Prospect of coal-based methanol market in Indonesia

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Abstract. Coal is one of the commodities in the mining sector which is currently being pushed to strengthen the structure of the upstream petrochemical industry, including methanol as a raw material for various derivative industries, most of which are still imported. Currently, Indonesia has only one methanol plant with a production capacity of 660,000 tons. During 2023-2035, Indonesia needs an average of 1.77 million tons of methanol per year. If, until 2035, Indonesia does not add and build a methanol plant, then Indonesia will always import 1.51 million tons per year. Results indicate that the methanol plant, through coal gasification, can support the growth of the methanol-base industry to reach domestic needs and reduce imports. It can also as an export commodity to generate foreign exchange.

1. Introduction
Indonesia is one of the largest coal-producing countries in the world. According to the Geology Agency, in 2020, Indonesia's coal resources are 143.73 billion tons and total reserves of 38.81 billion tons [1], ranking the sixth-largest in the world. Indonesia's coal production in 2019 amounted to 616 million tons, in which the use domestically of 22.44% and export of 77.56%. Until now, coal has become a source of foreign exchange because of the value of export, earned about USD 21.6 billion, and became the country with the second-largest coal export revenue in the world.

Since the enactment of Law No. 4 of 2009 concerning mineral and coal mining [2], the implementation of coal mining has been ineffective because it has not provided an optimal added value. The issuance of Indonesian Law No. 23 of 2020 which is related to the amendment of Law No. 4 of 2009, is expected to be able to provide significant changes to coal mining activities which are not only mining and selling raw/bulk coal but should be accompanied by efforts to develop and utilize coal to meet the needs of the domestic downstream industry.

The development and utilization activities are regulated in Government Regulation No. 23 of 2010 in conjunction with Government Regulation No. 77 of 2014, article 94 paragraph 1. Then, followed by the Minister of Energy and Mineral Resources Regulation No. 25 of 2018, article 16, which states that every company that wishes to apply for an extension of the mining business license (IUP) for production operations (OP) and a special IUP OP (OPK) must carry out one of the 6 suggested activities to increase the added value of coal. One of the activities that have good prospects for development is coal gasification technology. This process produces synthesis gas, which can be used directly or indirectly for various downstream industries such as power plants and industrial chemical feedstock such as methanol and ammonia. The process is in line with the National Industrial Development Master Plan 2015-2035, which compiled by the Ministry of Industry of the Republic of Indonesia that the development of the coal gasification industry as an upstream industry is part of the development priorities to support and strengthen the development of the domestic methanol industry.
There are several reasons for the Government to make methanol as a development priority. First, methanol is a petrochemical industry that plays a very important role in developing the chemical industry and the development of alternative energy. Second, about 75% of Indonesia's methanol needs are imported from abroad. Since 2016-2019, Indonesia's methanol trade balance deficits of about USD 216 million or nearly IDR. 3.13 trillion per year. Third, other strategic downstream industries use methanol as the primary raw material for their production activities.

This study aims to provide an overview of market developments and the benefits of methanol in Indonesia and the world including the opportunity of coal gasification development to meet the domestic methanol industry needs. It is hoped that it will provide the optimism of mining entrepreneurs to carry out coal downstream. Past, present, and future developments in the methanol market, both national and global, can be used as a basis for consideration in developing the methanol industry in Indonesia. The method used to analyze the future development of methanol is the regression analysis method.

2. Methodology

2.1. Collecting data method
In this study, secondary data is needed from various sources [3], including companies, related agencies/institutions, such as the Ministry of Energy and Mineral Resources, Ministry of Industry, Ministry of Trade, Central Bureau of Statistics, and results of some previous researches and other literature related to this topic as well as related internet media.

2.2. Regression model
One of the statistical methods that are often used to predict a situation in the future at a certain time, both quantitatively and qualitatively, is the regression model [4]. This method is also used to detect the extent of the relationship between the independent and the dependent variables. The independent variable or the predictor variable is usually denoted as X, while the response or dependent variables is denoted as Y. The relationship between independent and dependent variable within a certain time can be expressed in a linear regression equation model as shown in Equation 1 [5]:

\[ Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \ldots + \beta_k X_{kt} + \varepsilon_t \] (1)

where:
- \( Y_t \) = dependent variable at time \( t \),
- \( X_{kt} \) = independent variable \( k \) or estimator variable \( k \) at time \( t \)
- \( \beta_0 \) = constant value
- \( \beta_k \) = regression coefficient of variable \( X_k \)
- \( \varepsilon_t \) = error term

The model will be used to calculate or predict the changes of the estimator variables on the dependent variable at a certain period.

