Business analysis of implementation of UCG technology in Indonesia

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Abstract. There is a deep-seated coal potency with a depth more than 100 meters below surface in Indonesia that has not been exploited yet. Underground Coal Gasification (UCG) is an unconventional technology that can become the solution to exploit the deep-seated coal potential by extracting coal into in-situ gas that can be converted to electricity or chemicals. Based on business analysis, this paper aims to analyze the implementation of UCG technology in Indonesia, whether it is potential or not. Data are collected from literature and analyzed using Porter Five Forces and PESTLE Analysis. The Porter Five Forces analysis shows that the implementation of UCG in Indonesia is still potential as an industry because the only threat will come from substitute products. PESTLE analysis shows that almost all the factors, except for technology, are very supportive of implementing UCG commercial plants in Indonesia. Based on both studies, it can be concluded that the UCG project is very potential to be developed in Indonesia. However, it needs full support and control from the government because it will become a pioneer project with financial and environmental risk still has not quantified ideally.

1. Introduction

1.1. Background
The demand for electricity and chemicals in Indonesia is increasing, along with the population increase and positive economy. Indonesia's economy has been dependent on natural resources as the second leading contributor to the country's income. Indonesia is still reliant on fossil fuels, especially oil and gas. Based on the projected energy needs undertaken by National Energy Council (DEN), oil import dependence will reach 72.5% in 2025 and 95.5% by 2050 for the business as usual (BAU) scenario. In the same scenario, natural gas imports will increase significantly. By 2025, gas imports will be 31 million TOE and will increase to 221 million TOE in 2050 [1]. It means that Indonesia's new reserve of gas is crucial to be found either from conventional gas or unconventional gas.

Indonesia has not only oil and gas but also coal. According to data from the Geological Agency of the Ministry of Energy and Mineral Resources in 2021, Indonesia's coal resources up to December 2020 amounted to 143.73 billion tons of coal, while coal reserves of 38.81 billion tons. Indonesia has abundant coal resources classified as surface resources (with depth 0-100 m below surface) and deep-seated coal resources (with depth 100-500 m below surface). There are about 40 billion tonnes of deep-seated coal resources explored, as can be seen in Table 1 [2]. The total resources of deep-seated coal until December 2020 is 43.53 billion tons, while the reserves are 173.51 million tons [3]. The resources in South Sumatera are the biggest, followed by East Kalimantan and South Kalimantan.
Table 1. Potential deep-seated coal in Indonesia [2]

| No | Basin      | Resources (ton) |
|----|------------|-----------------|
| 1. | South Sumatera | 21,292,210,000  |
| 2. | Kutai      | 16,005,562,610  |
| 3. | Barito     | 904,587,721     |
| 4. | Pasir      | 129,481,296     |
| 5. | Tarakan    | 2,480,675,828   |
| 6. | Ombilin    | 7,987,200       |
|    | Total      | 40,820,304,655  |

Unconventional mining or methods will be needed to exploit the deep-seated coal potential. Indonesia recently is reviewing the use of underground coal gasification (UCG) technology to utilize deep-seated coal potential because UCG is an unconventional technology for extracting coal into in-situ gas directly in the underground layers without excavating rock cover and coal seam first. It can provide an economical approach to utilize coal reserves. Because of located in great seam depths and complex geological boundary conditions, it is not suitable for exploitation using conventional coal mining [5][6]. UCG offers a coal extraction and conversion method in a single process that avoids many of the challenges associated with conventional mining practices. UCG could provide a cost-effective, near-zero-carbon energy source through the use of a self-contained system with a closed carbon loop [7].

There are around 43.5 billion tons of deep-seated coal as resources in Indonesia. If assuming that 1 kg of coal can convert to 27.78 scf of syngas and some correction factors, the potential gas resources from UCG is 764 Tcf. This is a huge resource and almost two times higher than CBM (Coal Bed Methane) resources, about 337-453 Tcf [8]. It is also much higher than natural gas reserves in Indonesia which are around 142.72 Tscf, as mentioned in Indonesian Natural Gas Balance 2018-2027.

The demand for gas in Indonesia will increase significantly for industrial and chemical use. Currently, some chemicals in Indonesia, such as olefin and aromatic, are still imported. Raw materials used for the chemical industry use naptha from oil, which 90% of is imported. In the future, Indonesia can use raw materials from domestic and reduce imports. Therefore Indonesia needs another source of gas. The demand for gas in Indonesia will increase. It is in line with the world condition that the demand for gas for chemicals is predicted to increase in the future [9] (Figure 1).

