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Article

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Forecasting of Biodiesel Prices in Thailand using Time Series Decomposition Method for Long Term from 2017 to 2036

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ABSTRACT

Currently, the Thailand government is promoting biofuel, especially the producer of biodiesel. Starting from 2015, the Ministry of Energy of Thailand has determined that the palm oil remaining from domestic consumption is 14 million liters per day in 2036. Forecasting biodiesel prices are most important since biodiesel price volatility affects renewable energy consumption in the future. This paper presents the biodiesel prices in Thailand with the time series decomposition method. The source of time series data comes from the energy policy and planning office, Ministry of Energy of Thailand, monthly average retail price of regular-grade biodiesel, during 2007-2016, 120 months in total. This study aims to use forecasting methods to deter biodiesel prices in Thailand over the next 20 years, from 2017 to 2036. This solution starts with decomposing data into a trend, a cycle, seasonal, and any irregular components and then calculates biodiesel prices with a multiplicative model. The model shows a continuous decreasing trend of biodiesel prices from around 27.50 to 25.84 THB/liter in 2017 to 22.36 THB/liter in 2036. Moreover, the forecasting method has the least mean absolute present error (MAPE) at 0.24651.

Keywords: Biodiesel, Forecasting, Time-Series Method
JEL Classifications: C01, C10, E17, O21

1. INTRODUCTION

Developing and emerging economies like Thailand face the challenge of meeting their energy needs sustainably through a transition to clean, low carbon energy sources (Institute for Population and Social Research, 2017). Biodiesel, which is produced from vegetable oils, is one such low carbon energy source. Biodiesel can substitute diesel fuel, particularly for transport use.

Biodiesel can come from sustainably cultivated or produced vegetable oils, a such, biodiesel is a renewable energy source, and therefore, its use eliminates or reduces significantly net carbon dioxide emissions. Biodiesel also eliminates emissions of other greenhouse gas emissions and air pollutants such as unburned hydrocarbons, carbon monoxide, and particulates (Fattah et al., 2013).

Thailand 2015 Alternative Energy Development Plan (2015 AEDP) has the following objectives:

- Reducing oil imports
- Increasing energy security
- Enhancing the development of alternative energy sources
- Developing renewable energy technologies.

Under this plan, biodiesel demand increased, the production of palm oil, and, in turn, increased the land area for the cultivation of palm trees. Land for palm tree production is expected to increase from 6,720 million square meters to 12,000 million square meters by 2036. It is also expected that biodiesel's increase production from palm oil will benefit both the farmer households and their communities (The Ministry of Energy, 2015).

Forecasting biodiesel prices is an important input in projecting trends in biodiesel demand and economic analysis of future renewable energy consumption in Thailand. These forecasting, projections, and economic analyses help the Thailand Ministry of Energy and biodiesel producers develop both medium- and long-term plans. These plans need to be flexible, given the uncertainties of future prices of biodiesel.

In the next 20 years, biodiesel can reduce fossil fuel demand and promote energy diversity, allowing Thailand to play an important role in renewable energy production and consumption in the ASEAN, even making the country a leader in the region.

This study looks at the importance of forecasting biodiesel prices in Thailand for the next 20 years to increase the use of biodiesel and thus, help achieve the targets of reducing fossil fuel consumption and increasing diversity of energy supply.

2. BIODIESEL IN THE AEDP 2015

As mentioned previously, biodiesel is produced from renewable energy sources. It is a clean fuel that does not contribute to carbon dioxide emissions and an environmentally friendly energy supply (Cheah, 2004).

Many countries have already been heavily consuming biodiesel in the past few years for transport and electricity generation. For example, based on reports from the U.S. Energy Information Administration, biodiesel consumption in the U.S. grew from 326 million gallons in 2009 to 878 million gallons in 2011 (although there was 1 year declined in 2010).

