066	1.00 038	1.00 053	0.97 358	0.98 376	1.00 308
May	0.98 832	0.97 983	1.00 938	0.99 958	0.99 232	0.99 947	1.00 057	1.01 155	1.01 732	0.99 77
Jun	1.06 109	1.02 914	0.97 966	0.99 966	0.97 976	0.99 825	0.99 761	1.02 444	1.03 065	0.98 656
Jul	1.09 938	1.00 032	0.99 131	1.00 577	0.99 11	0.99 534	0.99 304	0.99 613	1.00 891	0.98 391
Aug	0.97 035	1.03 022	1.01 132	1.00 365	0.99 973	0.99 519	0.99 708	0.96 354	0.97 593	0.99 517
Sep	1.02 189	0.99 017	0.99 198	0.97 164	1.00 868	1.00 684	1.01 222	1.00 257	0.98 257	1.00 57
Oct	0.98 463	0.98 003	0.98 107	1.02 099	1.00 152	1.00 331	1.00 934	1.01 776	1.01 428	1.00 311
Nov	0.95 191	1.01 552	1.00 209	0.98 399	0.99 274	0.99 326	1.01 728	1.02 291	0.97 33	1.01 18
Dec	0.94 911	0.99 305	1.00 994	0.98 072	0.99 81	0.99 87	0.99 597	0.99 296	1.00 476	1.04 238

	Year				
	2018	**2019**	**2020**	**2021**	**2022**
Jan	0.96762	1.00176	1.0019	1.00186	1.00171
Feb	0.98819	1.00065	1.00061	1.00083	1.00075
Mar	1.00000	1.00027	1.00022	1.00006	1.00025
Apr	1.00028	1.00014	1.00009	0.99998	1.00017
May	1.00007	1.00003	1.00005	1.00006	1.00002
Jun	0.99975	0.99979	0.99983	0.99987	0.99956
Jul	0.99921	0.99925	0.9993	0.99935	0.9995
Aug	1.00225	1.00221	1.00216	1.00211	1.00211
Sep	0.9997	0.99971	0.99972	0.99978	0.9998
Oct	0.99885	0.99882	0.99873	0.99879	0.99875
Nov	0.99915	0.99922	0.99919	0.99902	0.99998
Dec	0.99819	0.99809	0.99822	0.99831	0.99982

Before forecasting the biodiesel price of Thailand in the next five years, from 2018 to 2022, we can consider the accuracy of the predictive value is close to the true value between 2008 to 2022.

6. Comparison of the predictive value and true value in the biodiesel price of Thailand, from 2008 to 2022

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2008	Jan	29.43	30.54380	1.03	0.97608	30.71
	Feb	29.29	30.49539	1.01	0.98597	30.37
	Mar	30.71	30.44697	0.97	1.00429	29.66
	Apr	32.49	30.39856	0.91	1.00468	27.79
	May	36.02	30.35014	0.84	1.01076	25.77
	Jun	40.92	30.30173	0.80	1.01468	24.60
	Jul	42.40	30.25331	0.80	1.01686	24.61

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
	Aug	34.37	30.20490	0.86	1.00888	26.21
	Sep	31.65	30.15649	0.97	0.99433	29.09
	Oct	26.22	30.10807	1.12	0.99345	33.50
	Nov	22.22	30.05966	1.29	0.99970	38.77
	Dec	19.69	30.01124	1.43	0.99033	42.50
2009	Jan	18.63	29.96283	1.50	0.97608	43.87
	Feb	19.59	29.91441	1.48	0.98597	43.65
	Mar	20.99	29.86600	1.41	1.00429	42.29
	Apr	23.05	29.81759	1.32	1.00468	39.54
	May	23.84	29.76917	1.24	1.01076	37.31
	Jun	26.68	29.72076	1.16	1.01468	34.98
	Jul	26.96	29.67234	1.12	1.01686	33.79
	Aug	28.17	29.62393	1.09	1.00888	32.58
	Sep	26.83	29.57551	1.09	0.99433	32.05
	Oct	26.70	29.52710	1.08	0.99345	31.68
	Nov	28.19	29.47869	1.06	0.99970	31.24
	Dec	27.63	29.43027	1.05	0.99033	30.60

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2010	Jan	28.09	29.38186	1.03	0.97608	29.54
	Feb	27.93	29.33344	1.02	0.98597	29.50
	Mar	28.94	29.28503	1.01	1.00429	29.70
	Apr	29.64	29.23661	1.01	1.00468	29.67
	May	29.20	29.18820	1.02	1.01076	30.09
	Jun	28.07	29.13979	1.03	1.01468	30.45
	Jul	28.24	29.09137	1.04	1.01686	30.77
	Aug	28.58	29.04296	1.04	1.00888	30.47
	Sep	27.79	28.99454	1.03	0.99433	29.70
	Oct	27.83	28.94613	1.01	0.99345	29.04
	Nov	29.26	28.89771	0.99	0.99970	28.60
	Dec	29.89	28.84930	0.97	0.99033	27.71
2011	Jan	29.99	28.80089	0.95	0.97608	26.71
	Feb	29.99	28.75247	0.95	0.98597	26.93
	Mar	29.96	28.70406	0.96	1.00429	27.67
	Apr	29.99	28.65564	0.96	1.00468	27.64
	May	29.99	28.60723	0.96	1.01076	27.76
	Jun	29.99	28.55881	0.97	1.01468	28.11
	Jul	29.99	28.51040	0.97	1.01686	28.12
	Aug	29.51	28.46199	0.98	1.00888	28.14
	Sep	27.99	28.41357	0.98	0.99433	27.69
	Oct	29.51	28.36516	0.97	0.99345	27.33
	Nov	28.88	28.31674	0.96	0.99970	27.18
	Dec	29.12	28.26833	0.94	0.99033	26.32

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2012	Jan	30.45	28.21991	0.92	0.97608	25.34
	Feb	31.31	28.17150	0.90	0.98597	25.00
	Mar	32.12	28.12309	0.89	1.00429	25.14
	Apr	31.99	28.07467	0.90	1.00468	25.39
	May	30.51	28.02626	0.92	1.01076	26.06
	Jun	29.58	27.97784	0.94	1.01468	26.69
	Jul	29.74	27.92943	0.95	1.01686	26.98
	Aug	29.89	27.88101	0.94	1.00888	26.44
	Sep	29.93	27.83260	0.93	0.99433	25.74
	Oct	29.79	27.78419	0.93	0.99345	25.67
	Nov	29.79	27.73577	0.92	0.99970	25.51
	Dec	29.79	27.68736	0.92	0.99033	25.23
2013	Jan	29.79	27.63894	0.91	0.97608	24.55
	Feb	29.95	27.59053	0.91	0.98597	24.76
	Mar	29.99	27.54211	0.92	1.00429	25.45
	Apr	29.99	27.49370	0.92	1.00468	25.41
	May	29.99	27.44529	0.92	1.01076	25.52
	Jun	29.99	27.39687	0.93	1.01468	25.85
	Jul	29.99	27.34846	0.92	1.01686	25.58
	Aug	29.89	27.30004	0.92	1.00888	25.34
	Sep	29.99	27.25163	0.91	0.99433	24.66
	Oct	29.99	27.20322	0.90	0.99345	24.32
	Nov	29.99	27.15480	0.90	0.99970	24.43
	Dec	29.99	27.10639	0.89	0.99033	23.89

Year	Date	Retail Price (true value)	Trend $(\hat{T})$	cyclical $(\widehat{C})$	seasonal $(\hat{S})$	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2014	Jan	29.99	27.05797	0.89	0.97608	23.51
	Feb	29.99	27.00956	0.89	0.98597	23.70
	Mar	29.99	26.96114	0.90	1.00429	24.37
	Apr	29.99	26.91273	0.90	1.00468	24.33
	May	29.99	26.86432	0.91	1.01076	24.71
	Jun	29.91	26.81590	0.91	1.01468	24.76
	Jul	29.85	26.76749	0.91	1.01686	24.77
	Aug	29.86	26.71907	0.90	1.00888	24.26
	Sep	29.99	26.67066	0.90	0.99433	23.87
	Oct	29.66	26.62224	0.90	0.99345	23.80
	Nov	29.42	26.57383	0.92	0.99970	24.44
	Dec	27.60	26.52542	0.95	0.99033	24.96
2015	Jan	25.83	26.4770	0.98	0.97608	25.33
	Feb	26.22	26.42859	1.00	0.98597	26.06
	Mar	26.76	26.38017	1.01	1.00429	26.76
	Apr	25.26	26.33176	1.02	1.00468	26.98
	May	26.07	26.28334	1.03	1.01076	27.36
	Jun	25.90	26.23493	1.05	1.01468	27.95
	Jul	24.53	26.18652	1.08	1.01686	28.76
	Aug	22.90	26.13810	1.11	1.00888	29.27
	Sep	23.21	26.08969	1.12	0.99433	29.05
	Oct	23.31	26.04127	1.13	0.99345	29.23
	Nov	23.06	25.99286	1.15	0.99970	29.88
	Dec	21.37	25.94444	1.19	0.99033	30.58

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2016	Jan	19.84	25.89603	1.23	0.97608	31.09
	Feb	20.31	25.84762	1.23	0.98597	31.35
	Mar	21.86	25.79920	1.19	1.00429	30.83
	Apr	22.32	25.75079	1.14	1.00468	29.49
	May	24.15	25.70237	1.09	1.01076	28.32
	Jun	25.04	25.65396	1.07	1.01468	27.85
	Jul	24.55	25.60554	1.07	1.01686	27.86
	Aug	23.38	25.55713	1.08	1.00888	27.85
	Sep	23.21	25.50872	1.07	0.99433	27.14
	Oct	24.38	25.46030	1.05	0.99345	26.56
	Nov	24.20	25.41189	1.02	0.99970	25.91
	Dec	25.61	25.36347	0.99	0.99033	24.87
2017	Jan	26.43	25.31506	0.96	0.97608	23.72
	Feb	26.57	25.26664	0.96	0.98597	23.92
	Mar	25.80	25.21823	0.97	1.00429	24.57
	Apr	25.57	25.16982	0.99	1.00468	25.03
	May	25.02	25.12140	1.01	1.01076	25.65
	Jun	24.52	25.07299	1.02	1.01468	25.95
	Jul	24.52	25.02457	1.02	1.01686	25.96
	Aug	24.99	24.97616	1.00	1.00888	25.20
	Sep	25.46	24.92774	0.98	0.99433	24.29
	Oct	25.93	24.87933	0.96	0.99345	23.73
	Nov	26.46	24.83092	0.95	0.99970	23.58
	Dec	26.70	24.78250	0.96	0.99033	23.56

