Fuel replacement: a possible option for Thailand energy security?

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Abstract. Natural gas has been playing an important role in strengthening energy security of Thailand as over 60 percent of total natural gas consumed in the country is from the Gulf of Thailand. In the past 20 years, the average growth of natural gas demand is 5.5 percent per year. Thanks to its low carbon content, natural gas is considered as cleaner fuel comparing to other fossil-based fuels. Still, there are usages of carbon-intensive fuels such as fuel oil and coal in Thailand e.g. in the industrial sector. Most of fuel oil and coal consumed are imported from foreign countries. Replacing these fuels with natural gas may be an option for the country to promote domestic clean energy and reduce overall carbon emissions. This paper forecasts the possibility of replacing fuel oil and coal in the industrial sector with natural gas. The research starts with examining the limitations of Thai regulations, estimating the amount of natural gas required for the replacement, and forecasting future prices of all three fuels. The price projection shows an attractive option for fuel oil users as the long term price of natural gas is projected to be lower than that of fuel oil. On the contrary, the projected coal price alone will not encourage coal users to switch their fuels. Thus, strong government measures will be required to stimulate coal replacement. The result of the study will be useful for determining appropriate policies to support long-term demand for natural gas of the country.

Keywords: Natural gas, Fuel oil replacement, Coal replacement, Energy security, Carbon emissions mitigation

1. Introduction
Since the first production of indigenous gas in 1981, natural gas has been playing an important role in strengthening energy security of Thailand as over 60 percent of total natural gas consumed in the country is from the Gulf of Thailand. Its average demand growth during the past 20 years is about 5.5 percent per year [1]. However, it is found that there are usages of carbon-intensive fuels such as fuel oil and coal e.g. in the industrial sector. Besides their negative environmental impacts, most of fuel oil and coal consumed are imported from foreign countries [1]. Replacing these fuels with natural gas may be an option for the country to promote domestic clean energy and reduce overall carbon emissions. The objective of this study is to assess the possibility of replacing fuel oil and coal in the industrial sector with natural gas.
The first step to assess the possibility of replacing fuel oil and coal with natural gas is to clarify whether there are regulatory obstacles to doing it. Thus, Thai laws and regulations are firstly reviewed. Next, the total amount of natural gas required to replace fuel oil and coal in the industrial sector is forecasted. The main reason to focus on the industrial sector is that it has a significant amount of fuel consumption comparing to others [1]. Also, it does not have government obligations on fuel mix, unlike the power generation sector [2]. After that, the future price of natural gas, fuel oil, and coal are forecasted.

It should be noted that liquefied natural gas (LNG) is included in this study because LNG is one form of natural gas. The procurement of LNG is mainly for meeting the domestic energy demand. Besides, it is expected that Thailand will need to increase its LNG imports to be able to satisfy the increasing demand [3].

The result of the study can be used as initial data for the energy planning of the industrial operators. It can also be useful for determining appropriate policies to support long-term demand for natural gas of the country.

2. Methodology
The research consists of 3 steps: a review of Thai laws and regulation, fuel demand projection and fuel price projection.

2.1. Review of Thai laws and regulations
Relevant laws and regulations are reviewed throughout the natural gas supply chain to examine regulatory limitations on switching fuel oil and coal to natural gas in the industrial sector.

2.2. Fuel demand projection

2.2.1. Demand projection of each fuel. In the fuel demand projection, the supply chain of each fuel is examined to identify sources of supply and users. Then, the trend of fuel demand is forecasted using the historical demand data. In this regard, the national gas management plan 2018 – 2037 (or Gas Plan 2018) and the power development plan are examined for the country’s fuel plan in relevant sectors.

Next, the fuel demand forecasting model is developed based on the time series analysis. The econometric analysis with an autoregressive model is applied. The main assumption is that the growth rate of previous fuel demand has reflected the influences of domestic and external macroeconomic factors. Therefore, if there is no significant macro-level change in the trend, future demand will follow the existing trend. Equations for determining future fuel demand are as follow:

\[ r_t = \alpha + \sum_{k=1}^{m} \beta_k r_{t-k} \]  
\[ Q_t = Q_{t-1} (1 + r_t) \]

where
- \( r_t \) = growth rate of fuel demand in year \( t \)
- \( r_{t-k} \) = growth rate of fuel demand in previous years (year \( t-k \))
- \( \alpha \) = constant
- \( \beta_k \) = coefficient of fuel demand growth in year \( t-k \)
- \( Q_t \) = fuel demand in year \( t \)
- \( Q_{t-1} \) = fuel demand in the previous year
- \( m \) = total number of prior years taken into consideration in the model

The maximum likelihood estimation and the least squares method are applied to estimate the constant and coefficient.
2.2.2. Estimation of natural gas amount for fuel replacement. To examine the maximum natural gas requirement for replacing fuel oil and coal, it is assumed that 100 percent of both fuel oil and coal used as fuel in the industrial sector are replaced by natural gas.

2.3. Fuel price projection
Similar to the fuel demand projection, the econometric analysis with an autoregressive model is applied to project the fuel price for the year 2019 to 2037. The model is shown as in equation (3)

\[ p_t = \alpha + \sum_{k=1}^{m} \beta_k p_{t-k} + \gamma \]

where
- \( p_t \) = fuel price at month \( t \)
- \( p_{t-k} \) = fuel price in the preceding year at month \( t-k \)
- \( \alpha \) = constant
- \( \beta_k \) = coefficient of fuel price at month \( t-k \)
- \( \gamma \) = average monthly growth rate trend of fuel price
- \( m \) = total months taken into consideration in the model

The maximum likelihood estimation and the least squares method are applied to estimate the constant and coefficient.