In Thailand, even if the fuel consumption is increasing rapidly and the country has been affected by the high volatility of crude oil prices (due to surges in oil demand, particularly in Southeast Asia, and the political instability of major oil supply regions), consumption of biodiesel blends of 3% to 4% has increased. A regional biodiesel report found out that Thailand is a larger biodiesel producer than Colombia, accounting for 4% of global output (Rosamond and Matthew, 2017), yet the Thai government commitment to the biodiesel sector has not been firmed.

Thailand had implemented an earlier Renewable and Alternative Energy Development Plan in 2012 (AEDP2012) when oil prices were high, and palm oil prices were dropping. At that time, the government established a blending mandate of B7, which included pilot projects targeted for fleet trucks and fishing boats using fuel blends ranging from B10 to B20 (Preechajarn and Prasertsri, 2015). However, this national mandate was not strictly enforced and lowered on more than one occasion due to a shortage of palm oil (the main biodiesel feedstock) and concerns over an escalation in food prices.

In 2015, Thailand adopted the 2015 Renewable and Alternative Energy Development Plan (AEDP2015) that focused on promoting energy production using domestic renewable energy resources' full potential. One of the intents of AEDP2015 was to foster appropriate renewable energy production that will be socially and environmentally beneficial to communities. The development of renewable energy in Thailand increased steadily under this plan. This was due to the active government's promotion of domestic biodiesel production to reduce energy imports, diversify its energy economy, and lower greenhouse gas emissions.

Biodiesel's use increased significantly in 2011 when the Ministry of Energy (MOE) announced a policy to blend a larger proportion of biodiesel from 3-5 percent. In 2014, MOE increased the proportion of biodiesel blends to be 7 percent. However, because the volume of crude palm oil supply, the raw material for biodiesel production, is seasonal, MOE would sometimes reduce the biodiesel's proportion to match the domestic supply. In 2013, the biodiesel blend was increased to 10%. This required 4.96 million gallons per day of raw material. Biodiesel used to replace regular diesel was at 1,054.92 million liters, equivalent to 2.89 million liters per day (The Ministry of Energy, 2015).

Thailand is the world's third-largest palm oil producer, following Indonesia and then Malaysia. Thailand, however, has developed its biodiesel sector almost exclusively around its domestic palm oil sector. It differed from that of Indonesia and Malaysia, as it has developed almost entirely through smallholder production on established agricultural lands (Byerlee et al., 2017). Currently, it seems unlikely that Thailand will expand its biodiesel sector and enforce a B10 mandate by 2020, especially if crude oil prices remain low.

3. QUANTITATIVE METHODS OF FORECASTING BIODIESEL PRICES

Forecasting is a quantitative estimation of the values of variables in the future. In this study, the variables under study are the demand for and the price of a good or commodity, particularly biodiesel. Quantitative forecasting methods can be divided into two types as follows:

3.1. Causal Model or Regression Analysis

A causal forecasting model's goal is to develop the best statistical relationship between a dependent variable and one or more independent variables. When one tries to predict a dependent variable using a single independent variable is causal forecasting models, it is called a simple regression model. When one uses more than one independent variable to forecast the dependent variable, it is called a multiple regression model.

In our earlier study (Phase 1), we selected regression analysis for assessing factors affecting downstream biodiesel prices at consumer locations like gas stations. The factors assessed in the study included ex-refinery prices, excise taxes, oil fund contributions, municipal taxes, exchange rate (USD), energy conservation fund contributions, and marketing margin. The results found that all of these factors were significant ($R^2 = 0.867$). The most significant factor was the ex-refinery price, while the least was the marketing margin. The study also showed that while biodiesel's consumer price in Thailand can be mostly attributed to cost factors, there was some unexplained variance in price (Laung-iem and Thanarak, 2016).

The results of Phase 1 showed the many factors that affect biodiesel price. However, the setting of energy supply prices, particularly biodiesel, by the Ministry of Energy, was aimed more towards affordable prices that can satisfy the energy demand that was consistent with the target economic growth rate. Forecasting the biodiesel prices was also necessary for planning renewable energy production targets that can reduce crude oil imports.