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2018	Jan	23.72	24.73409	0.98	0.97608	23.66
	Feb	23.92	24.68567	1.01	0.98597	24.58
	Mar	24.32	24.63726	1.02	1.00429	25.24
	Apr	24.29	24.58884	1.02	1.00468	25.20
	May	24.38	24.54043	1.02	1.01076	25.30
	Jun	24.42	24.49202	1.02	1.01468	25.35
	Jul	24.41	24.44360	1.02	1.01686	25.35
	Aug	24.24	24.39519	1.02	1.00888	25.10
	Sep	23.76	24.34677	1.02	0.99433	24.69
	Oct	23.65	24.29836	1.02	0.99345	24.62
	Nov	23.76	24.24994	1.02	0.99970	24.73
	Dec	23.50	24.20153	1.02	0.99033	24.45
2019	Jan	23.25	24.15312	1.02	0.97608	24.05
	Feb	23.45	24.10470	1.01	0.98597	24.00
	Mar	23.85	24.05629	1.01	1.00429	24.40
	Apr	23.81	24.00787	1.01	1.00468	24.36
	May	23.90	23.95946	1.01	1.01076	24.46
	Jun	23.94	23.91104	1.01	1.01468	24.50
	Jul	23.93	23.86263	1.01	1.01686	24.51
	Aug	23.76	23.81422	1.01	1.00888	24.27
	Sep	23.29	23.76580	1.01	0.99433	23.87
	Oct	23.18	23.71739	1.02	0.99345	24.03
	Nov	23.29	23.66897	1.02	0.99970	24.14
	Dec	23.03	23.62056	1.01	0.99033	23.63

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2020	Jan	22.79	23.57214	1.01	0.97608	23.24
	Feb	22.98	23.52373	1.01	0.98597	23.43
	Mar	23.37	23.47532	1.01	1.00429	23.81
	Apr	23.33	23.42690	1.01	1.00468	23.77
	May	23.42	23.37849	1.01	1.01076	23.87
	Jun	23.46	23.33007	1.01	1.01468	23.91
	Jul	23.45	23.28166	1.01	1.01686	23.91
	Aug	23.28	23.23324	1.01	1.00888	23.67
	Sep	22.82	23.18483	1.01	0.99433	23.28
	Oct	22.71	23.13642	1.01	0.99345	23.21
	Nov	22.82	23.08800	1.01	0.99970	23.31
	Dec	22.57	23.03959	1.01	0.99033	23.04
2021	Jan	22.33	22.99117	1.01	0.97608	22.67
	Feb	22.52	22.94276	1.01	0.98597	22.85
	Mar	22.89	22.89434	1.00	1.00429	22.99
	Apr	22.85	22.84593	1.00	1.00468	22.95
	May	22.94	22.79752	1.00	1.01076	23.04
	Jun	22.98	22.74910	1.00	1.01468	23.08
	Jul	22.97	22.70069	1.00	1.01686	23.08
	Aug	22.80	22.65227	1.00	1.00888	22.85
	Sep	22.35	22.60386	1.01	0.99433	22.70
	Oct	22.24	22.55544	1.01	0.99345	22.63
	Nov	22.34	22.50703	1.01	0.99970	22.73
	Dec	22.10	22.45862	1.00	0.99033	22.24

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2022	Jan	21.86	22.41020	1.01	0.97608	21.87
	Feb	22.05	22.36179	1.01	0.98597	22.05
	Mar	22.42	22.31337	1.01	1.00429	22.41
	Apr	22.38	22.26496	1.01	1.00468	22.37
	May	22.46	22.21654	1.01	1.01076	22.46
	Jun	22.49	22.16813	1.01	1.01468	22.49
	Jul	22.49	22.11972	1.01	1.01686	22.49
	Aug	22.32	22.07130	1.01	1.00888	22.27
	Sep	21.88	22.02289	1.01	0.99433	21.90
	Oct	21.77	21.97447	1.01	0.99345	21.83
	Nov	21.87	21.92606	1.01	0.99970	21.92
	Dec	21.63	21.87764	1.01	0.99033	21.67

7. Forecasting the biodiesel price of Thailand in the next five years, from 2023 to 2027

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2023	Jan	.	21.82923	1.0092	0.97608	21.50
	Feb	.	21.78082	1.0092	0.98597	21.67
	Mar	.	21.73240	1.0092	1.00429	22.03
	Apr	.	21.68399	1.0092	1.00468	21.99
	May	.	21.63557	1.0092	1.01076	22.07
	Jun	.	21.58716	1.0092	1.01468	22.11
	Jul	.	21.53874	1.0092	1.01686	22.10
	Aug	.	21.49033	1.0092	1.00888	21.88
	Sep	.	21.44192	1.0092	0.99433	21.52
	Oct	.	21.39350	1.0092	0.99345	21.45
	Nov	.	21.34509	1.0092	0.99970	21.54
	Dec	.	21.29667	1.0092	0.99033	21.29
2024	Jan	.	21.24826	1.0092	0.97608	20.93
	Feb	.	21.19984	1.0092	0.98597	21.10
	Mar	.	21.15143	1.0092	1.00429	21.44
	Apr	.	21.10302	1.0092	1.00468	21.40
	May	. .	21.05460	1.0092	1.01076	21.48.
	Jun	.	21.00619	1.0092	1.01468	21.51
	Jul	.	20.95777	1.0092	1.01686	21.51
	Aug	.	20.90936	1.0092	1.00888	21.29
	Sep	.	20.86094	1.0092	0.99433	20.93
	Oct	.	20.81253	1.0092	0.99345	20.87
	Nov	.	20.76412	1.0092	0.99970	20.95
	Dec	.	20.71570	1.0092	0.99033	20.70

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2025	Jan	.	20.66729	1.0092	0.97608	20.36
	Feb	.	20.61887	1.0092	0.98597	20.52
	Mar	.	20.57046	1.0092	1.00429	20.85
	Apr	.	20.52204	1.0092	1.00468	20.81
	May	.	20.47363	1.0092	1.01076	20.88
	Jun	.	20.42522	1.0092	1.01468	20.92
	Jul	.	20.37680	1.0092	1.01686	20.91
	Aug	.	20.32839	1.0092	1.00888	20.70
	Sep	.	20.27997	1.0092	0.99433	20.35
	Oct	.	20.23156	1.0092	0.99345	20.28
	Nov	.	20.18314	1.0092	0.99970	20.36
	Dec	.	20.13473	1.0092	0.99033	20.12
2026	Jan	.	20.08632	1.0092	0.97608	19.79
	Feb	.	20.03790	1.0092	0.98597	19.94
	Mar	.	19.98949	1.0092	1.00429	20.26
	Apr	.	19.94107	1.0092	1.00468	20.22
	May	.	19.89266	1.0092	1.01076	20.29
	Jun	.	19.84424	1.0092	1.01468	20.32
	Jul	.	19.79583	1.0092	1.01686	20.32
	Aug	.	19.74742	1.0092	1.00888	20.11
	Sep	.	19.69900	1.0092	0.99433	19.77
	Oct	.	19.65059	1.0092	0.99345	19.70
	Nov	.	19.60217	1.0092	0.99970	19.78
	Dec	.	19.55376	1.0092	0.99033	19.54

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2027	Jan	.	19.50534	1.0092	0.97608	19.21
	Feb	.	19.45693	1.0092	0.98597	19.36
	Mar	.	19.40852	1.0092	1.00429	19.67
	Apr	.	19.36010	1.0092	1.00468	19.63
	May	.	19.31169	1.0092	1.01076	19.70
	Jun	.	19.26327	1.0092	1.01468	19.73
	Jul	.	19.21486	1.0092	1.01686	19.72
	Aug	.	19.16644	1.0092	1.00888	19.51
	Sep	.	19.11803	1.0092	0.99433	19.18
	Oct	.	19.06962	1.0092	0.99345	19.12
	Nov	.	19.02120	1.0092	0.99970	19.19
	Dec	.	18.97279	1.0092	0.99033	18.96

APPENDIX E TO FIND THE FOUR PARTS ARE TREND SEASONALITY, CYCLES, IRREGULAR INDEX AND FORECASTING THE BIODIESEL PRICE OF THAILAND IN THE NEXT FIVE YEARS, FROM 2028 TO 2032

1. The results of the trend component

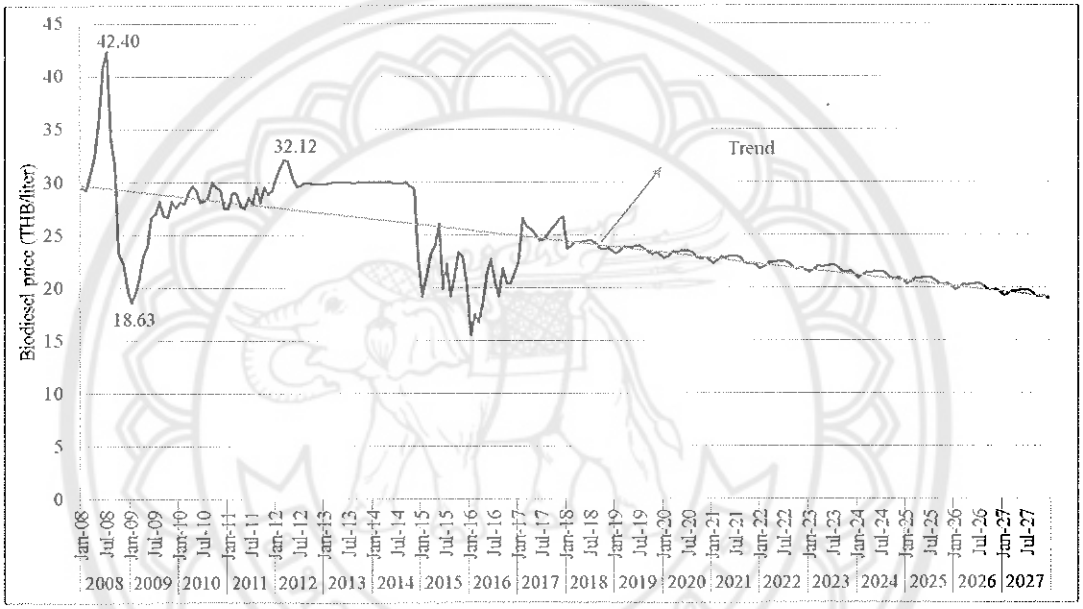

Figure 26 The results of the trend component

The trend of biodiesel price in oil market of Thailand from January 2008 to December 2027.

2. The results of a seasonal index

Month	Seasonal index (%)
Jan	97.4
Feb	98.4
Mar	100.3
Apr	100.4
May	101.0
Jun	101.4

Month	Seasonal index (%)
Jul	101.7
Aug	101.0
Sep	99.5
Oct	99.5
Nov	100.1
Dec	99.2

From the seasonal index in the above, the influence of the season in the month Jan, Feb, Sep, Oct, and Dec leads to the biodiesel price decrease that below the average 2.6%, 1.6%, 0.5%, 0.5% and 0.8% consecutively. In the dominant part of the season in month Mar, Apr, May, Jun, Jul, Aug, and Nov it would lead the biodiesel price increase that's higher than the average number of 0.3%, 0.4%, 1.0%, 1.๓%, 1.7% 1.0% and 0.1%, respectively.

3. To find the appropriate trend equation

The format of trend equation that is appropriate for the biodiesel price from January 2008 to December 2027.

Equation model	**The trend equation**	**R^2**
1. Linear	$\hat{Y} = 31.534 - 0.062(t)$	0.769
2. Exponential	$\hat{Y} = 32.44 - 0.003(t)$	0.754
3. Quadratic	$\hat{Y} = 29.531 - 0.012(t) + 0.00(t^2)$	0.737

As we can see in the above table, the most appropriate trend equation is the linear equation because it has the highest R^2.

