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A New Approach for East Natuna Gas Utilization

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ABSTRACT - The Natuna Gas Field has a potential gas reserve of 222 TCF, but this gas field has a very high CO_2 content of up to 71%. The high composition of CO_2 content and its location, which is too far from the market, causes the best option to use the Natuna's gas by converting it to liquid. Dimethyl Ether (DME) is a choice of liquid products that have a good potential as alternative energy for household LPG. A more in-depth study of the options for using the Natuna's gas into DME product via direct process was carried out in this study. The methodology used is initiated by determining the type of facilities needed and then conducting a process simulation to determine the mass balance, energy balance, and design of the equipment used. Process simulation and economic simulation show that the Natuna Gas Field is technically feasible to be developed into a DME product with a capacity of 1,800 MMSCFD, resulting in 21,245 MT/day DME. Upstream and downstream integration economic scheme produces a better economic result (ROI: 6.34%) compared to an upstream economic scheme (ROI: 0.63%). Apart from that, tax incentives on the downstream scheme can increase the project economy, and the scenario of tax holiday is the most beneficial for developers and the government.

Keywords: Natuna, Syngas, DME

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INTRODUCTION

The East Natuna gas field is estimated to have 222 TCF of gas reserves (Indonesia General Director of Oil and Gas, 2007) consisting of 71% CO_2, 28% hydrocarbons (70% methane),0.5% H_2S, and 0.4% N_2 (Sumartono, 2010). Carbon dioxide is one of the main components of natural gas that must be removed to an acceptable level by the gas producer before export (Hart & Gnanendran, 2009). The high composition of CO_2 content and its location that is too far from the market make the East Natuna gas field classified as a stranded gas field (Joe, 2015). The area of the Natuna gas field, which is far from the market, causes the most optimum technology option to be used for this gas field is a technology that can convert gas to liquid product (Wood, et al., 2008). It is essential to develop alternative energy and find ways to reduce CO_2 in the natural gas and convert it to Dimethyl Ether (DME) product (Sills, 2000).

DME seems to be a superior candidate, especially for the integrated methods (Park, et al., 2014). DME is a gas to liquid conversion technology product that can be a household energy supply alternative with Liquid Petroleum Gas (LPG) and a transportation energy alternative with diesel (Rulianto, et al., 2016). LPG consumption in Indonesia reaches 7.3 million tons, while LPG supply from domestic LPG refineries is only 2 million tons per year, so LPG imports are still needed at 5.3 million tons. DME can reduce LPG consumption by up to 20% because DME is stable to be mixed with LPG in household LPG tubes up to 20% composition (Sukaharja, 2010). Hence, an eastern Natuna gas utilization study is conducted to become a DME with integrated business management between the upstream and downstream sections (One Business Entity).

There are two mechanisms to produce DME through indirect and direct processes. The indirect process is based on the dehydration of methanol produced from syngas (Huang, et al., 2015). Methanol is produced from syngas, and in a subsequent reactor, after that converted to DME, as reactions below.

$$CO = 2H_2 \rightarrow CH_3OH \quad \Delta H^o = -90.6 kJ/mol \quad (1)$$

$$2CH_3OH \rightarrow CH_3OH\,CH_3 + H_2O \quad \Delta H^o = -23.5 kJ/mol \quad (2)$$

The operating temperature and pressure are relatively low, safer, and less costly in the indirect process. However, the maximum conversion value obtained is 50% using this method. In addition, the process uses sulfuric acid, which is corrosive, so equipment with corrosion-resistant construction materials is needed, which is more expensive and less economical.

Another mechanism to produce DME is using a direct reaction process. In this process, the DME is produced by a synthesis of methanol from syngas and dehydration of methanol which is processed in the same reactor as described in the following reaction:

$$CO + H_2O \rightarrow CO_2 + H_2 \quad \Delta H^o = -41.2\, kJ/mol \quad (3)$$

$$3CO + 3H_2 \rightarrow CH_3OCH_3 + CO_2 \quad \Delta H^o = -245.8\, kJ/mol \quad (4)$$

The basic reactor type used for direct reaction synthesis is similar to the FT (Fischer-Tropsch) synthesis reactor or methanol synthesis reactor (Takeishi & Akaike, 2010). The advantage of this method is that the process is simple, the equipment used is minimal.

The investment cost for the equipment used is small and the conversion value obtained is quite high, which is above 75%. Therefore, the process that will be discussed in this paper is the direct DME processing which has good prospects for further development. The design estimation could be approached by doing simulation process. Process simulation is done to produce mass and energy balance by using Petrosim process simulation software. The Equation of State used in the simulation is Peng Robinson.

DATA AND METHODS

The methodology of this study consists of 4 stages:

A. Process Simulation

Process simulation is done to produce mass and energy balance of DME Production by using Petrosim process simulation software. The Equation of State (EOS) used in the simulation is Peng-Robinson.

1. Cost Estimation

Costs are estimated using the information on investment costs in several papers to be processed using the sixth ten rule formulation and Levelized expenditure.

2. Revenue Estimation

Revenue is estimated by considering the selling price of DME and the volume of DME products. Selling Prices DME is calculated based on LPG prices. The selling price of DME or equal to the selling price of LPG (Rentschler, 2018). The average LPG Price in 2017 was 600 US$/MT (CP Aramco).