Because Thailand will need to increase its LNG imports to meet the increasing domestic demand [3], the future LNG price will be used in the comparison with future fuel oil and coal prices.

3. Results

3.1. Review of Thai laws and regulations
From the review, there is no legislation prohibiting the replacement of fuel oil or coal with natural gas. However, some regulatory limitations are found. Although LNG is expected to play a very important role in meeting domestic energy demand, Thailand still lacks specific legislations for LNG, for example, the identification of LNG as fuel or the description of its quality.

3.2. Fuel demand projection

3.2.1. Natural gas demand projection
Natural gas consumed in Thailand is mainly from 3 sources. The main sources are from domestic fields (72 percent) covering both onshore and offshore fields. Other sources are imports from Myanmar via pipeline (16 percent) and imports from other countries as LNG (12 percent). There are 4 major users of natural gas, which are petrochemical industry (22 percent), power generation sector (57 percent), industrial sector (16 percent) and transportation sector (i.e. natural gas vehicle) (5 percent) [1].

According to the forecast (figure 1(a)), the demand for natural gas in power and industrial sectors will be increased. This may be due to the need to substitute carbon-intensive fuels with natural gas. However, it is forecasted that the natural gas demand in the petrochemical industry will be decreased. As natural gas consumed in the petrochemical industry is primarily from domestic, the decline in domestic gas production will affect this industry. The demand in transportation is also expected to be decreased. Since current oil prices are not at a very high level and the government agrees to float NGV prices, there will be fewer new NGV cars entering the transportation system, while the old NGV cars are being discharged from the system.
3.2.2. Fuel oil demand projection
As for fuel oil, it can be procured from 2 sources: domestic crude oil (20 percent) and imported crude oil (80 percent). In Thailand, fuel oil is mainly used as fuel in 3 sectors: industry (47 percent), maritime transportation (52.75 percent) and power generation (0.25 percent) [1].

According to the projection (figure 1(b)), fuel oil use in the power generation sector will be decreased until there is no use remained. This may be because of the high price of fuel oil. On the contrary, the use of fuel oil in maritime transportation is expected to be stable if there are no compulsory measures to switch to other fuels. The use of fuel oil in the industrial sector is likely to be stable or slightly increased as many operators have already switched to other cheaper fuels. Operators who are still using it are the ones who cannot access to other types of fuels.

3.2.3. Coal demand projection
Coal consumed in Thailand is from both domestic (38 percent) and import (62 percent). Its use can be found in the power generation sector and the industrial sector [1].

It is forecasted that the demand for coal in both power generation and industrial sectors will be decreased (figure 1(c)). Although coal has a lower and less volatile price, it has more environmental issues compared with other fuels. Additionally, the prices of other fuels are currently at a low level, there is no motivation for the operators to switch their fuels to coal.

3.2.4. Estimation of natural gas amount for fuel replacement
It is found that replacing fuel oil and coal in the industrial sector in Thailand would increase the overall natural gas demand by approximately 20-24 percent annually (figure 2). It is also found that global LNG capacity is expected to be expanded (figure 3) [4]. Thus, although there is a signal of depletion of natural gas in the Gulf of Thailand, the increment of natural gas demand is considered to be achievable.
3.3. Fuel price projection

Price projections of natural gas, fuel oil, and coal are shown in figure 4. It can be seen that fuel oil prices are likely to be greater than natural gas prices since the year 2019 and the spread will keep expanding. Coal price, on the other hand, is forecasted to be relatively stable and lower than both fuel oil and natural gas prices.

Therefore, based only on the fuel price and assumption that there is no significant change in fuel price structure, replacing fuel oil with natural gas will financially benefit the industrial operators. On the contrary, if there are no compulsory measures from the government or other powerful external drivers, the fuel price solely will not incentivize the operators to switch their fuels from coal to natural gas.

4. Conclusion

According to the study, it can be concluded that natural gas is an interesting option for replacing fuel oil and coal in the industrial sector. The projected amount of natural gas for satisfying the replacement is considered to be achievable with the available global LNG supply capacities. The price projection shows an interesting option for fuel oil users as natural gas price is projected to be lower than fuel oil price in the long term. However, it should be noted that switching to natural gas will require additional costs such as infrastructure development and transportation costs. Such additional costs are not included in this study and thus should be further examined to assess actual financial feasibility.

In view of coal replacement, fuel price alone will not motivate coal users to switch their fuels. However, in the interest of the overall environment and public health benefits, it is suggested that the
government should have strong measures to stimulate coal-fired industries to switch their fuels to more environmentally friendly ones.

Certain fuels such as liquefied petroleum gas (LPG), which are also being consumed in the industrial sector, have not yet been included in this study. A further study is advised to assess total replacement possibilities for the country.

Finally but importantly, as LNG is expected to play an important role in Thailand, it is necessary to have specific laws of LNG. Priority should be given to the identification of LNG as fuel and the description of LNG quality. Other legislations can be modified from those of natural gas.

References
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