Therefore, the linear trend function as

$$\hat{Y} = a + b\,(t)$$

Where

$a = 31.534$, $b = -0.062$

t = mounts (initial on Jan,2008)

Therefore, the linear trend equation is

$$\hat{Y} = 31.534 - 0.062\,(t)$$

4. Calculate the cyclical variation

The cyclical change index is conducted by eliminating the trend (T) out of the moving average (MA) by $\hat{C} = (T \times C)/\hat{T}$ and $\hat{C}$ that was computed from the Figure 24 will be in the range of 0.80 to 1.50. It will be shown in the figure

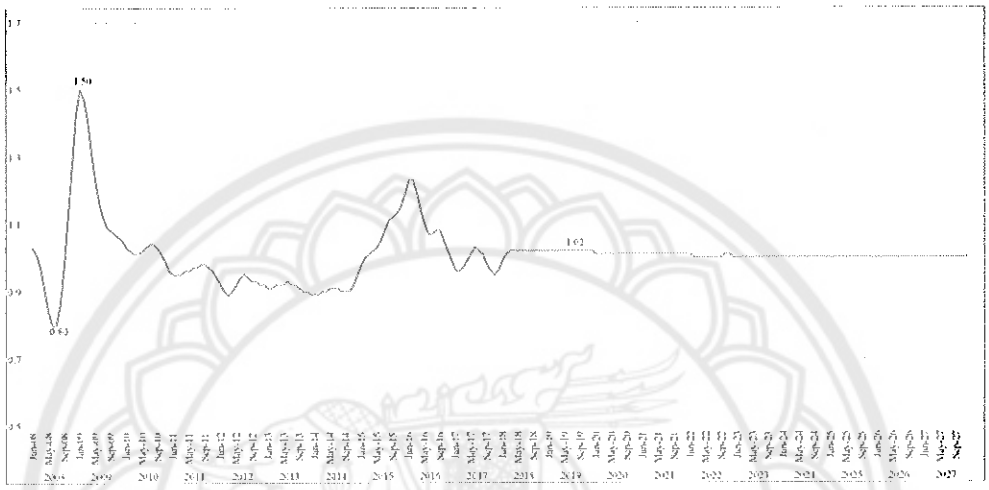

Figure 27 The cyclical change index of biodiesel price in oil market of Thailand from January 2008 to December 2027

6. Irregular index from January 2008 to December 2027

Month	Year									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Jan	1.019 55	0.954 71	1.012 31	1.014 66	1.014 2	1.009 15	1.011 09	0.974 33	0.961 76	1.029 16
Feb	0.985 44	0.980 26	0.989 73	1.004 89	1.010 28	1.005 67	1.004 3	1.001 3	0.976 81	1.020 3
Mar	0.977 24	0.984 84	0.998 34	0.992 82	1.011 66	0.994 54	0.993 49	1.017 59	1.003 83	0.989 33
Apr	0.971 81	1.012 33	1.021 56	1.000 44	1.020 65	1.000 37	1.000 51	0.973 56	0.983 74	1.003 07
May	0.988 34	0.979 85	1.009 4	0.999 6	0.992 34	0.999 49	1.000 6	1.011 58	1.017 34	0.997 73
Jun	1.061 09	1.029 15	0.979 67	0.999 67	0.979 77	0.998 25	0.997 62	1.024 44	1.030 65	0.986 56
Jul	1.099 42	1.000 35	0.991 34	1.005 81	0.991 14	0.995 38	0.993 08	0.996 17	1.008 94	0.983 94
Aug	0.970 23	1.030 08	1.011 19	1.003 52	0.999 6	0.995 06	0.996 94	0.963 42	0.975 81	0.995 03
Sep	1.021 94	0.990 19	0.992	0.971 66	1.008 7	1.006 86	1.012 24	1.002 59	0.982 59	1.005 72
Oct	0.984 73	0.980 11	0.981 15	1.021 07	1.001 61	1.003 39	1.009 42	1.017 85	1.014 36	1.003 19
Nov	0.951 97	1.015 59	1.002 16	0.984 06	0.992 81	0.993 33	1.017 35	1.022 97	0.973 37	1.011 87
Dec	0.949 3	0.993 26	1.010 16	0.980 93	0.998 32	0.998 91	0.996 17	0.993 16	1.004 98	1.042 59

Month	Year									
	2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Jan	0.967 41	1.001 55	1.001 7	1.001 65	1.001 5	1.003 39	0.999 62	0.999 84	0.999 96	0.999 68
Feb	0.988 1	1.000 57	1.000 54	1.000 75	1.000 67	1.001 01	1.000 03	1.000 01	0.999 94	0.999 98
Mar	0.999 99	1.000 26	1.000 2	1.000 05	1.000 24	1.000 1	0.999 96	0.999 98	0.999 95	0.999 97
Apr	1.000 26	1.000 12	1.000 07	0.999 96	1.000 16	1.000 05	1.000 0	1.000 04	1.000 03	0.999 97
May	1.000 09	1.000 06	1.000 07	1.000 08	1.000 04	0.999 95	1.000 07	0.999 82	0.999 94	1.000 00
Jun	0.999 75	0.999 79	0.999 83	0.999 87	0.999 57	1.000 15	0.999 9	1.000 17	0.999 91	1.000 14
Jul	0.999 24	0.999 29	0.999 33	0.999 38	0.999 53	0.999 87	1.000 12	0.999 95	1.000 16	1.000 11
Aug	1.002 12	1.002 08	1.002 03	1.001 98	1.001 98	0.999 82	0.999 89	0.999 96	0.999 93	0.999 72
Sep	0.999 72	0.999 73	0.999 74	0.999 81	0.999 82	1.000 11	0.999 84	1.000 04	1.000 03	0.999 9
Oct	0.998 93	0.998 9	0.998 81	0.998 87	0.998 83	1.000 0	1.000 24	0.999 99	0.999 96	1.000 21
Nov	0.999 22	0.999 29	0.999 26	0.999 09	0.998 64	1.000 15	1.000 12	1.000 05	1.000 24	0.999 99
Dec	0.998 41	0.998 3	0.998 43	0.998 52	0.996 91	1.000 3	1.000 02	1.000 1	1.000 13	0.998 59

Before forecasting the biodiesel price of Thailand in the next five years, from 2028 to 2032, we can consider the accuracy of the predictive value is close to the true value between 2008 to 2027.

7. Comparison of the predictive value and true value in the biodiesel price of Thailand, from 2008 to 2027

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2008	Jan	29.43	30.48557	1.03	0.97633	30.66
	Feb	29.29	30.43803	1.01	0.98622	30.32
	Mar	30.71	30.39050	0.97	1.00451	29.61
	Apr	32.49	30.34297	0.91	1.00486	27.75
	May	36.02	30.29543	0.84	1.01084	25.72
	Jun	40.92	30.24790	0.80	1.01474	24.56
	Jul	42.40	30.20036	0.80	1.01685	24.57
	Aug	34.37	30.15283	0.86	1.00897	26.16
	Sep	31.65	30.10530	0.97	0.99417	29.03
	Oct	23.22	30.05776	1.12	0.99313	33.43
	Nov	22.22	30.01023	1.28	0.99939	38.39
	Dec	19.69	29.96270	1.43	0.98998	42.42
2009	Jan	18.63	29.91516	1.50	0.97633	43.81
	Feb	19.59	29.86763	1.47	0.98622	43.30
	Mar	20.99	29.82010	1.41	1.00451	42.24
	Apr	23.05	29.77256	1.31	1.00486	39.19
	May	23.84	29.72503	1.23	1.01084	36.96
	Jun	26.68	29.67749	1.16	1.01474	34.93
	Jul	26.96	29.62996	1.12	1.01685	33.74
	Aug	28.17	29.58243	1.09	1.00897	32.53
	Sep	26.83	29.53489	1.08	0.99417	31.71
	Oct	26.70	29.48736	1.07	0.99313	31.33
	Nov	28.19	29.43983	1.06	0.99939	31.19
	Dec	27.63	29.39229	1.05	0.98998	30.55

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2010	Jan	28.09	29.34476	1.03	0.97633	29.51
	Feb	27.93	29.29722	1.02	0.98622	29.47
	Mar	28.94	29.24969	1.01	1.00451	29.68
	Apr	29.64	29.20216	1.01	1.00486	29.64
	May	29.20	29.15462	1.02	1.01084	30.06
	Jun	28.07	29.10709	1.03	1.01474	30.42
	Jul	28.24	29.05956	1.04	1.01685	30.73
	Aug	28.58	29.01202	1.04	1.00897	30.44
	Sep	29.99	28.96449	1.03	0.99417	29.66
	Oct	29.50	28.91696	1.01	0.99313	29.01
	Nov	29.26	28.86942	0.99	0.99939	28.56
	Dec	27.50	28.82189	0.96	0.98998	27.39
2011	Jan	27.56	28.77435	0.95	0.97633	26.69
	Feb	28.95	28.72682	0.95	0.98622	26.91
	Mar	28.96	28.67929	0.95	1.00451	27.37
	Apr	27.65	28.63175	0.96	1.00486	27.62
	May	27.50	28.58422	0.96	1.01084	27.74
	Jun	28.50	28.53669	0.97	1.01474	28.09
	Jul	27.85	28.48915	0.97	1.01685	28.10
	Aug	29.51	28.44162	0.98	1.00897	28.12
	Sep	27.99	28.39408	0.98	0.99417	27.66
	Oct	29.51	28.34655	0.97	0.99313	27.31
	Nov	28.88	28.29902	0.96	0.99939	27.15
	Dec	29.12	28.25148	0.94	0.98998	26.29

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2012	Jan	30.45	28.20395	0.92	0.97633	25.33
	Feb	31.31	28.15642	0.90	0.98622	24.99
	Mar	32.12	28.10888	0.89	1.00451	25.13
	Apr	31.99	28.06135	0.90	1.00486	25.38
	May	30.51	28.01382	0.92	1.01084	26.05
	Jun	29.58	27.96628	0.94	1.01474	26.68
	Jul	29.74	27.91875	0.95	1.01685	26.97
	Aug	29.89	27.87121	0.94	1.00897	26.43
	Sep	29.93	27.82368	0.93	0.99417	25.73
	Oct	29.79	27.77615	0.93	0.99313	25.65
	Nov	29.79	27.72861	0.92	0.99939	25.49
	Dec	29.79	27.68108	0.92	0.98998	25.21
2013	Jan	29.79	27.63355	0.91	0.97633	24.55
	Feb	29.95	27.58601	0.91	0.98622	24.76
	Mar	29.99	27.53848	0.92	1.00451	25.45
	Apr	29.99	27.49094	0.92	1.00486	25.41
	May	29.99	27.44341	0.92	1.01084	25.52
	Jun	29.99	27.39588	0.93	1.01474	25.85
	Jul	29.99	27.34834	0.92	1.01685	25.58
	Aug	29.89	27.30081	0.92	1.00897	25.34
	Sep	29.99	27.25328	0.91	0.99417	24.66
	Oct	29.99	27.20574	0.90	0.99313	24.32
	Nov	29.99	27.15821	0.90	0.99939	24.43
	Dec	29.99	27.11068	0.89	0.98998	23.89