In addition to regression, the average annual growth of a variable during a certain period is calculated using compound annual growth rate (CAGR) [6] as shown in Equation 2:

\[ \text{CAGR} = \left( \frac{\text{ending value}}{\text{starting value}} \right)^{\frac{1}{n}} - 1 \] X 100 (2)

where:
- \( n \) = number of years from starting to ending value

3. Result and Discussion

3.1. Coal gasification and methanol
As mention above, coal resources and reserves in Indonesia are abundant. However, most of them are categorized as low-rank coal [7]. The LRC was previously seen as uneconomical to be extracted and not
a feasible source of fuel because of its high moisture content, low heating values, and high spontaneous combustion tendency [8–10]. As a result, this type of coal is not economical for export. According to Balopi et al. [11], LRC is suitable for being used as a raw material for the gasification of coal into synthetic gas to produce methanol because LRC usually has higher reactivity than that of high-rank coal. According to the gasifier type, coal gasification technology is broadly divided into three majors, fixed bed, fluidized bed, and entrained flow [12]. The entrained flow consists of two types, slurry feed and dry feed.

Indonesian Government encourages mining companies to utilize this low-rank coal for petrochemical through coal gasification technology. Coal gasification (Figure 1) is the process of producing syngas—a mixture consisting primarily of carbon monoxide (CO), hydrogen (H₂), carbon dioxide (CO₂), natural gas (CH₄), and water vapor (H₂O) [13]. The syngas can be used to produce a range of chemicals, either directly or intermediates, such as methanol, dimethyl ether (DME), fertilizers, polypropylene, and other various high-value products [14].

Currently, most methanol is produced by the catalytic reaction of synthesis gas, as shown in Equation (3). Figure 1 shows the simple process flow diagram for the methanol production from the reforming of syngas [15].

\[
\text{CO} + 2\text{H}_2 \leftrightarrow \text{CH}_3\text{OH} \quad \Delta H = -90.64 \text{ kJ/mol} \quad (3)
\]

![Figure 1. Simplified block flow diagram of the synthetic gas reforming process for methanol production.](image)

The investment cost of a methanol plant with a capacity of 5,000 ton/d is about USD 2,425 with an operating cost of USD 286/ton. The type of coal used is sub-bituminous of USD 70/ton. Each ton of coal can produce 0.58 tons of methanol (the price is USD 359/ton). The internal rate of return (IRR) is 8.6.5% [16]. Economically, the construction of a coal-based methanol plant can be considered to be followed up.

Methanol and its derivatives in the chemical industry are used as raw materials for several chemical commodities [17]. Since 2016, the methanol industry development has become a part of the strategic plan of the Ministry of Industry, which is then outlined in the Regulation of the Minister of Industry of the Republic of Indonesia Number 85.1/ M-IND/ PER /12/2016. The Government continues to encourage the construction of domestic methanol plants whose raw materials come from the coal gasification process. The development of the coal gasification industry for methanol is very important for developing the domestic petrochemical industry because it contains olefin aromatic, synthetic gas, and other organic compounds derived from this material [18].

3.2. Domestic methanol’s development

Until now, Indonesia only has one methanol producer, namely PT. Kaltim Methanol Industry (KMI) with a production capacity of 660,000 tons per year. The raw material is natural gas from Badak Gas Field Center, Bontang, East Kalimantan [19]. About 70% of its product is exported, and about 30% is sold domestically [20]. Since 2008-2017, Indonesia's methanol production has mostly been for export. However, the composition of KMI's methanol sales has slowly changed every year. Early 2018, about
53% of KMI's methanol production was sold domestically, and the rest was exported to China, Thailand, the Philippines, Japan, Malaysia, and Vietnam. Until 2019, Indonesia's methanol domestic sales will grow up to 56%. This condition indicates that the growth of domestic methanol users in the downstream industry is growing, so Indonesian methanol producers prioritize domestic demand.