3.2. Time Series Method

This involves the Decomposition Method, a quantitative forecasting method consisting of mathematical models based on historical data on the variation in demand over a period (Fernandes and Anznello, 2010). The first step in the analysis of time series is a modeling study to show the variable's behavior over a period and identify the key factors in it; and then, make estimates how the factors are influencing the behavior of the variable over time then evaluate them. Time series analysis using the Decomposition Method may involve the following:

3.2.1. Trends

A time-series trend indicates the data's behavior during the long-term (i.e., if it increases, decreases, or remains stable, and which speed changes occur). Identifying the trend allows the removal of this component of the study series to get a better view of the other components that can interfere in the demand (Morettin and Toloi, 2004). Here the trend is considered linear as given by the least square method, which consists of variables that minimize squared residuals regression. This method was chosen as an example, but other methods can be used to calculate the trend as detailed and explained by Justiniano (2015).

$$\hat{Y} = a + b\left(t\right) \quad (1)$$

where
a is the intercept.
b is the slop.
t is amounts (initial).

3.2.2. Cyclical variations

Cyclical variations are fluctuations in the values of variables that follow the business cycle, which can be longer than a year. Such cyclical variations are long-term fluctuations within the trend but do not have the exact frequency characterizing seasonal patterns. However, irregular variations are derived from random components, arising from situations that cannot be unexplained.

3.2.3. Seasonal variations

Seasonal variations occur annually with durations less than a year, often within the same period and of almost the same magnitude. Seasonality in a series corresponds to the increases and drops in repeated fluctuations within a certain period, which can be in a year, month, week, or day.

This stage of the decomposition method, which involves s calculating the seasonal index, can be called depersonalizing the series data. The depersonalizing removes the seasonal effects on the data being analyzed and helps prevent wrong inferences about increases or decreases of values over time. The method used to calculate the seasonal index is known as the ratio- to-moving average approach. Irregular variations, which are that e that does not follow any pattern, its fluctuations, are, however, not explained.

The next step in the decomposition method is to explain the possible influence of the components in time series by breaking down each of these components, identifying how much this component is influencing the series, and predicting the influence of the components (Wang et al., 2012). This forecast of the multiplicative decomposition model consists of estimating the four components of the model as follows:

$$\hat{Y} = \hat{T} \times \hat{C} \times \hat{S} \times \hat{I} \quad (2)$$

4. METHODOLOGY

To make a long-term forecast (i.e., a 25 year-forecast from 2017 to 2036), the Time Series Decomposition Method was used based on data from the earlier period of 2007 to 2016. Time series forecasting is done based on time series data. The following are the details of the procedure done for this analysis.

1. Tabulate and graph the value using Microsoft Excel and analyze whether there is a trend towards increasing, decrease or remains stable, and at which speed these changes occur
2. Calculate the L-step moving average centered at the period, t, where L is the seasonality length (e.g., L would be 12 for a monthly series)
3. Calculate the seasonal change 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
4. calculate the trend $\hat{T}$ by Least Square method is made of the equation (1) Where t is mounted (initial on Jan 2007)
5. calculate the cyclical change index, and this is conducted by eliminating the trend (T) out of the moving average (M.A.) by $\hat{C} = (T \times C)/\hat{T}$ (3)
6. calculate irregular index ($\hat{I}$) by $\hat{I} = (S \times I)/\hat{S}$ (4)
7. create conduct forecasts by the multiplicative decomposition model consists of estimating the four components of the model as follows equation (2).

After finishing these steps, the forecasting performance is evaluated using the mean absolute percentage error (MAPE) method. MAPE measures the deviation between actual and predicted values. The smaller the values of MAPE, the closer is the predicted time series values to that of the actual value. Thus, MAPE can be used to evaluate the prediction error (Mehmet, 2014). The mean absolute percentage error (MAPE) is shown in equation 5.

$$\text{MAPE} = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{Ft - At}{At}\right| \times 100\% \quad (5)$$

In Equation 5, *Ft* is the forecasted value at the year *t*, At denotes the actual value at year *t*, *N* stands for the number of observations.