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2014	Jan	29.99	27.06314	0.89	0.97633	23.52
	Feb	29.99	27.01561	0.89	0.98622	23.71
	Mar	29.99	26.96807	0.90	1.00451	24.38
	Apr	29.99	26.92054	0.90	1.00486	24.35
	May	29.99	26.87301	0.91	1.01084	24.72
	Jun	29.91	26.82547	0.91	1.01474	24.77
	Jul	29.85	26.77794	0.91	1.01685	24.78
	Aug	29.86	26.73041	0.90	1.00897	24.27
	Sep	29.99	26.68287	0.90	0.99417	23.87
	Oct	29.66	26.63534	0.90	0.99313	23.81
	Nov	29.42	26.5878	0.92	0.99939	24.45
	Dec	22.60	26.54027	0.95	0.98998	24.96
2015	Jan	19.20	26.49274	0.98	0.97633	25.35
	Feb	21.20	26.44520	1.00	0.98622	26.08
	Mar	23.25	26.39767	1.01	1.00451	26.78
	Apr	24.00	26.35014	1.02	1.00486	27.01
	May	26.07	26.30260	1.03	1.01084	27.39
	Jun	19.90	26.25507	1.05	1.01474	27.97
	Jul	22.22	26.20754	1.08	1.01685	28.78
	Aug	19.20	26.16000	1.11	1.00897	29.30
	Sep	21.10	26.11247	1.12	0.99417	29.08
	Oct	23.31	26.06493	1.13	0.99313	29.25
	Nov	23.06	26.01740	1.15	0.99939	29.90
	Dec	20.75	25.96987	1.19	0.98998	30.59

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2016	Jan	15.60	25.92233	1.23	0.97633	31.13
	Feb	17.50	25.87480	1.23	0.98622	31.39
	Mar	16.75	25.82727	1.19	1.00451	30.87
	Apr	18.50	25.77973	1.14	1.00486	29.53
	May	21.32	25.73220	1.10	1.01084	28.61
	Jun	22.65	25.68466	1.07	1.01474	27.89
	Jul	20.65	25.63713	1.07	1.01685	27.89
	Aug	19.20	25.58960	1.08	1.00897	27.88
	Sep	21.80	25.54206	1.08	0.99417	27.42
	Oct	20.45	25.49453	1.05	0.99313	26.59
	Nov	20.43	25.44700	1.02	0.99939	25.94
	Dec	21.43	25.39946	0.99	0.98998	24.89
2017	Jan	22.43	25.35193	0.96	0.97633	23.76
	Feb	26.57	25.30440	0.96	0.98622	23.96
	Mar	25.80	25.25686	0.97	1.00451	24.61
	Apr	25.57	25.20933	0.99	1.00486	25.08
	May	25.02	25.16179	1.01	1.01084	25.69
	Jun	24.52	25.11426	1.03	1.01474	26.25
	Jul	24.52	25.06673	1.02	1.01685	26.00
	Aug	24.99	25.01919	1.01	1.00897	25.50
	Sep	25.46	24.97166	0.98	0.99417	24.33
	Oct	25.93	24.92413	0.96	0.99313	23.76
	Nov	26.46	24.87659	0.95	0.99939	23.62
	Dec	26.70	24.82906	0.96	0.98998	23.60

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2018	Jan	23.72	24.78152	0.99	0.97633	23.95
	Feb	23.92	24.73399	1.01	0.98622	24.64
	Mar	24.32	24.68646	1.02	1.00451	25.29
	Apr	24.29	24.63892	1.02	1.00486	25.25
	May	24.38	24.59139	1.02	1.01084	25.36
	Jun	24.42	24.54386	1.02	1.01474	25.40
	Jul	24.41	24.49632	1.02	1.01685	25.41
	Aug	24.24	24.44879	1.02	1.00897	25.16
	Sep	23.76	24.40126	1.02	0.99417	24.74
	Oct	23.65	24.35372	1.02	0.99313	24.67
	Nov	23.76	24.30619	1.02	0.99939	24.78
	Dec	23.50	24.25865	1.02	0.98998	24.50
2019	Jan	23.25	24.21112	1.02	0.97633	24.11
	Feb	23.45	24.16359	1.02	0.98622	24.31
	Mar	23.85	24.11605	1.02	1.00451	24.71
	Apr	23.81	24.06852	1.02	1.00486	24.67
	May	23.90	24.02099	1.02	1.01084	24.77
	Jun	23.94	23.97345	1.02	1.01474	24.81
	Jul	23.93	23.92592	1.02	1.01685	24.82
	Aug	23.76	23.87838	1.02	1.00897	24.57
	Sep	23.29	23.83085	1.02	0.99417	24.17
	Oct	23.18	23.78332	1.02	0.99313	24.09
	Nov	23.29	23.73578	1.02	0.99939	24.20
	Dec	23.03	23.68825	1.02	0.98998	23.92

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2020	Jan	22.79	23.64072	1.01	0.97633	23.31
	Feb	22.98	23.59318	1.01	0.98622	23.50
	Mar	23.37	23.54565	1.01	1.00451	23.89
	Apr	23.33	23.49812	1.01	1.00486	23.85
	May	23.42	23.45058	1.01	1.01084	23.94
	Jun	23.46	23.40305	1.01	1.01474	23.99
	Jul	23.45	23.35551	1.01	1.01685	23.99
	Aug	23.28	23.30798	1.01	1.00897	23.75
	Sep	22.82	23.26045	1.01	0.99417	23.36
	Oct	22.71	23.21291	1.01	0.99313	23.28
	Nov	22.82	23.16538	1.01	0.99939	23.38
	Dec	22.57	23.11785	1.01	0.98998	23.12
2021	Jan	22.33	23.07031	1.01	0.97633	22.75
	Feb	22.52	23.02278	1.01	0.98622	22.93
	Mar	22.89	22.97524	1.01	1.00451	23.31
	Apr	22.85	22.92771	1.01	1.00486	23.27
	May	22.94	22.88018	1.01	1.01084	23.36
	Jun	22.98	22.83264	1.01	1.01474	23.40
	Jul	22.97	22.78511	1.01	1.01685	23.40
	Aug	22.80	22.73758	1.01	1.00897	23.17
	Sep	22.35	22.69004	1.01	0.99417	22.78
	Oct	22.24	22.64251	1.01	0.99313	22.71
	Nov	22.34	22.59498	1.01	0.99939	22.81
	Dec	22.10	22.54744	1.01	0.98998	22.54

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2022	Jan	21.86	22.49991	1.01	0.97633	22.19
	Feb	22.05	22.45237	1.00	0.98622	22.14
	Mar	22.42	22.40484	1.00	1.00451	22.51
	Apr	22.38	22.35731	1.00	1.00486	22.47
	May	22.46	22.30977	1.00	1.01084	22.55
	Jun	22.49	22.26224	1.00	1.01474	22.59
	Jul	22.49	22.21471	1.00	1.01685	22.59
	Aug	22.32	22.16717	1.00	1.00897	22.37
	Sep	21.88	22.11964	1.00	0.99417	21.99
	Oct	21.77	22.07210	1.01	0.99313	22.14
	Nov	21.87	22.02457	1.01	0.99939	22.23
	Dec	21.63	21.97704	1.00	0.98998	21.76
2023	Jan	21.50	21.92950	1.00	0.97633	21.41
	Feb	21.67	21.88197	1.00	0.98622	21.58
	Mar	22.03	21.83444	1.00	1.00451	21.93
	Apr	21.99	21.78690	1.00	1.00486	21.89
	May	22.07	21.73937	1.00	1.01084	21.98
	Jun	22.11	21.69184	1.00	1.01474	22.01
	Jul	22.10	21.64430	1.00	1.01685	22.01
	Aug	21.88	21.59677	1.00	1.00897	21.79
	Sep	21.52	21.54923	1.00	0.99417	21.42
	Oct	21.45	21.50170	1.00	0.99313	21.35
	Nov	21.54	21.45417	1.00	0.99939	21.44
	Dec	21.29	21.40663	1.00	0.98998	21.19

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2024	Jan	20.93	21.35910	1.00	0.97633	20.85
	Feb	21.10	21.31157	1.00	0.98622	21.02
	Mar	21.44	21.26403	1.00	1.00451	21.36
	Apr	21.40	21.21650	1.00	1.00486	21.32
	May	21.48	21.16896	1.00	1.01084	21.40
	Jun	21.51	21.12143	1.00	1.01474	21.43
	Jul	21.51	21.07390	1.00	1.01685	21.43
	Aug	21.29	21.02636	1.00	1.00897	21.21
	Sep	20.93	20.97883	1.00	0.99417	20.86
	Oct	20.87	20.93130	1.00	0.99313	20.79
	Nov	20.95	20.88376	1.00	0.99939	20.87
	Dec	20.70	20.83623	1.00	0.98998	20.63
2025	Jan	20.36	20.78870	1.00	0.97633	20.30
	Feb	20.52	20.74116	1.00	0.98622	20.46
	Mar	20.85	20.69363	1.00	1.00451	20.79
	Apr	20.81	20.64609	1.00	1.00486	20.75
	May	20.88	20.59856	1.00	1.01084	20.82
	Jun	20.92	20.55103	1.00	1.01474	20.85
	Jul	20.91	20.50349	1.00	1.01685	20.85
	Aug	20.70	20.45596	1.00	1.00897	20.64
	Sep	20.35	20.40843	1.00	0.99417	20.29
	Oct	20.28	20.36089	1.00	0.99313	20.22
	Nov	20.36	20.31336	1.00	0.99939	20.30
	Dec	20.12	20.26582	1.00	0.98998	20.06

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\widehat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2026	Jan	19.79	20.21829	1.00	0.97633	19.74
	Feb	19.94	20.17076	1.00	0.98622	19.89
	Mar	20.26	20.12322	1.00	1.00451	20.21
	Apr	20.22	20.07569	1.00	1.00486	20.17
	May	20.29	20.02816	1.00	1.01084	20.25
	Jun	20.32	19.98062	1.00	1.01474	20.28
	Jul	20.32	19.93309	1.00	1.01685	20.27
	Aug	20.11	19.88556	1.00	1.00897	20.06
	Sep	19.77	19.83802	1.00	0.99417	19.72
	Oct	19.70	19.79049	1.00	0.99313	19.65
	Nov	19.78	19.74295	1.00	0.99939	19.73
	Dec	19.54	19.69542	1.00	0.98998	19.50
2027	Jan	19.21	19.64789	1.00	0.97633	19.18
	Feb	19.36	19.60035	1.00	0.98622	19.33
	Mar	19.67	19.55282	1.00	1.00451	19.64
	Apr	19.63	19.50529	1.00	1.00486	19.60
	May	19.70	19.45775	1.00	1.01084	19.67
	Jun	19.73	19.41022	1.00	1.01474	19.70
	Jul	19.72	19.36268	1.00	1.01685	19.69
	Aug	19.51	19.31515	1.00	1.00897	19.49
	Sep	19.18	19.26762	1.00	0.99417	19.16
	Oct	19.12	19.22008	1.00	0.99313	19.09
	Nov	19.19	19.17255	1.00	0.99939	19.16
	Dec	18.96	19.12502	1.00	0.98998	18.93