During 2008-2019 the domestic demand for methanol increased with a CAGR of 21.78% per year. The increase in methanol domestic demand shows the rapid development of the methanol user industry. In 2008 the amount of methanol domestic demand was only 107,000 tons, but in 2019 the methanol demand increased to 1.14 million tons. The availability of methanol cannot match the high methanol demand due to the limited production. Even though KMI has tried to reduce its exports to meet domestic needs, Indonesia still has to import methanol as much as 772,000 tons from Malaysia and the Middle East (BPS, 2010). Meanwhile, Indonesia's methanol production is exported to China, Thailand, the Philippines, Japan, Malaysia, and Vietnam. Indonesia's methanol imports of about 772 thousand tons are an indicator of market opportunities for investors who wish to build domestic methanol plants so that Indonesia can save USD 273 million in foreign exchange [21].

Signs of increasing growth in the chemical industry as a methanol user in Indonesia can be seen from the increasing growth rate of imports, which increased by 22.38% on average, exports decreased by 6.08% per year, and domestic sales increased by 20.06% per year.

During 2008-2012, Indonesia's methanol trade balance surplus in an average of USD 61.52 million per year, due to the most of its products were exported. However, in 2013 Indonesia's methanol trade began deficit with a value of USD 9 million, this situation continued until 2019 the deficit reached USD 216 million or equivalent to Rp. 3.04 trillion. The large difference in the methanol trade deficit is influenced by the difference in prices between exports and imports. For example, the export price of Indonesian methanol in 2019 was USD 217, while the import price was USD 362 (Figure 2)[21].

Methanol is an intermediate compound used as raw material for various derivative industries, such as acetic acid, formaldehyde, olefins, methyl tertiary butyl ether (MTBE), polyvinyl, polyester, rubber, synthetic resins, pharmaceuticals, and dimethyl ether (DME) industries. Olefin is the most important petrochemical base material in producing ethylene which is used as the base material for polyethylene to produce plastic packages, such as plastic bags and plastic wraps and covers [22].

![Figure 2](image_url)  
**Figure 2.** Indonesia's methanol trade balance, 2008-2019 (USD million) [21]

Central Bureau of Statistic [22] noted that the main industrial trade transactions of methanol derivatives during 2019 reached USD 472.39 million with an export composition of USD 128.77 million (27%) and imports reaching USD 343.62 (72%) million. Except for formaldehyde and methyl
methacrylate surplus in trade, almost all methanol derivative products were deficient. In general, the industrial trade transactions of the methanol derivative in Indonesia were a deficit of USD 214.84 million or equal to Rp. 2.99 trillion.

There are 3 (three) methanol derivative industries with the largest trade transaction value, i.e. olefins of USD 296.87 million, followed by acetic acid of USD 96.42 million and ethyl acetate of USD 68.15 million (Figure 3). Although the three products had the largest transactions, this industry also had the largest deficit of USD 106.68 million, USD 91.96 million, and USD 68.11 million, respectively. In general, the dependence on imports of Indonesian methanol derivative industries is very high, at about 60-99%. This condition shows that Indonesia's methanol industry has not been able to meet the needs of domestic derivative industries due to limited production. Therefore, the development of the coal-based methanol industry is very important to increase the competitiveness of its derivative products and the petrochemical industry’s independence in Indonesia.

The largest consumer of methanol in Indonesia is the formaldehyde industry (80%), and the rest of 20% is distributed to be used by the acetic acid, MTBE, and other industries that use methanol as raw material. Products produced by the formaldehyde industry are adhesives for plywood and other wood processing industries. As the largest domestic methanol user, the formaldehyde industry can use this raw material to become an export commodity so that the trade in this commodity has a surplus of USD 18.77 million. The dependence of the petrochemical industry and its derivative industries on methanol is very high, and limited supply from domestic methanol producers makes Indonesia import a quite large amount of methanol.

The trade value of each derivative product is much higher than the value of its raw material (methanol). For example, Indonesian methanol's trade (export/import) price in 2019 at an average of USD 289 per ton. Meanwhile, the trade (export) price of formaldehyde is USD 1,141 per ton, and the selling price is 5.26 times the price of raw materials. If it is processed into formic acid, the price is USD 578 / ton, almost 3 times more expensive than methanol.