5. RESULTS

By using the trend analysis, the time series forecasting method produced a line graph showing a series of monthly average retail prices of regular-grade biodiesel for a total of 120 months. The results are shown in e Figure 1.

Moving averages are a method to reduce the side effect of parameters or variables such as season, business cycle, and random variation from time series forecasting. It is appropriate for short-term load forecasting and trend calculating and is displayed as a stretched line constant on the horizon.

This paper used 12-month series. The decomposition time series data on biodiesel prices totaling 120 months were s split into four components or parts, trend, seasonality, cycles, and irregular index. The values to determine the graphical trend line was calculated using the Least Square Method, as shown by the equation below. The results are shown in the following Table 1.

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

Where
a is 28.657
b is –0.016
t is amounts (initial on Jan,2007)

Therefore, the linear trend equation is

$$\hat{Y} = 28.657 – 0.016\ (t) \qquad (6)$$

Before making forecasts of the biodiesel prices in Thailand for the next 20 years (2017 to 2036), we need to consider the accuracy of the predictive value being close to the true values from 2007 to 2016. Table 2 shows that the MAPE overall is 0.246517. Meaning the forecast is highly accurate (Emang et al., 2010). The smallest error estimation was in 2011 (MAPE = 0.190743 %), followed by 2007 and 2014 (more details in Table 2 and Figure 1).

This study selected four components of the time series, i.e., trend, irregular, cyclical, and seasonal indexes, for forecasting the biodiesel price in Thailand over the next 20 years (2017 to 2036). The analysis of the four components by decomposition using IBM's SPSS software showed that the irregular component was in the range of 0.9165 to 1.1102, which is equivalent to 1.00, while the cyclical change index was between 0.700 to 1.300, which means two components have relatively little effect on the forecasting of the biodiesel prices in Thailand for the next 20 years (2017 to 2036).

However, from Figure 2, the forecast found that the biodiesel prices in Thailand for the long term of 2017 to 2036 will be n continuously decreasing during the last years. In the 1st year (2017), biodiesel prices are forecasted around 27.504 to 25.842 THB/liter. By December 2036, the retail price is forecasted to fall to its lowest price of 22.361 THB/liter (details in Figures 2 and 3).

The forecasting of biodiesel prices in Thailand using the time series decomposition Method for 2017 to 2036 showed a continuously decreasing biodiesel prices trend over the last years (2036). In the 1st year (2017), the biodiesel prices were around 27.50 to 25.84 THB/liter. At the end of the final year (2036), the retail price had fallen to the lowest price, at 22.36 THB/liter. The error evaluation showed that the classical time series decomposition is well suited for biodiesel price data in the matter of forecasting as the errors obtained are small (MAPE = 0.246517) (Figure 4).

6. DISCUSSION

6.1. Biodiesel Prices and Consumption

During the 2008 world energy crisis, crude oil prices rose above US$150 a barrel, resulting in an increased demand for biofuels

Figure 1: The trend of biodiesel price in Thailand's oil market from January 2007 to December 2016