8. Forecasting the biodiesel price of Thailand in the next five years, from 2028 to 2032

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2028	Jan	.	19.07748	1.00758	0.97633	18.77
	Feb	.	19.02995	1.00758	0.98622	18.91
	Mar	.	18.98242	1.00758	1.00451	19.21
	Apr	.	18.93488	1.00758	1.00486	19.17
	May	.	18.88735	1.00758	1.01084	19.24
	Jun	.	18.83981	1.00758	1.01474	19.26
	Jul	.	18.79228	1.00758	1.01685	19.25
	Aug	.	18.74475	1.00758	1.00897	19.06
	Sep	.	18.69721	1.00758	0.99417	18.73
	Oct	.	18.64968	1.00758	0.99313	18.66
	Nov	.	18.60215	1.00758	0.99939	18.73
	Dec	.	18.55461	1.00758	0.98998	18.51
2029	Jan	.	18.50708	1.00758	0.97633	18.21
	Feb	.	18.45954	1.00758	0.98622	18.34
	Mar	.	18.41201	1.00758	1.00451	18.64
	Apr	.	18.36448	1.00758	1.00486	18.59
	May	.	18.31694.	1.00758	1.01084	18.66
	Jun	.	18.26941	1.00758	1.01474	18.68
	Jul	.	18.22188	1.00758	1.01685	18.67
	Aug	.	18.17434	1.00758	1.00897	18.48
	Sep	.	18.12681	1.00758	0.99417	18.16
	Oct	.	18.07928	1.00758	0.99313	18.09
	Nov	.	18.03174	1.00758	0.99939	18.16
	Dec	.	17.98421	1.00758	0.98998	17.94

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2030	Jan	.	17.93667	1.00758	0.97633	17.64
	Feb	.	17.88914	1.00758	0.98622	17.78
	Mar	.	17.84161	1.00758	1.00451	18.06
	Apr	.	17.79407	1.00758	1.00486	18.02
	May	.	17.74654	1.00758	1.01084	18.07
	Jun	.	17.69901	1.00758	1.01474	18.10
	Jul	.	17.65147	1.00758	1.01685	18.09
	Aug	.	17.60394	1.00758	1.00897	17.90
	Sep	.	17.55640	1.00758	0.99417	17.59
	Oct	.	17.50887	1.00758	0.99313	17.52
	Nov	.	17.46134	1.00758	0.99939	17.58
	Dec	.	17.41380	1.00758	0.98998	17.37
2031	Jan	.	17.36627	1.00758	0.97633	17.08
	Feb	.	17.31874	1.00758	0.98622	17.21
	Mar	.	17.27120	1.00758	1.00451	17.48
	Apr	.	17.22367	1.00758	1.00486	17.44
	May	.	17.17614	1.00758	1.01084	17.49
	Jun	.	17.12860	1.00758	1.01474	17.51
	Jul	.	17.08107	1.00758	1.01685	17.50
	Aug	.	17.03353	1.00758	1.00897	17.32
	Sep	.	16.98600	1.00758	0.99417	17.02
	Oct	.	16.93847	1.00758	0.99313	16.95
	Nov	.	16.89093	1.00758	0.99939	17.01
	Dec	.	16.84340	1.00758	0.98998	16.80

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2032	Jan	.	16.79587	1.00758	0.97633	16.52
	Feb	.	16.74833	1.00758	0.98622	16.64
	Mar	.	16.70080	1.00758	1.00451	16.90
	Apr	.	16.65326	1.00758	1.00486	16.86
	May	.	16.60573	1.00758	1.01084	16.91
	Jun	.	16.55820	1.00758	1.01474	16.93
	Jul	.	16.51066	1.00758	1.01685	16.92
	Aug	.	16.46313	1.00758	1.00897	16.74
	Sep	.	16.41560	1.00758	0.99417	16.44
	Oct	.	16.36806	1.00758	0.99313	16.38
	Nov	.	16.32053	1.00758	0.99939	16.43
	Dec	.	16.27300	1.00758	0.98998	16.23

APPENDIX F TO FIND THE FOUR PARTS ARE TREND SEASONALITY, CYCLES, IRREGULAR INDEX AND FORECASTING THE BIODIESEL PRICE OF THAILAND IN THE NEXT FOUR YEARS, FROM 2033 TO 2036

1. The results of the trend component

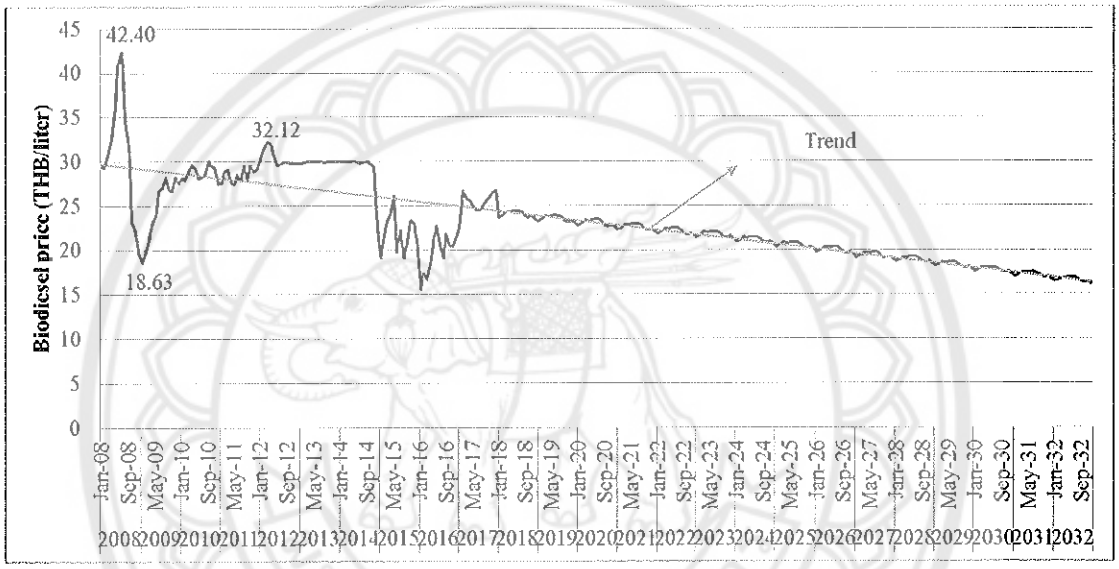

Figure 28 The results of the trend component

The trend of biodiesel price in oil market of Thailand from January 2008 to December 2032.

1. The results of a seasonal index

Month	Seasonal index (%)
Jan	97.6
Feb	98.6
Mar	100.5
Apr	100.5
May	101.1
Jun	101.5
Jul	101.7

Month	Seasonal index (%)
Aug	100.9
Sep	99.4
Oct	99.3
Nov	99.9
Dec	99.0

From the seasonal index in the above, the influence of the season in the month Jan, Feb, Sep, Oct, Nov, and Dec leads to the biodiesel price decrease that below the average 2.4%, 1.4%, 0.6%, 0.7%,0.1% and 1.0% consecutively. In the dominant part of the season in month Mar, Apr, May, Jun, Jul, and Aug it would lead the biodiesel price increase that's higher than the average number of 0.5%, 0.5%, 1.1%, 1.5%, 1.7%, and 0.9%, respectively.

2. To find the appropriate trend equation

The format of trend equation that is appropriate for the biodiesel price from January 2008 to December 2027.

Equation model	**The trend equation**	**R^2**
1. Linear	$\hat{Y} = 30.495 - 0.047(t)$	0.817
2. Exponential	$\hat{Y} = 31.066 - 0.022(t)$	0.778
3. Quadratic	$\hat{Y} = 30.096 - 0.045(t) + 0.00(t^2)$	0.778

As we can see in the above table, the most appropriate trend equation is the linear equation because it has the highest R^2.

Therefore, the linear trend function as

$$\hat{Y} = a + b\,(t)$$

Where

$a = 30.495$, $b = -0.047$

t = mounts (initial on Jan,2008)

Therefore, the linear trend equation is

$$\hat{Y} = 30.495 - 0.047\,(t)$$

3. Calculate the cyclical variation

The cyclical change index is conducted by eliminating the trend (T) out of the moving average (MA) by $\hat{C} = (T \times C)/\hat{T}$ and $\hat{C}$ that was computed from the Figure 25 will be in the range of 0.80 to 1.50. It will be shown in the figure

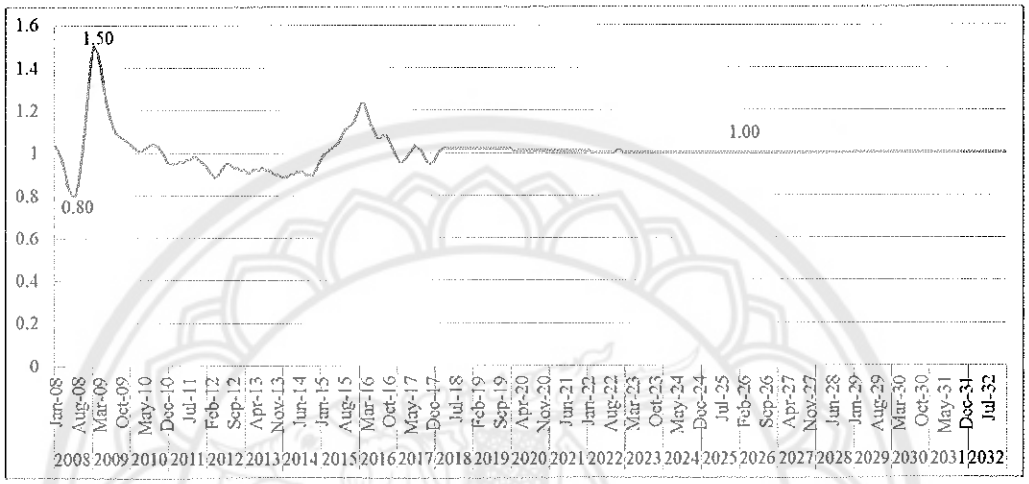

Figure 29 The cyclical change index of biodiesel price in oil market of Thailand from January 2008 to December 2032

5. Irregular index from January 2008 to December 2032

Month	Year									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Jan	1.019 55	0.954 63	1.012 22	1.014 58	1.014 12	1.009 06	1.011 01	0.974 25	0.961 68	1.029 08
Feb	0.985 43	0.980 23	0.989 69	1.004 86	1.010 25	1.005 63	1.004 27	1.001 26	0.976 77	1.020 26
Mar	0.977 23	0.984 83	0.998 33	0.992 82	1.011 66	0.994 53	0.993 48	1.017 58	1.003 82	0.989 32
Apr	0.971 81	1.012 32	1.021 56	1.000 44	1.020 64	1.000 36	1.000 51	0.973 56	0.983 74	1.003 07
May	0.988 35	0.979 86	1.009 41	0.999 61	0.992 35	0.999 5	1.000 61	1.011 59	1.017 35	0.997 74
Jun	1.061 09	1.029 15	0.979 67	0.999 67	0.979 77	0.998 25	0.997 62	1.024 44	1.030 65	0.986 57
Jul	1.099 41	1.000 34	0.991 33	1.005 8	0.991 13	0.995 37	0.993 07	0.996 16	1.008 93	0.983 93
Aug	0.970 23	1.030 08	1.011 18	1.003 52	0.999 6	0.995 05	0.996 94	0.963 42	0.975 8	0.995 03
Sep	1.021 94	0.990 19	0.991 99	0.971 66	1.008 7	1.006 86	1.012 23	1.002 59	0.982 59	1.005 72
Oct	0.984 75	0.980 12	0.981 16	1.021 08	1.001 62	1.003 4	1.009 43	1.017 86	1.014 37	1.003 2
Nov	0.952	1.015 62	1.002 19	0.984 09	0.992 84	0.993 36	1.017 38	1.023	0.973 4	1.011 9
Dec	0.949 38	0.993 35	1.010 25	0.981 03	0.998 41	0.999	0.996 26	0.993 25	1.005 07	1.042 68