![Figure 3. Trade balance of methanol-based industries, in 2019 [21]](image)

### 3.3. World methanol development

Methanol is used as a fuel and as a feedstock for producing pesticides, medicines, formaldehyde, acetic acid, and dimethyl ether [23]. Globally, the use of methanol in 2019 reached 98.3 million tons,
an increase of 7.18% compared to 2018, which amounted to 91.71 million tons [24,25]. Based on the
data for 2015-2019, the CAGR of world methanol demand increased by 5.54% per year. The five
industries with the highest growth in the methanol derivative industries group are the CAGR of olefins
of 10.98%, the acetic acid industry of 5.95%, formaldehyde of 4.05%, Methyl Chloride (Chloromethane)
of 3.8%, methyl tert-Butyl Ether of 4.34%, and Methylamines of 2.65%. The highest growth rates of
CAGR in the alternative fuels group were Biodiesel of 24.20% and fuel cells of 12.46%.

3.4. Prospect of methanol industry development through coal gasification

3.4.1. Domestic methanol market prospects. The high growth of methanol import volume indicates
that the demand for methanol in Indonesia is enormous, along with the development of its derivative
industries. Based on methanol import data from 2008-2019, the average annual growth of methanol
imports increased by 22.38% [26].

The projection of methanol imports follows a regression model as shown in Equation 4.

\[ m = \beta_0 + \beta_1t \]  

where:
- \( m \) = import
- \( t \) = span of time of the projection
- \( \beta_0, \beta_1 \) = intercept (constant value) and coefficient of time variable (t) respectively.

Based on the regression, the volume of import (m) is estimated in the form of:

\[ m = 5.62 + 53.66t \]

The result is that methanol imports in 2023 or 16 years from the base year are expected to reach \( m = 5.62 + (53.66 \times 16) = 864 \) thousand tons. Indonesia’s methanol imports in 2025 (\( t = 18 \)) will increase to
972 thousand tons. In 2030 and 2035, imports will increase by 1.24 million tons and 1.51 million tons,
respectively [25]. In 2023, Indonesia’s economic condition is expected to return to normal after being
hit by the Covid-19 pandemic.

Indonesia’s methanol exports are estimated according to Equation 5.

\[ x = \beta_0 + \beta_1t \]  

where:
- \( x \) = export
- \( t \) = span of time of the projection
- \( \beta_0, \beta_1 \) = intercept and coefficient of time variable (t) respectively.

The regression result shows that the export of methanol is estimated by:

\[ x = 573.93 - 22.95t \]

Indonesia’s methanol exports in 2023 (\( t = 16 \)) are estimated to reach 207 thousand tons. In 2025 (\( t = 18 \)), Indonesia’s methanol exports will decrease to 161 thousand tons. Zero exports will occur in 2032,
where Indonesia will no longer export methanol (Figure 4) due to increasing demand. Indonesian
methanol producers prioritize domestic industrial needs (Figure 4).
Domestic methanol consumption every year increases significantly, reaching 21.78%, almost directly proportional to the development of Indonesia's methanol imports. By using multiple linear regression model, the future methanol demand of Indonesia is estimated in the form of:

\[ c = 657.29 - 0.99x + 1m + 0.17t. \]  

Using the above model, Indonesia's methanol demand in 2023 \((t = 16)\) is \(c = 657.29-0.99(207) +1 (864) +0.17 (16) = 1.32\) million tons. In 2025 \((t = 18)\), the amount needed will increase to \(c = 1.47\) million tons. Domestic methanol consumption will continue to increase until 2035 \((t = 28)\) to 2.17 million tons.

The increasing demand for domestic methanol consumption every year forces domestic methanol producers, whose production is only 660 thousand tons, to reduce their exports to meet domestic demand for methanol gradually. Although starting in 2032, the total domestic methanol production is to meet domestic methanol needs. This amount is not enough to meet all domestic demand, so Indonesia still has to import it. This condition continues until 2035 the demand is almost four times higher than the current production capacity (Figure 4).