Figure 1. Global gas demand 2019-50 (bcm)
1.2. Research objectives

Until now, there is only one commercial UCG plant that still operated. It was a small-scale power plant (<100 MW) in Angren City of Uzbekistan, built-in 1960. Since then, several studies have been conducted to analyze the economics of large-scale UCG syngas plants (>100MW) for a variety of uses, including for fuel in combined cycle power plants [10,11] and raw materials in liquid fuel synthesis [12], methanol [13] and hydrogen [14]. Even though the results of the above study recommending the excellent potential of UCG technology, no UCG-plant have been built. Because of that, to implement UCG technology in Indonesia, economic analysis is needed and business analysis is also required. Therefore, this research aims to analyze the implementation of UCG technology in Indonesia whether it is potential or not based on business analysis.

2. Methods

2.1. Conceptual framework

Conceptual framework of business issue exploration will be performed as the following:

![Figure 2. Conceptual framework](image)

2.2. Method of Data Collection and Analysis

Data was collected through study literature, expert recommendation, and data collection from UCG pilot plant in South Sumatra. Study literature by using references, including paper and textbooks. Data were processed by business analysis such as PESTLE analysis and competitive analysis using Porter Five Forces.

3. Results and Discussion

UCG commercial plant will become a pioneer project in Indonesia in order to optimize deep-seated coal utilization. Several studies should be taken to ensure the development of UCG in Indonesia will succeed. Porter 5 forces analysis and PESTLE analysis will be used to analyze the business situation.

3.1. Porter Five Forces Analysis

Porter Five Forces Analysis is a powerful instrument for thoroughly analyzing the industry's environmental forces and market structures. The model provided a flexible framework to describe and assess competitive pressures and industry attractiveness [15]. In this theory, Porter identifies five undeniable forces that play an essential part in shaping every market and industry in the world. The purposes of this model are conducting an external analysis by measuring the degree of rivalry, bargaining power of suppliers, bargaining power of buyers, the threat of substitute products, and the threat of new entrants [16].

1. Threat from new entrants

This part is to measures potential threats from new entrants to the industry. Some industry may have barriers that will prevent new competitors from entering, and some other may have fewer barriers or
even does not have at all that will make it easier for a new rivalry to enter the industry. The existing company usually will prefer to have fewer competitors.

In UCG industry, the threat from new entrants is low. The reasons are because: first, it is a pioneer project in Indonesia, so the risk is still relatively high; second, it requires specific technology, experts, and high capital to build UCG commercial plant; third, need to secure a buyer or specific market before the project began; fourth, it requires a special permit from the government to enter the UCG industry; fifth, it requires specific locations with sufficient coal reserves.

2. Bargaining power of suppliers

This part is to measures how strong the bargaining position of suppliers is. Suppliers with high bargaining positions might impact the overall cost and could reduce the margin. An industry usually has many suppliers, and each supplier could have a different bargaining position.

The supplier for UCG commercial plant mainly does not have high bargaining position because it primarily uses standard equipment and materials usually used in mining, gas industry, and power generation. The highest bargaining position could be from a technological supplier. However, the technology provider can be asked to become a partner in developing UCG in Indonesia. After all, the successful development of UCG in Indonesia will become excellent publicity of their technology to the world. Therefore, the bargaining power of suppliers is low.

3. Bargaining power of buyers

This part is to measures how strong the bargaining power of buyers. More substantial bargaining power may put pressure on the company for lower prices or higher product quality. The product of UCG is mainly used to generate electricity or chemical. In terms of the electricity industry, PT PLN still dominates the electricity market in Indonesia, so it has high bargaining power. However, the electricity tariff is determined by the Government of Indonesia through the Ministry of Energy and Mineral Resources. The government is also concerned about the successful development of UCG industry because it will help the economic growth in Indonesia. Regarding the chemical product, will mostly depend on the market. Therefore, it can be concluded that the power of buyers is medium.

4. Threat from substitute products or services

This part is to measures the threat from substitute products or services. Customers will choose products or services that offer attractive prices with the equal specification. The product of UCG mainly will become an electricity or chemical product. The energy sources for electricity in Indonesia, especially in South Kalimantan, are much. There are oil, gas, surface coal, and new renewable energy. The cost to generate electricity from different sources is varied also. The lowest is coal, and the most expensive is from new renewable energy (excl. water). The cost to generate electricity of UCG technology is predicted to be lower than diesel but higher than coal and water. Therefore, the threat from substitute products is high.