Month	Year									
	2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Jan	0.967 32	1.001 47	1.001 62	1.001 57	1.001 42	1.003 3	0.999 53	0.999 75	0.999 87	0.999 6
Feb	0.988 07	1.000 53	1.000 5	1.000 71	1.000 64	1.000 98	0.999 99	0.999 98	0.999 91	0.999 94
Mar	0.999 98	1.000 25	1.000 2	1.000 04	1.000 23	1.000 09	0.999 95	0.999 97	0.999 94	0.999 96
Apr	1.000 26	1.000 12	1.000 06	0.999 96	1.000 15	1.000 05	0.999 99	1.000 04	1.000 03	0.999 97
May	1.000 1	1.000 07	1.000 08	1.000 09	1.000 05	0.999 96	1.000 08	0.999 83	0.999 95	1.000 02
Jun	0.999 75	0.999 79	0.999 83	0.999 87	0.999 57	1.000 15	0.999 91	1.000 18	0.999 91	1.000 14
Jul	0.999 23	0.999 28	0.999 32	0.999 37	0.999 52	0.999 86	1.000 11	0.999 95	1.000 16	1.000 1
Aug	1.002 12	1.002 08	1.002 03	1.001 98	1.001 98	0.999 82	0.999 89	0.999 96	0.999 93	0.999 72
Sep	0.999 72	0.999 73	0.999 74	0.999 8	0.999 82	1.000 11	0.999 84	1.000 04	1.000 02	0.999 89
Oct	0.998 94	0.998 91	0.998 82	0.998 88	0.998 84	1.000 01	1.000 25	1.000 0	0.999 97	1.000 22
Nov	0.999 25	0.999 32	0.999 29	0.999 12	0.998 68	1.000 18	1.000 16	1.000 08	1.000 28	0.999 37
Dec	0.998 5	0.998 39	0.998 52	0.998 61	0.997	1.000 39	1.000 1	1.000 19	1.000 22	0.997 95

Month	Year				
	2028	**2029**	**2030**	**2031**	**2032**
Jan	1.00207	1.00005	0.99964	0.99978	0.99987
Feb	1.00066	0.99976	1.00011	1.00003	0.99995
Mar	0.99988	1.00019	1.00004	0.99999	0.99995
Apr	0.99996	0.99977	1.00013	1.00012	1.00005
May	1.0002	1.00016	0.99969	0.99989	0.9999
Jun	0.99991	0.99997	1.0001	0.99992	0.99999
Jul	0.99982	0.99992	1.00009	0.99996	1.00014
Aug	1.00019	1.0001	1.0000	1.00008	1.00011
Sep	1.00004	1.00003	1.00008	1.00014	0.99979
Oct	0.99991	0.99988	0.99996	0.99992	1.00015
Nov	0.99994	1.00015	0.99993	1.00009	0.99985
Dec	1.00016	1.00014	1.00017	1.00008	0.99854

Before forecasting the biodiesel price of Thailand in the next four years, from 2033 to 2036, we can consider the accuracy of the predictive value is close to the true value between 2008 to 2032.

6. Comparison of the predictive value and true value in the biodiesel price of Thailand, during 2008 to 2032

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2008	Jan	29.43	30.44833	1.03	0.97645	30.62
	Feb	29.29	30.40123	1.01	0.98632	30.29
	Mar	30.71	30.35412	0.97	1.0046	29.58
	Apr	32.49	30.30701	0.91	1.00493	27.72
	May	36.02	30.25991	0.84	1.01087	25.69
	Jun	40.92	30.21280	0.80	1.01475	24.53
	Jul	42.40	30.16570	0.80	1.01685	24.54
	Aug	34.37	30.11859	0.86	1.00895	26.13
	Sep	31.65	30.07149	0.97	0.99412	29.00
	Oct	26.22	30.02438	1.12	0.99304	33.39
	Nov	22.22	29.97728	1.28	0.99927	38.34
	Dec	19.69	29.93017	1.43	0.98985	42.37
2009	Jan	18.63	29.88307	1.50	0.97645	43.77
	Feb	19.59	29.83596	1.47	0.98632	43.26
	Mar	20.99	29.78885	1.40	1.0046	41.90
	Apr	23.05	29.74175	1.31	1.00493	39.15
	May	23.84	29.69464	1.23	1.01087	36.92
	Jun	26.68	29.64754	1.16	1.01475	34.90
	Jul	26.96	29.60043	1.12	1.01685	33.71
	Aug	28.17	29.55333	1.09	1.00895	32.50
	Sep	26.83	29.50622	1.08	0.99412	31.68
	Oct	26.70	29.45912	1.07	0.99304	31.30
	Nov	28.19	29.41201	1.06	0.99927	31.15
	Dec	27.63	29.36491	1.05	0.98985	30.52

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2010	Jan	28.09	29.36491	1.05	0.98985	30.52
	Feb	27.93	29.31780	1.03	0.97645	29.49
	Mar	28.94	29.27069	1.02	0.98632	29.45
	Apr	29.64	29.22359	1.01	1.00460	29.65
	May	29.20	29.17648	1.01	1.00493	29.61
	Jun	28.07	29.12938	1.02	1.01087	30.03
	Jul	28.24	29.08227	1.03	1.01475	30.40
	Aug	28.58	29.03517	1.04	1.01685	30.71
	Sep	29.99	28.98806	1.03	1.00895	30.12
	Oct	29.50	28.94096	1.03	0.99412	29.63
	Nov	29.26	28.89385	1.01	0.99304	28.98
	Dec	27.50	28.84675	0.99	0.99927	28.54
2011	Jan	27.56	28.79964	0.96	0.98985	27.37
	Feb	28.95	28.75253	0.95	0.97645	26.67
	Mar	28.96	28.70543	0.95	0.98632	26.90
	Apr	27.65	28.65832	0.95	1.00460	27.35
	May	27.50	28.61122	0.96	1.00493	27.60
	Jun	28.50	28.56411	0.96	1.01087	27.72
	Jul	27.85	28.51701	0.96	1.01475	27.78
	Aug	29.51	28.46990	0.97	1.01685	28.08
	Sep	27.99	28.42280	0.98	1.00895	28.10
	Oct	29.51	28.37569	0.98	0.99412	27.64
	Nov	28.88	28.32859	0.97	0.99304	27.29
	Dec	29.12	28.28148	0.96	0.99927	27.13

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2012	Jan	30.45	28.18727	0.92	0.97645	25.32
	Feb	31.31	28.14016	0.90	0.98632	24.98
	Mar	32.12	28.09306	0.89	1.0046	25.12
	Apr	31.99	28.04595	0.90	1.00493	25.37
	May	30.51	27.99885	0.92	1.01087	26.04
	Jun	29.58	27.95174	0.94	1.01475	26.66
	Jul	29.74	27.90464	0.95	1.01685	26.96
	Aug	29.89	27.85753	0.94	1.00895	26.42
	Sep	29.93	27.81043	0.93	0.99412	25.71
	Oct	29.79	27.76332	0.93	0.99304	25.64
	Nov	29.79	27.71621	0.92	0.99927	25.48
	Dec	29.79	27.66911	0.92	0.98985	25.20
2013	Jan	29.79	27.62200	0.91	0.97645	24.54
	Feb	29.95	27.57490	0.91	0.98632	24.75
	Mar	29.99	27.52779	0.92	1.0046	25.44
	Apr	29.99	27.48069	0.92	1.00493	25.41
	May	29.99	27.43358	0.92	1.01087	25.51
	Jun	29.99	27.38648	0.93	1.01475	25.85
	Jul	29.99	27.33937	0.92	1.01685	25.58
	Aug	29.89	27.29227	0.92	1.00895	25.33
	Sep	29.99	27.24516	0.91	0.99412	24.65
	Oct	29.99	27.19805	0.90	0.99304	24.31
	Nov	29.99	27.15095	0.90	0.99927	24.42
	Dec	29.99	27.10384	0.89	0.98985	23.88

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2014	Jan	29.99	27.05674	0.89	0.97645	23.51
	Feb	29.99	27.00963	0.89	0.98632	23.71
	Mar	29.99	26.96253	0.90	1.00460	24.38
	Apr	29.99	26.91542	0.90	1.00493	24.34
	May	29.99	26.86832	0.91	1.01087	24.72
	Jun	29.91	26.82121	0.91	1.01475	24.77
	Jul	29.85	26.77411	0.91	1.01685	24.77
	Aug	29.86	26.72700	0.9	1.00895	24.27
	Sep	29.99	26.67989	0.9	0.99412	23.87
	Oct	29.66	26.63279	0.9	0.99304	23.80
	Nov	29.42	26.58568	0.92	0.99927	24.44
	Dec	22.60	26.53858	0.95	0.98985	24.96
2015	Jan	19.20	26.49147	0.98	0.97645	25.35
	Feb	21.20	26.44437	1.00	0.98632	26.08
	Mar	23.25	26.39726	1.01	1.00460	26.78
	Apr	24.00	26.35016	1.02	1.00493	27.01
	May	26.07	26.30305	1.03	1.01087	27.39
	Jun	19.90	26.25595	1.05	1.01475	27.98
	Jul	22.22	26.20884	1.08	1.01685	28.78
	Aug	19.20	26.16174	1.11	1.00895	29.30
	Sep	21.10	26.11463	1.12	0.99412	29.08
	Oct	23.31	26.06752	1.13	0.99304	29.25
	Nov	23.06	26.02042	1.15	0.99927	29.90
	Dec	20.75	25.97331	1.19	0.98985	30.59

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2016	Jan	15.60	25.92621	1.23	0.97645	31.14
	Feb	17.50	25.87910	1.23	0.98632	31.40
	Mar	16.75	25.83200	1.19	1.00460	30.88
	Apr	18.50	25.78489	1.14	1.00493	29.54
	May	21.32	25.73779	1.10	1.01087	28.62
	Jun	22.65	25.69068	1.07	1.01475	27.89
	Jul	20.65	25.64358	1.07	1.01685	27.90
	Aug	19.20	25.59647	1.08	1.00895	27.89
	Sep	21.80	25.54936	1.08	0.99412	27.43
	Oct	20.45	25.50226	1.05	0.99304	26.59
	Nov	20.43	25.45515	1.02	0.99927	25.95
	Dec	21.43	25.40805	0.99	0.98985	24.90
2017	Jan	22.43	25.36094	0.96	0.97645	23.77
	Feb	26.57	25.31384	0.96	0.98632	23.97
	Mar	25.80	25.26673	0.97	1.00460	24.62
	Apr	25.57	25.21963	0.99	1.00493	25.09
	May	25.02	25.17252	1.01	1.01087	25.70
	Jun	24.52	25.12542	1.03	1.01475	26.26
	Jul	24.52	25.07831	1.02	1.01685	26.01
	Aug	24.99	25.03120	1.01	1.00895	25.51
	Sep	25.46	24.98410	0.98	0.99412	24.34
	Oct	25.93	24.93699	0.96	0.99304	23.77
	Nov	26.46	24.88989	0.95	0.99927	23.63
	Dec	26.70	24.84278	0.96	0.98985	23.61