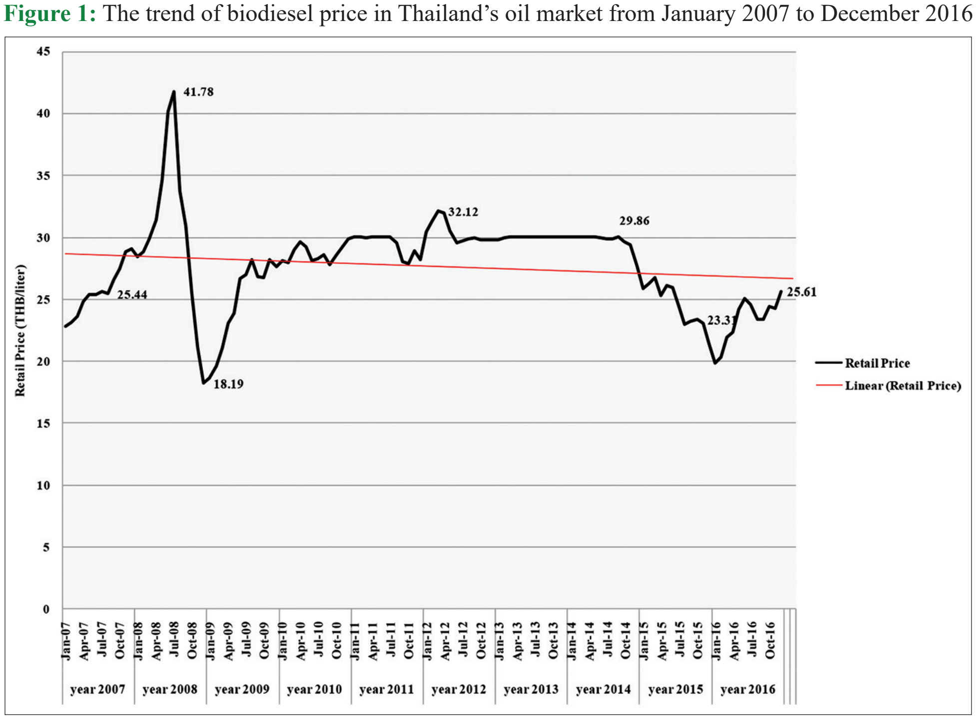


Table 1: Summary of the decomposition time series results from 2007 to 2016

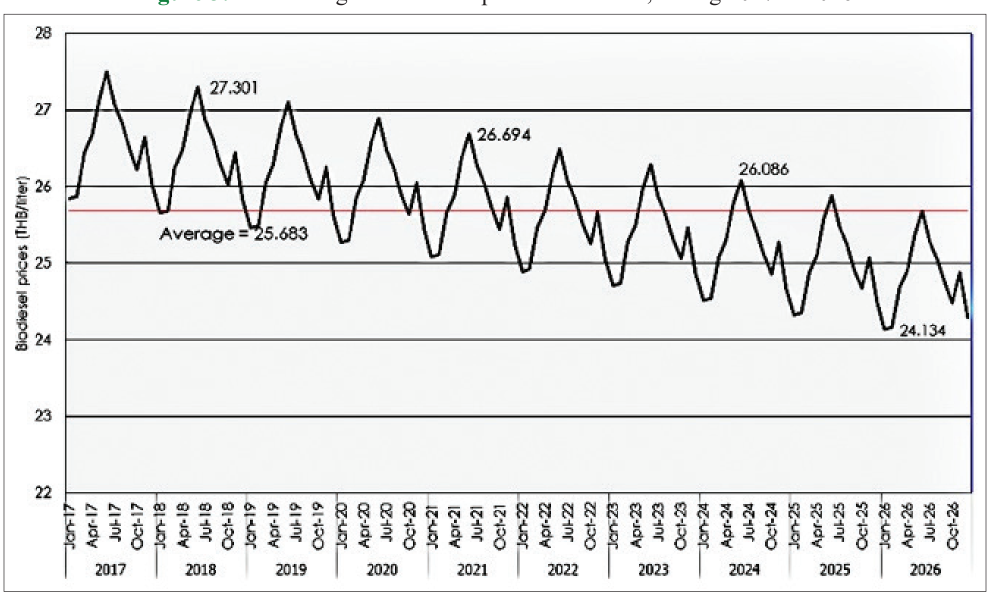
Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$	Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$
2007	1	28.64079	0.99975	0.82	0.96952	2008	1	28.44485	0.99588	1.04	0.96952
	2	28.62446	1.00432	0.83	0.97128		2	28.42852	0.99335	1.05	0.97128
	3	28.60813	0.98771	0.84	0.99313		3	28.41219	0.98225	1.08	0.99313
	4	28.5918	1.01446	0.85	1.00262		4	28.39586	0.97087	1.14	1.00262
	5	28.57547	1.00608	0.86	1.02214		5	28.37953	0.97408	1.23	1.02214
	6	28.55914	0.98713	0.87	1.03506		6	28.3632	1.05657	1.3	1.03506
	7	28.54282	1.00004	0.88	1.01946		7	28.34688	1.11024	1.3	1.01946
	8	28.52649	0.97964	0.9	1.01066		8	28.33055	0.97249	1.21	1.01066
	9	28.51016	1.00044	0.93	0.99846		9	28.31422	1.02099	1.07	0.99846
	10	28.49383	1.00569	0.97	0.98912		10	28.29789	0.99627	0.92	0.98912
	11	28.4775	1.00391	1	1.0059		11	28.28156	0.93445	0.79	1.0059
	12	28.46117	1.016	1.02	0.98266		12	28.26523	0.91651	0.71	0.98266
Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$	Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$
2009	1	28.24891	0.97593	0.7	0.96952	2010	1	28.05297	1.01135	1.02	0.96952
	2	28.23258	0.99372	0.72	0.97128		2	28.03664	0.99473	1.03	0.97128
	3	28.21625	0.98946	0.76	0.99313		3	28.02031	1.00254	1.04	0.99313
	4	28.19992	1.01509	0.8	1.00262		4	28.00398	1.02341	1.03	1.00262
	5	28.18359	0.97596	0.85	1.02214		5	27.98765	1.00469	1.02	1.02214
	6	28.16726	1.01869	0.9	1.03506		6	27.97132	0.96956	1	1.03506
	7	28.15094	1.00498	0.93	1.01946		7	27.955	0.99605	0.99	1.01946
	8	28.13461	1.03223	0.96	1.01066		8	27.93867	1.01036	1	1.01066
	9	28.11828	0.98785	0.97	0.99846		9	27.92234	0.9839	1.01	0.99846
	10	28.10195	0.98452	0.98	0.98912		10	27.90601	1.00273	1.03	0.98912
	11	28.08562	1.00832	0.99	1.0059		11	27.88968	0.98935	1.05	1.0059
	12	28.06929	0.99591	1.01	0.98266		12	27.87335	1.01	1.08	0.98266
Summary of the decomposition time series results during 2007 to 2016 (Cont.)											
Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$	Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$
2011	1	27.85703	1.01367	1.1	0.96952	2012	1	27.66109	1.02008	1.11	0.96952
	2	27.8407	1.00992	1.1	0.97128		2	27.64476	1.01872	1.14	0.97128
	3	27.82437	0.99689	1.09	0.99313		3	27.62843	1.01575	1.15	0.99313