5. Degree of rivalry

This part is to measures how intense the competition between players in the particular industry. More intense competition will make the industry unattractive to existing players. UCG commercial plant until now still on the plan or not yet realized in Indonesia. Since it will be the first commercial plant, it will have no competitors. Therefore, the threat from competitors is low.
Based on Figure 3, above all, the UCG industry is still a potential industry because the only threat will come from substitute products. However, because it will become a pioneer, it still needs government support so the industry will have sustainable development.

3.2. **PESTLE Analysis**

PESTLE analysis is a framework or method used for strategic business planning. It can be used by the management of both commercial and non-profit organizations. It can be used to identify the external factors that influence an organization. Marketers or investors, or governments to analyze and monitor the external factors that impact a business or an organization [17]. The factors are:

1. **Political**
   
   Political factors determine the extent to which a government may influence the economy or a particular industry. Political factors have areas including tax policies, fiscal policy, trade restriction, tariffs, and political stability. In Indonesia, some conditions that have influences UCG investment are as follows:
   
   - Political stability is good and stable. The government has support from the majority of parties in the house of representatives of the Republic of Indonesia.
   - The government under President Jokowi has been prioritizing infrastructure development in Indonesia, especially outside of Java island. It will help for business because it will reduce the transportation and electricity cost.
   - GOI also encourages downstream coal business and provides fiscal and non-fiscal incentives such as tax holidays, tax reduction, national strategic projects, and 0% coal royalty [18].

2. **Economical**

   Economic factors, such as inflation rate, interest rates, foreign exchange rates, economic growth, are determinants of an economy's performance that directly impacts a company and have long-term resonating effects. It would affect the purchasing power of a consumer and change demand/supply models for that economy. It also accounts for the FDI (foreign direct investment) depending on certain specific industries undergoing this analysis.

   Indonesia's economic factors are quite stable, and the growth rate tends to increase better than other countries. GDP is commonly used to measure the economic performance of a country and can be used to measure the growth of the economy from year to year. Inflation rates could be used as a reference to predict the increase in raw material costs and revenue of all industries.
Figure 4. GDP per capita of Indonesia [19]

Figure 5. Consumer price index of Indonesia

Figure 6. The inflation rate of Indonesia

Figure 4 shows that Indonesia has a stable economic development. This can be illustrated in the growth of GDP per capita that increased each year until 2019. The CPI is a reference of purchasing power of products and services, and it has kept increasing from 2011 until now (Figure 5). Even though the inflation rate fluctuates, it is still tolerable since the GDP also increases, and since 2015 the inflation rate has been relatively stable (Figure 6). Another important economic indicator is the change in the currency.
Figure 7 above shows that even the currency change has fluctuated in the last ten years; however, since 2016, the currency change has been relatively stable. The fluctuation of dollar currency is substantial because it will affect the UCG industry. After all, the capital investment is most likely in USD, but the revenue most likely will be in IDR.

3. Social

Social factors consist of the social environment of the market and gauge determinants like cultural aspects, demographics, population growth rate, age distribution. Trends in social factors could affect the demand for a company's products and how that company operates.

The component of social factors in Indonesia is related to people's beliefs, values, attitudes, opinions, and lifestyles to the company or industry. The company should prepare to contact and embrace figures in society around the company's location so the community will support or at least not disrupt the company's operation. Information should be clear and easy to get so there will be no misunderstanding between the company and the community.

As a pioneer and new company that establishes in a certain location in Indonesia, it should be followed the local tradition and provide certain benefits. There is usually labor recruitment that prioritizes the local community and contributes to public and religious facilities around the company. Fortunately, in Kalimantan, the community is already used to the mining company, so the adaption of community through UCG commercial plants will become faster and easier.

4. Technological

Technological factors include technological aspects such as innovations in technology that may affect the operations of the industry and the market favorably or unfavorably. Technology refers to automation, research and development, and technological awareness that a market possesses. It can determine entry barriers, minimum production level and affect the outsourcing decisions.