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2018	Jan	23.72	24.79568	0.99	0.97645	23.97
	Feb	23.92	24.74857	1.01	0.98632	24.65
	Mar	24.32	24.70147	1.02	1.00460	25.31
	Apr	24.29	24.65436	1.02	1.00493	25.27
	May	24.38	24.60726	1.02	1.01087	25.37
	Jun	24.42	24.56015	1.02	1.01475	25.42
	Jul	24.41	24.51304	1.02	1.01685	25.42
	Aug	24.24	24.46594	1.02	1.00895	25.18
	Sep	23.76	24.41883	1.02	0.99412	24.76
	Oct	23.65	24.37173	1.02	0.99304	24.69
	Nov	23.76	24.32462	1.02	0.99927	24.79
	Dec	23.5	24.27752	1.02	0.98985	24.51
2019	Jan	23.25	24.23041	1.02	0.97645	24.13
	Feb	23.45	24.18331	1.02	0.98632	24.33
	Mar	23.85	24.1362	1.02	1.00460	24.73
	Apr	23.81	24.0891	1.02	1.00493	24.69
	May	23.9	24.04199	1.02	1.01087	24.79
	Jun	23.94	23.99488	1.02	1.01475	24.84
	Jul	23.93	23.94778	1.02	1.01685	24.84
	Aug	23.76	23.90067	1.02	1.00895	24.60
	Sep	23.29	23.85357	1.02	0.99412	24.19
	Oct	23.18	23.80646	1.02	0.99304	24.11
	Nov	23.29	23.75936	1.02	0.99927	24.22
	Dec	23.03	23.71225	1.02	0.98985	23.94

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2020	Jan	22.79	23.66515	1.02	0.97645	23.57
	Feb	22.98	23.61804	1.01	0.98632	23.53
	Mar	23.37	23.57094	1.01	1.00460	23.92
	Apr	23.33	23.52383	1.01	1.00493	23.88
	May	23.42	23.47672	1.01	1.01087	23.97
	Jun	23.46	23.42962	1.01	1.01475	24.01
	Jul	23.45	23.38251	1.01	1.01685	24.01
	Aug	23.28	23.33541	1.01	1.00895	23.78
	Sep	22.82	23.28830	1.01	0.99412	23.38
	Oct	22.71	23.24120	1.02	0.99304	23.54
	Nov	22.82	23.19409	1.01	0.99927	23.41
	Dec	22.57	23.14699	1.01	0.98985	23.14
2021	Jan	22.33	23.09988	1.01	0.97645	22.78
	Feb	22.52	23.05278	1.01	0.98632	22.96
	Mar	22.89	23.00567	1.01	1.00460	23.34
	Apr	22.85	22.95856	1.01	1.00493	23.30
	May	22.94	22.91146	1.01	1.01087	23.39
	Jun	22.98	22.86435	1.01	1.01475	23.43
	Jul	22.97	22.81725	1.01	1.01685	23.43
	Aug	22.8	22.77014	1.01	1.00895	23.20
	Sep	22.35	22.72304	1.01	0.99412	22.82
	Oct	22.24	22.67593	1.01	0.99304	22.74
	Nov	22.34	22.62883	1.01	0.99927	22.84
	Dec	22.10	22.58172	1.01	0.98985	22.58

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2022	Jan	21.86	22.53462	1.01	0.97645	22.22
	Feb	22.05	22.48751	1.01	0.98632	22.40
	Mar	22.42	22.44041	1.01	1.00460	22.77
	Apr	22.38	22.39330	1.01	1.00493	22.73
	May	22.46	22.34619	1.01	1.01087	22.81
	Jun	22.49	22.29909	1.01	1.01475	22.85
	Jul	22.49	22.25198	1.01	1.01685	22.85
	Aug	22.32	22.20488	1.01	1.00895	22.63
	Sep	21.88	22.15777	1.01	0.99412	22.25
	Oct	21.77	22.11067	1.01	0.99304	22.18
	Nov	21.87	22.06356	1.01	0.99927	22.27
	Dec	21.63	22.01646	1.00	0.98985	21.79
2023	Jan	21.50	21.96935	1.00	0.97645	21.45
	Feb	21.67	21.92225	1.00	0.98632	21.62
	Mar	22.03	21.87514	1.00	1.00460	21.98
	Apr	21.99	21.82803	1.00	1.00493	21.94
	May	22.07	21.78093	1.00	1.01087	22.02
	Jun	22.11	21.73382	1.00	1.01475	22.05
	Jul	22.10	21.68672	1.00	1.01685	22.05
	Aug	21.88	21.63961	1.00	1.00895	21.83
	Sep	21.52	21.59251	1.00	0.99412	21.47
	Oct	21.45	21.5454	1.00	0.99304	21.40
	Nov	21.54	21.4983	1.00	0.99927	21.48
	Dec	21.29	21.45119	1.00	0.98985	21.23

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2024	Jan	20.93	21.40409	1.00	0.97645	20.90
	Feb	21.10	21.35698	1.00	0.98632	21.06
	Mar	21.44	21.30987	1.00	1.0046	21.41
	Apr	21.40	21.26277	1.00	1.00493	21.37
	May	21.48	21.21566	1.00	1.01087	21.45
	Jun	21.51	21.16856	1.00	1.01475	21.48
	Jul	21.51	21.12145	1.00	1.01685	21.48
	Aug	21.29	21.07435	1.00	1.00895	21.26
	Sep	20.93	21.02724	1.00	0.99412	20.90
	Oct	20.87	20.98014	1.00	0.99304	20.83
	Nov	20.95	20.93303	1.00	0.99927	20.92
	Dec	20.70	20.88593	1.00	0.98985	20.67
2025	Jan	20.36	20.83882	1.00	0.97645	20.35
	Feb	20.52	20.79171	1.00	0.98632	20.51
	Mar	20.85	20.74461	1.00	1.0046	20.84
	Apr	20.81	20.6975	1.00	1.00493	20.80
	May	20.88	20.6504	1.00	1.01087	20.87
	Jun	20.92	20.60329	1.00	1.01475	20.91
	Jul	20.91	20.55619	1.00	1.01685	20.90
	Aug.	20.70	20.50908	1.00	1.00895	20.69
	Sep	20.35	20.46198	1.00	0.99412	20.34
	Oct	20.28	20.41487	1.00	0.99304	20.27
	Nov	20.36	20.36777	1.00	0.99927	20.35
	Dec	20.12	20.32066	1.00	0.98985	20.11

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\widehat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2026	Jan	19.79	20.27355	1.00	0.97645	19.80
	Feb	19.94	20.22645	1.00	0.98632	19.95
	Mar	20.26	20.17934	1.00	1.0046	20.27
	Apr	20.22	20.13224	1.00	1.00493	20.23
	May	20.29	20.08513	1.00	1.01087	20.30
	Jun	20.32	20.03803	1.00	1.01475	20.33
	Jul	20.32	19.99092	1.00	1.01685	20.33
	Aug	20.11	19.94382	1.00	1.00895	20.12
	Sep	19.77	19.89671	1.00	0.99412	19.78
	Oct	19.70	19.84961	1.00	0.99304	19.71
	Nov	19.78	19.8025	1.00	0.99927	19.79
	Dec	19.54	19.75539	1.00	0.98985	19.55
2027	Jan	19.21	19.70829	1.00	0.97645	19.24
	Feb	19.36	19.66118	1.00	0.98632	19.39
	Mar	19.67	19.61408	1.00	1.0046	19.70
	Apr	19.63	19.56697	1.00	1.00493	19.66
	May	19.70	19.51987	1.00	1.01087	19.73
	Jun	19.73	19.47276	1.00	1.01475	19.76
	Jul	19.72	19.42566	1.00	1.01685	19.75
	Aug	19.51	19.37855	1.00	1.00895	19.55
	Sep	19.18	19.33145	1.00	0.99412	19.22
	Oct	19.12	19.28434	1.00	0.99304	19.15
	Nov	19.19	19.23723	1.00	0.99927	19.22
	Dec	18.96	19.19013	1.00	0.98985	19.00

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\widehat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2028	Jan	18.77	19.14302	1.00	0.97645	18.69
	Feb	18.91	19.09592	1.00	0.98632	18.83
	Mar	19.21	19.04881	1.00	1.0046	19.14
	Apr	19.17	19.00171	1.00	1.00493	19.10
	May	19.24	18.9546	1.00	1.01087	19.16
	Jun	19.26	18.9075	1.00	1.01475	19.19
	Jul	19.25	18.86039	1.00	1.01685	19.18
	Aug	19.06	18.81329	1.00	1.00895	18.98
	Sep	18.73	18.76618	1.00	0.99412	18.66
	Oct	18.66	18.71908	1.00	0.99304	18.59
	Nov	18.73	18.67197	1.00	0.99927	18.66
	Dec	18.51	18.62486	1.00	0.98985	18.44
2029	Jan	18.21	18.57776	1.00	0.97645	18.14
	Feb	18.34	18.53065	1.00	0.98632	18.28
	Mar	18.64	18.48355	1.00	1.0046	18.57
	Apr	18.59	18.43644	1.00	1.00493	18.53
	May	18.66	18.38934	1.00	1.01087	18.59
	Jun	18.68	18.34223	1.00	1.01475	18.61
	Jul	18.67	18.29513	1.00	1.01685	18.60
	Aug	18.48	18.24802	1.00	1.00895	18.41
	Sep	18.16	18.20092	1.00	0.99412	18.09
	Oct	18.09	18.15381	1.00	0.99304	18.03
	Nov	18.16	18.1067	1.00	0.99927	18.09
	Dec	17.94	18.0596	1.00	0.98985	17.88

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T}\times\hat{C}\times\hat{S}$
2030	Jan	17.64	18.01249	1.00	0.97645	17.59
	Feb	17.78	17.96539	1.00	0.98632	17.72
	Mar	18.06	17.91828	1.00	1.0046	18.00
	Apr	18.02	17.87118	1.00	1.00493	17.96
	May	18.07	17.82407	1.00	1.01087	18.02
	Jun	18.10	17.77697	1.00	1.01475	18.04
	Jul	18.09	17.72986	1.00	1.01685	18.03
	Aug	17.90	17.68276	1.00	1.00895	17.84
	Sep	17.59	17.63565	1.00	0.99412	17.53
	Oct	17.52	17.58854	1.00	0.99304	17.47
	Nov	17.58	17.54144	1.00	0.99927	17.53
	Dec	17.37	17.49433	1.00	0.98985	17.32
2031	Jan	17.08	17.44723	1.00	0.97645	17.04
	Feb	17.21	17.40012	1.00	0.98632	17.16
	Mar	17.48	17.35302	1.00	1.0046	17.43
	Apr	17.44	17.30591	1.00	1.00493	17.39
	May	17.49	17.25881	1.00	1.01087	17.45
	Jun	17.51	17.2117	1.00	1.01475	17.47
	Jul	17.50	17.1646	1.00	1.01685	17.45
	Aug	17.32	17.11749	1.00	1.00895	17.27
	Sep	17.02	17.07038	1.00	0.99412	16.97
	Oct	16.95	17.02328	1.00	0.99304	16.90
	Nov	17.01	16.97617	1.00	0.99927	16.96
	Dec	16.80	16.92907	1.00	0.98985	16.76