	4	27.80804	1.00225	1.07	1.00262		4	27.6121	1.02222	1.13	1.00262
	5	27.79171	0.99505	1.06	1.02214		5	27.59577	0.98754	1.1	1.02214
	6	27.77538	0.98945	1.05	1.03506		6	27.57944	0.96963	1.07	1.03506
	7	27.75906	1.01064	1.05	1.01946		7	27.56312	0.99584	1.06	1.01946
	8	27.74273	1.01225	1.04	1.01066		8	27.54679	1.00171	1.07	1.01066
	9	27.7264	0.9821	1.03	0.99846		9	27.53046	1.00628	1.08	0.99846
	10	27.71007	0.99004	1.03	0.98912		10	27.51413	1.00606	1.09	0.98912
	11	27.69374	0.9969	1.04	1.0059		11	27.4978	0.98566	1.09	1.0059
	12	27.67741	0.96796	1.07	0.98266		12	27.48147	1.00094	1.1	0.98266
Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$	Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$
2013	1	27.46515	1.00818	1.11	0.96952	2014	1	27.26921	1.01014	1.12	0.96952
	2	27.44882	1.0107	1.11	0.97128		2	27.25288	1.00933	1.12	0.97128
	3	27.43249	0.99862	1.10	0.99313		3	27.23655	0.99756	1.11	0.99313
	4	27.41616	1.00218	1.09	1.00262		4	27.22022	1.00231	1.10	1.00262
	5	27.39983	0.99493	1.08	1.02214		5	27.20389	0.99603	1.08	1.02214
	6	27.3835	0.98767	1.07	1.03506		6	27.18756	0.98741	1.08	1.03506
	7	27.36718	0.99937	1.08	1.01946		7	27.17124	0.99781	1.08	1.01946
	8	27.35085	0.9994	1.09	1.01066		8	27.15491	0.99908	1.09	1.01066
	9	27.33452	1.00371	1.09	0.99846		9	27.13858	1.00981	1.10	0.99846
	10	27.31819	1.00748	1.10	0.98912		10	27.12225	1.01397	1.09	0.98912
	11	27.30186	0.98617	1.11	1.0059		11	27.10592	1.01021	1.07	1.0059
	12	27.28553	1.00155	1.12	0.98266		12	27.08959	0.99906	1.04	0.98266
Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$	Year	M	$(\hat{T})$	$(\hat{I})$	$(\hat{C})$	$(\hat{S})$
2015	1	27.07327	0.97359	1.01	0.96952	2016	1	26.87733	0.79	0.79	0.96952
	2	27.05694	1.00628	0.99	0.97128		2	26.861	0.79	0.79	0.97128
	3	27.04061	1.02168	0.98	0.99313		3	26.84467	0.81	0.81	0.99313
	4	27.02428	0.97525	0.96	1.00262		4	26.82834	0.84	0.84	1.00262
	5	27.00795	1.00707	0.94	1.02214		5	26.81201	0.87	0.87	1.02214
	6	26.99162	1.01436	0.91	1.03506		6	26.79568	0.88	0.88	1.03506
	7	26.9753	1.00065	0.89	1.01946		7	26.77936	0.89	0.89	1.01946
	8	26.95897	0.96583	0.87	1.01066		8	26.76303	0.88	0.88	1.01066
	9	26.94264	1.00028	0.86	0.99846		9	26.7467	0.89	0.89	0.99846
	10	26.92631	1.02242	0.86	0.98912		10	26.73037	0.91	0.91	0.98912
	11	26.90998	1.01582	0.84	1.0059		11	26.71404	0.93	0.93	1.0059
	12	26.89365	0.99607	0.81	0.98266		12	26.69771	0.95	0.95	0.98266