Currently, there is two primary technology of UCG: CRIP UCG and εUCGTM that have been researched, operated and developed in the world in the last 20 years. Projects are undergoing in China, India, South Africa, Australia, Indonesia, and Alaska. There are also several new UCG projects under consideration in Turkey, India, Canada, Argentina, Pakistan, and other locations [4,21–23]. Even though the UCG technologies above are not yet commercially proven, it is very potential that the technology provider became a partner to operate and develop the UCG commercial plant in Indonesia.

5. Legal

Legal factors have both external and internal sides. Including in legal factors are laws, regulations, and policies. Some laws only affect the business environment in a certain country, while some policies that companies maintain for themselves.

In general, Indonesia's energy policy is contained in Government Regulation (PP) 79/2014 on National Energy Policy (KEN), replacing Presidential Regulation (Perpres) 05/2006 on National
Energy Policy. Based on crucial policies in KEN, UCG is an essential alternative for coal utilization in Indonesia. Related to coal, KEN requires the portion of coal use in 2050 by 25% in the national energy mix explicitly [24]. The target of the energy mix is the target of providing and utilizing primary energy as well as the direction of national energy management. Other regulations related to UCG implementation in Indonesia are Law no 3 of 2020 on amendment of Law No. 4 of 2009 on Mineral and Coal Mining and Law no 11 of 2020 on Job Creation. The laws provided a legal basis for operational and incentives to encourage coal downstream technology in Indonesia in general. However, specific regulations regarding UCG are not yet formulated. Environmental protection such as groundwater preservation requirements and site restoration obligation should be a prime consideration while drafting a UCG contract. The regulatory outline is required to assume a viable implementation to safeguard the worth of the resource and guarantee the commercial feasibility of utility development [25].

6. Environmental

Environmental factors include all those that influence or are determined by the surrounding environment. The business environmental analysis includes but is not limited to climate, weather, climate change, geographical location, and environmental offsets, which could affect industries. The awareness regarding the environment is increasing in people. Awareness of climate change, for example, will affect how companies should operate and whether the market or society could accept the products.

The environmental requirements also become stringent, especially with the use of fossil fuels. Indonesia has been proactive in protecting the environment by ratified the Paris Agreement. Indonesia became the world's sixth-largest emitter of carbon dioxide in 2012, accounting for 4.5% of global emissions. Due to that, Indonesia has promised to reduce the emission in the future. Indonesia has targeted reducing greenhouse gas emissions around 29% from business as usual (BAU) in 2030 or 41% if there is any financial aid from developed countries.

These factors are forcing new directions in the research on alternative technologies for energy conversion and energy utilization. UCG technology is a clean coal technology that emits low emissions, especially compared to the conventional coal power plant. Table 2 below shows the life cycle greenhouse gas (GHG) emissions for power generation.

| Power Generation                              | Emission (kgCO2e/MWh) |
|-----------------------------------------------|-----------------------|
| Pulverized Coal Fired (PCC)                   | 1080                  |
| Supercritical Coal Fired (SCPC)               | 961                   |
| Integrated Gasification Combined Cycle Plants (Coal-IGCC) | 784                   |
| Combined Cycle Gas Turbine Plants for UCG (UCG-CCGT) | 774                   |

Blinderman and Anderson have studied the CO2 emissions at the Chinchilla UCG-IGCC project in Australia. It is estimated that the CO2 emissions from this plant are a 55% reduction compared to a supercritical coal-fired power plant and a 25% reduction compared to a gas-fired power plant [27].

Figure 8 below shows the result of the PESTLE analysis regarding the development of UCG commercial plant in Indonesia. Except for the technology factors then other factors are very supportive in the establishment of UCG commercial plant.
4. Conclusions

4.1. Conclusions
Porter's five forces analysis shows that the implementation of UCG in Indonesia is still potential as an industry because the only threat will come from substitute products. PESTLE analysis also shows that almost all the factors except for the technology factor support implementing UCG commercial plants in Indonesia. Therefore, UCG project is very potential to be developed in Indonesia. However, it needs full support and control from the government because it will become a pioneer project with financial and environmental risk still has not quantified ideally.

4.2. Recommendation
1. Government should support the implementation of UCG technology in Indonesia. It will utilize deep-seated coal, which has not been exploited. Meanwhile, the state's revenue will remain intact and will increase because coal from traditional mining can still be exported instead of used for electricity domestically.
2. There should be many studies regarding the implementation of UCG in Indonesia, such as scenario planning of UCG, environmental study of UCG project, risk analysis of UCG project. There will help government and investors make a wise decision and regulation regarding the implementation of UCG technology in Indonesia.

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