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2032	Jan	16.52	16.88196	1	0.97645	16.48
	Feb	16.64	16.83486	1	0.98632	16.60
	Mar	16.90	16.78775	1	1.0046	16.86
	Apr	16.86	16.74065	1	1.00493	16.82
	May	16.91	16.69354	1	1.01087	16.87
	Jun	16.93	16.64644	1	1.01475	16.89
	Jul	16.92	16.59933	1	1.01685	16.88
	Aug	16.74	16.55222	1	1.00895	16.70
	Sep	16.44	16.50512	1	0.99412	16.41
	Oct	16.38	16.45801	1	0.99304	16.34
	Nov	16.43	16.41091	1	0.99927	16.40
	Dec	16.23	16.3638	1	0.98985	16.20

7. Forecasting the biodiesel price of Thailand in the next four years, from 2033 to 2036

Year	Date	Retail Price (true value)	Trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2033	Jan	.	16.3167	1.0063	0.97645	16.03
	Feb	.	16.26959	1.0063	0.98632	16.15
	Mar	.	16.22249	1.0063	1.0046	16.40
	Apr	.	16.17538	1.0063	1.00493	16.36
	May	.	16.12828	1.0063	1.01087	16.41
	Jun	.	16.08117	1.0063	1.01475	16.42
	Jul	.	16.03406	1.0063	1.01685	16.41
	Aug	.	15.98696	1.0063	1.00895	16.23
	Sep	.	15.93985	1.0063	0.99412	15.95
	Oct	.	15.89275	1.0063	0.99304	15.88
	Nov	.	15.84564	1.0063	0.99927	15.93
	Dec	.	15.79854	1.0063	0.98985	15.74
2034	Jan	.	15.75143	1.0063	0.97645	15.48
	Feb	.	15.70433	1.0063	0.98632	15.59
	Mar	.	15.65722	1.0063	1.0046	15.83
	Apr	.	15.61012	1.0063	1.00493	15.79
	May	.	15.56301	1.0063	1.01087	15.83
	Jun	.	15.5159	1.0063	1.01475	15.84
	Jul	.	15.4688	1.0063	1.01685	15.83
	Aug	.	15.42169	1.0063	1.00895	15.66
	Sep	.	15.37459	1.0063	0.99412	15.38
	Oct	.	15.32748	1.0063	0.99304	15.32
	Nov	.	15.28038	1.0063	0.99927	15.37
	Dec	.	15.23327	1.0063	0.98985	15.17

Year	Date	Retail Price (true value)	trend ($\hat{T}$)	cyclical ($\hat{C}$)	seasonal ($\hat{S}$)	Retail Price (predict value) $\hat{Y}=\hat{T} \times \hat{C} \times \hat{S}$
2035	Jan	.	15.18617	1.0063	0.97645	14.92
	Feb	.	15.13906	1.0063	0.98632	15.03
	Mar	.	15.09196	1.0063	1.00460	15.26
	Apr	.	15.04485	1.0063	1.00493	15.21
	May	.	14.99775	1.0063	1.01087	15.26
	Jun	.	14.95064	1.0063	1.01475	15.27
	Jul	.	14.90353	1.0063	1.01685	15.25
	Aug	.	14.85643	1.0063	1.00895	15.08
	Sep	.	14.80932	1.0063	0.99412	14.81
	Oct	.	14.76222	1.0063	0.99304	14.75
	Nov	.	14.71511	1.0063	0.99927	14.80
	Dec	.	14.66801	1.0063	0.98985	14.61
2036	Jan	.	14.6209	1.0063	0.97645	14.37
	Feb	.	14.5738	1.0063	0.98632	14.46
	Mar	.	14.52669	1.0063	1.0046	14.69
	Apr	.	14.47959	1.0063	1.00493	14.64
	May	.	14.43248	1.0063	1.01087	14.68
	Jun	.	14.38537	1.0063	1.01475	14.69
	Jul	.	14.33827	1.0063	1.01685	14.67
	Aug	.	14.29116	1.0063	1.00895	14.51
	Sep	.	14.24406	1.0063	0.99412	14.25
	Oct	.	14.19695	1.0063	0.99304	14.19
	Nov	.	14.14985	1.0063	0.99927	14.23
	Dec	.	14.10274	1.0063	0.98985	14.05

APPENDIX G THE MAIN PLANS THAT HAVE EFFECTS ON THE PRICE OF BIODIESEL

1. Alternative Energy Development Plan (AEDP 2015) This plan is focused on supporting the production of energy by using efficiency alternative energy inside the country. Also, developing technology can help to produce more alternative energy, and help society and the environment. The alternative energy development plan shows in Table 12.

Table 12 The goal of Alternative Energy Development Plan (AEDP 2015)

Type of renewable energy	in the 2014 year		in the 2036 year	
Bio-fuel	Million liter/d	ktoe	Million liter/d	ktoe
1. Ethanol	3.21	872.88	11.3	2,103.50
2. Bio-diesel	2.89	909.98	14.0	4,404.82
3. Pyrolysis-oil			0.53	170.87
4.Alternative renewable energy				10
Total			1,782.16	6,689.19
The share of Renewable Energy in Final Energy consumption (%)	6.65%		25.04%	

Note: Thai government (AEDP2015) aim to replace 20-25 percent of final energy consumption by use biofuel by 2036

Source: Follow on AEDP 2015, Ministry of Energy

2. The Energy Efficiency Development Plan (EEP 2015)

This plan created by the Ministry of Energy for forecasting the demand for energy in the future. The aimed of EEP2015 was to reduce energy intensity (EI) by 30% in 2036, in comparison with 2010. According to the EEP, six of the most feasible measures from 34 energy conservation measures would be implemented in electricity sectors accounting for 89,672 GWh of energy savings in the year 2036 as shown in Table 13, 14 and 15

Table 13 The energy targets classified by measure (GWh)

Measures	Energy Conservation Targets				
	2016	2021	2016	2031	2036
1. Specific Energy Consumption (SEC)	1,802	6,992	11,669	14,738	19,648
2. Building Energy Code (BEC)	-	770	2,719	6,402	13,686
3. High Energy Performance Standard (HEPs) & Minimum Energy Performance Standard (MEPs)	857	3,446	8,163	14,776	23,760
4. Monetary incentives	905	5,133	9,691	11,564	15,074
5. LED promotion	160	1,862	4,909	8,129	11,632
6. Energy Efficiency Resource Standard (EERS)	-	-	870	3,085	5,872
Total	3,724	18,203	38,021	58,694	89,672

Source: Follow on EEP 2015, Ministry of Energy

Table 14 The energy conservation targets in the year 2036 classified by measure (GWh)

Measures	Energy Conservation Targets				
	Residential	Industrial	Business	Government	Total
1. Specific Energy Consumption (SEC)	-	10,814	5,654	3,180	19,648
2. Building Energy Code (BEC)	-	-	11,975	1,711	13,686
3. High Energy Performance Standard (HEPs) & Minimum Energy Performance Standard (MEPs)	8,963	6,226	7,609	989	23,760
4. Monetary incentives	-	9,133	5,941	-	15,074
5. LED promotion	3,354	3,303	3,711	1,264	11,632
6. Energy Efficiency Resource Standard (EERS)	1,343	2,367	2,162	-	5,872
Total	13,633	31,843	37,052	7,144	89,672

Source: Follow on EEP2015, Ministry of Energy

Table 15 The energy conservation targets classified by economic sector (GWh)

Economic sectors	Energy Conservation Targets				
	2016.	**2021**	**2016**	**2031**	**2036**
Industrial	2,174	9,420	17,497	22,845	31,843
Business	853	5,156	12,687	22,406	36,052
Residential and Agricultural	395	1,914	4,877	8,760	13,633
Government	302	1,713	2,960	4,683	7,144
Total	3,724	18,203	38,021	58,694	89,672

Source: Follow on EEP2015, Ministry of Energy

3. Thailand Power Development Plan 2015 – 2036 (PDP 2015)

The plan focuses on the stability of the electrical system by spreading the fuel and reducing natural gas, increasing the propertion of renewable energy, and developing the electricity distribution system. These strategies will help to support the development of alternative energy, and also becoming the Association of Southeast Asian Nations (AEC).

Thailand's new Power Demand Forecast was calculated upon the average long term GDP growth during the year 2014-2036 estimated by the NESDB of 3.94 percent and the average population growth of 0.03 percent. Also, the energy saving target from the EEDP accounts for 89,672 GWh (PDP,2015).

Thailand's new Power Demand Forecast would grow 2.67 percent annually from the year 2014 to 2036. In the year 2036, the expected energy and power demand would be326,119 GWh and 49,655 MW respectively. The Power Demand Forecast of the PDP2010 Revision 3 and the PDP2015 are compared as shown in the Table 16 below:

Table 16 Key assumptions of PDP 2015 classified by years

Year	PDP2010 Rev3		PDP2015		Change (%)	
	Peak (MW)	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak (MW)	Energy (GWh)
2016	31,809	210,619	30,218	197,891	-1,591	**-12,728**
2026	46,003	304,548	40,791	267,629	-5,212	**-36,919**
2030	52,256	346,767	44,424	291,519	-7,832	**-55,248**
2036	-	-	49,655	326,116	-	-

Source: Follow on PDP 2015, Ministry of energy

4. Oil plan 2015 – 2036

Oil plan is a long-term plan to support fuel management in line with the goal of energy conservation plan and alternative energy development plan. It serves as a framework for the management of the future fuel mix which takes into account the

environment and risks that may impact both directly and indirectly to the development of the country's energy (Oil plan ,2015). The formulation of oil is the integration between the EEP2015 and AEDP2015. It is begin with the fuels demand forecasting with the fuels demand includes oil, liquefied petroleum gas used as fuel and natural gas. The goal of the oil plan was shown in Table 17

Table 17 The forecast information on fuel demand classified by economic sector

Economic Sector	Type of Oil	Business as Usual		Energy Efficiency Plan	
		2026	2036	2026	2036
Transport	Gasoline	9,303	12,934	4,683	4,523
	Diesel	17,085	24,309	9,898	10,067
	LPG	4,601	8,001	2,785	4,264
	NG	5,731	9,269	4,020	5,447
	Jet fuel	7,206	10,036	7,206	10,036
	Fuel oil	1,010	909	1,010	909
	total	44,937	65,459	29,602	35,246
Over all sector	Gasoline	9,381	13,012	4,760	4,600
	Diesel	23,972	32,389	16,784	18,147
	LPG	8,986	13,022	7,170	9,285
	NG	5,731	9,269	4,020	5,447
	Jet fuel	7,217	10,047	7,217	10,047
	Fuel oil	1,699	1,598	1,699	1,598
	total	56,985	79,338	41,650	49,125

Source: Energy Policy and Planning Office