Table 2: Percent of mean absolute percentage error (MAPE%)

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Overall
MAPE (%)	0.196	0.309	0.300	0.218	0.190	0.226	0.241	0.201	0.254	0.326	0.246

Figure 2: Comparison of predicted value and the true value of the retail price from January 2007 to December 2016

Figure 3: Forecasting the biodiesel price of Thailand, during 2017 to 2026



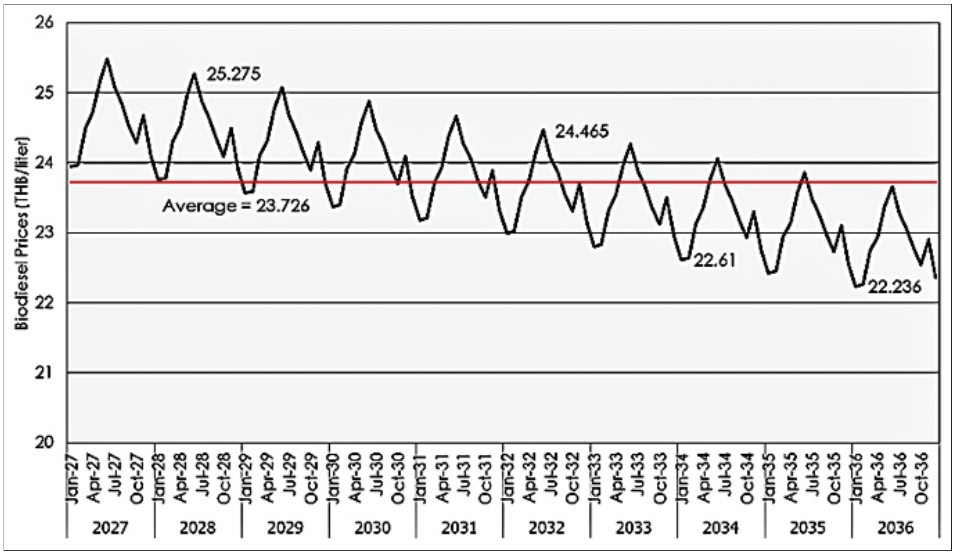
to replace and reduce imports of crude oil. One of the targets of the AEDP2015 plan for renewable energy development was to replace 30 percent of final energy consumption.