Suppose there is no addition of a methanol plant or an increase in the capacity of a methanol plant. In that case, imports will likely increase so that Indonesia will be a net importer of methanol, which is certainly unfavorable for the development of the domestic petrochemical industry. Therefore, the government encourages the domestic petrochemical industry to develop upstream industries such as methanol. of the domestic petrochemical industry through the development of upstream industries such as methanol. Therefore, the development of the coal-based methanol industry must be accelerated to anticipate the deficit in Indonesia's methanol trade balance in the future.

Currently, Indonesia is preparing to build a coal-fired methanol plant through a gasification process, located in the Batuta Coal Industry Park (BCIP), East Kutai, East Kalimantan. This plant is projected to produce methanol of about 1.8 million tons, which is processed of about 4.7-6.1 million tons of coal per year with about USD 2 billion investment. Another plan of the Ministry of Industry is to develop a petrochemical industrial estate and a methanol plant in Bintuni Bay, West Papua. BP Tangguh is ready to support and distribute natural gas of 90 MMSCFD to the methanol plant with a capacity of 900,000 tons per year. If these two plants are realized, domestic demand for methanol will be fulfilled until 2035,
and the excess can be sold globally. Domestic market opportunities are also quite large because the petrochemical industry and its derivatives depend on the methanol industry, among others as raw materials such as the olefins, acetic acid, and formaldehyde industries, which have a very large trade deficit in Indonesia.

### 3.4.2. Global methanol market outlook

Global methanol imports in 2019 reached 29.91 million tons, an increase of 10.81% compared to the previous year, which was 26.99 million tons. During 2015-2019, the CAGR of global methanol imports increased by 5.45% [25]. China is the largest importer that imported 7.7 million tons of methanol of about 28.87% of total world imports in 2017. The second position is the United States, with imports of 2.5 million tons, or 9.37% of the total import. The Netherlands, which imports 2.4 million tons or 9.00% of total world imports, takes third place in the importer ranking.

In the future, it is estimated that the use of methanol will be dominated by formaldehyde [26], methanol-to-olefins, MTBE, and gasoline blending & combustion industries. Based on the CAGR of each methanol user industry, the total world demand for methanol in 2024 is estimated to reach about 135.21 million tons. With the development of the petrochemical and automotive industries, the world demand for methanol in 2035 will increase by about 363.4 million tons (Figure 5).

![Figure 5. Realization and forecast of world methanol demand according to industry users, 2015-2019 and 2020-2035 (million tons) [25]](image-url)

Based on the CAGR of world methanol production, which is 5.66% per year, the total world methanol production in 2025 is estimated to reach 137 million tons. Meanwhile, methanol consumption in the same year is estimated to reach 145 million tons. It means that there will be a methanol deficit of 8 million tons. Based on the current methanol production capacity (147 million tons), world demand for methanol is expected to be met by 2026. However, if there is no additional production capacity or no additional methanol plants in the world, in 2028, there will be a world deficit of methanol supply of about 37 million tons.

The world demand for methanol in 2035 is estimated to reach 363 million tons. If production capacity is not increased, the world will suffer from methanol supply deficit of 217 million tons. This world methanol trade statistic is an indicator of Indonesia's market opportunities if it can develop the methanol industry in the country by utilizing coal from the domestic coal gasification process. Therefore, the next seven years are an opportunity for Indonesian coal mining players to accelerate coal gasification for methanol development because global market opportunities are widely open.
4. Conclusions
The development of the coal gasification industry to produce methanol is a priority of the Ministry of Industry because these methanol derivatives are widely used in various aspects of life. It can be indicated by the high demand of the petrochemical industry and its derivatives. The coal-based methanol industry reduces the domestic methanol deficit, substitutes for methanol derivatives products, and potential to be exported. The methanol industry through coal gasification is expected to play a role in supporting the growth of the formaldehyde industry to reach domestic needs and reduce imports. It can also as an export commodity to generate foreign exchange. In addition, it is expected to reduce the dependence on the olefins and acetic acid industries and to reduce the trade balance deficit of the two commodities. Therefore, the construction of a methanol plant through coal gasification to support the development of a methanol-based industry is very urgent and strategic to reduce the independence of the national industry, increasing competitiveness and reducing the trade balance deficit due to the high dependence on imported raw materials of the chemical industry. Further research is very important to study the economics of the methanol plants and their derivatives through the coal gasification process.

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