The results of this study are reflections of the policies and plans under the AEDP2015. Under the AEDP 2015, the MOE has been making a concerted effort to promote biofuels since 2004 through the following actions; licensing of biofuel factories, expanding more biofuel stations and promoting public relations activities people get more confident in using biofuels.

The Thai government has targeted to increase renewable energy consumption under AEDP2015. The (AEDP2015) aims to replace 20-25 percent of final energy consumption using biofuel by 2036.

The forecasting done in this study showed that biodiesel prices would continually decrease over the 20 years from 2017 to 2036. In the 1st year (2017), the biodiesel prices will be around 27.504 to 25.842 THB per liter. By December 2036, the retail price will fall to the lowest price, at 22.361 THB per liter. This accomplishes

Figure 4: Forecasting the biodiesel price of Thailand, during 2027 to 2036



AEDP 2015 for biofuel development, which is to lower the cost of biofuel by increasing its demand.

The forecast generated by this study that the trend of biodiesel prices will be continuously decreasing during the last year of the forecast period (2036) until the demand for biodiesel energy steadily increases and becomes a significant portion of the energy consumption the country has also been consistent with AEDP2015.

Looking at forecasts of biodiesel demand growth in other countries, Melikoglu (2014) found that the biodiesel demand in Turkey can drastically rise to 3.4 million m^3 in 2023. This is the same as the study of Indrawan et al. (2017), which found out that a biofuel mandate to replace 23% of fossil fuels with renewable energy has been set as the target in 2025.

6.2. Other Factors Affecting Biodiesel Consumption

A study by Chanthawong and Dhakal (2016) defined four strategies for developing and promoting increasing consumption for biofuels in Thailand as follows;

1. Improving farm management and promoting contract farming (average = 4.77)
2. Promoting biodiesel through long-term research and development (average = 4.62)
3. Encouraging the free trade in the domestic ethanol market (average = 4.55)
4. Improving farm management and expanding the cultivation area (average = 4.50).

An effective program for developing biofuels should be an integrated one. It should include promoting more biofuel consumption, increasing the cultivation area and yield of biofuel feedstock or raw materials to ensure that the biodiesel supply balance the demand and the biodiesel price is competitive and affordable. The strategies 1, 3 and 4 mentioned above can be key components of this integrated program.

Besides, the program should also include forecasting studies that provide future biodiesel demand and supply scenarios and the overall scenario for the production, supply, and alternative demand for and uses of biodiesel feedstock, particularly palm oil.

Furthermore, it should also include future scenarios of diesel fuel use, which is the fuel biodiesel will be replacing in the future. It should also look at future scenarios of other alternative transport fuels or energy sources, particularly electricity.

Currently, more than 90% of transport fuels are petroleum-based, such as diesel and gasoline. In the future, many countries, including Thailand, aim to reduce dependence on these fossil fuels and are now targeting increasing electric vehicles' use. As such, electric vehicles' growth should be another factor that should be considered in forecasting demand for biodiesel for transport. An assessment of the possible growth trend of electric vehicles in Thailand showed an S-shaped growth curve (Laoonual, 2015). In France, it is forecasted that 34% of cars will be electric vehicles by 2040.

The displacement of petroleum fuels will depend on how much electricity is generated from non-petroleum or non-fossil fuel sources. In some parts of the U.S., E.V.s will reduce the per-mile use of petroleum by 90% because a large percentage of electricity production is not from fossil fuels (Wang and DeLuchi, 1992).

7. CONCLUSION

The study of biodiesel price in Thailand is forecasted using time series decomposition models for the years 2017 to 2036. This study compared biodiesel price forecasting methods based on time series average monthly data from 2007 to 2016. This minimizes the error in forecasting biodiesel price and can be a tool for the Ministry of Energy in decision-making and policy formulation to promote biodiesel demand through the price mechanism.

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