3. Economic Simulation

Economic simulation is done using the gross split and integrated model. The assumptions used in the economic simulation are as follows

a. Calculation Method: Gross Split Upstream & Downstream Integrated
b. Project Lifetime: 30 years
c. GS Contractor share: 77% (Upstream Scheme)
d. Depreciation Method: Double Decline Balance
e. Discount Rate: 10%
f. Corporate Tax: 25% (Downstream Scheme)
g. VAT: 10% (Downstream Scheme)
h. Tax Incentive Option :
   - Contractor share improvement (Upstream Scheme)
   - Tax Holiday (Downstream Scheme)
   - Tax Allowance (Downstream Scheme)

In this section, simulations are also carried out on the economic calculation without developing the DME refinery. In this scenario, it is assumed that the gas selling price at the wellhead is 7.3 US $ / MMBTU which is the highest wellhead gas price (SKK Migas, 2018).

RESULTS AND DISCUSSION

A. Production Facility

The production facility used to process the Natuna's gas into lean takes from a study conducted by Batubara in 2015 except DME Plant, which consists of:

- Wellhead flow line facility: this facility serves to flow gas from the wellhead to the sweetening gas facility. In this paper, we assume using two train flow lines with a diameter of 10 inches and a length of 10 km.
- Central Processing Facilities (CPF): This facility separates natural gas from impurities such as CO_2, H_2S, Mercury, and water. This facility uses cryogenic technology to separate CO_2 from natural gas due to the high CO_2 content in the East Natuna gas field. For now, there are two types of cryogenic technology that are commonly developed in the world, namely Cryocell technology (Hart & Gnanendran, 2009) and Controlled Freeze Zone (CFZ) technology (Northrop & Valencia, 2009). CFZ technology is chosen in this paper because it can produce CO_2 in the liquid phase, making it easier to transport to land and not use too much space.
- Flowline injection well facility: This facility serves to drain CO_2 output from the sweetening gas facility for injection into the designated area to become CO_2 storage. In this paper, we assume using one train flow line with a diameter of 20 inches and a length of 35 km. CO_2 transported must be in the liquid or saturated liquid phase so that when injected into storage can be more effectively trapped in the soil.
- DME Plant along with 225 km pipeline. This facility functions to process lean gas into DME. In this study, gas processing becomes DME using the direct method. The process consists of three main parts, namely the preparation of syngas (auto-thermal reformer), synthesis of DME (slurry reactor), and distillation/purification (CO_2, DME, methanol distillation columns). The Natural gas is first converted to syngas with O_2 (steam) and CO_2 by-products in an auto-thermal reformer. The formed syngas is then compressed and channeled to the DME Slurry Reactor (De Falco, et al., 2017). The main product of the reactor is DME with CO_2 by-products, a small amount of methanol, and unreacted syngas. DME and by-products are then cooled and separated as a liquid from the rest of the unreacted gas. In this separation process, DME works as a solvent that separates CO_2 from syngas that does not react and returns the syngas to the reactor. DME and by-products are then fed to the distillation column to separate DME, methanol, and water. CO_2 is returned to ATR while methanol is returned to the DME reactor. Figure 1 shows a direct method in the gas processing to DME.

B. Process Simulation Result

The process flow diagram is shown in Figure 2.

Mass and Energy Balance are shown in Table 1. Based on Table 1, it can be seen that the DME product produced was 21.245 TPD, while natural gas used was 78,137 TPD, resulting in a conversion of 27.19%. The low conversion rate in this process is due to the composition of Natuna gas which has high CO_2 content.

However, if the estimated conversion of lean generated is equal to 24,068 TPD, the conversion increase to 78.27%. Conversion above 70% for vapor to liquid systems with chemical reactions is a reasonable value. Similar conversions were also experienced in the simulation of the DME KOGAS Plant (Kim, et al., 2010).

C. Cost Estimation

Investment costs for the development of the East Natuna gas field are estimated based on data obtained from literature studies by considering the output of

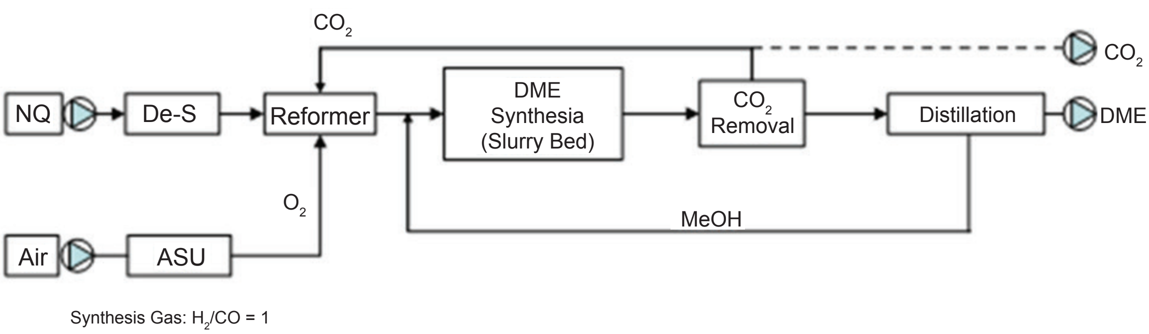

Figure 1
DME direct process.

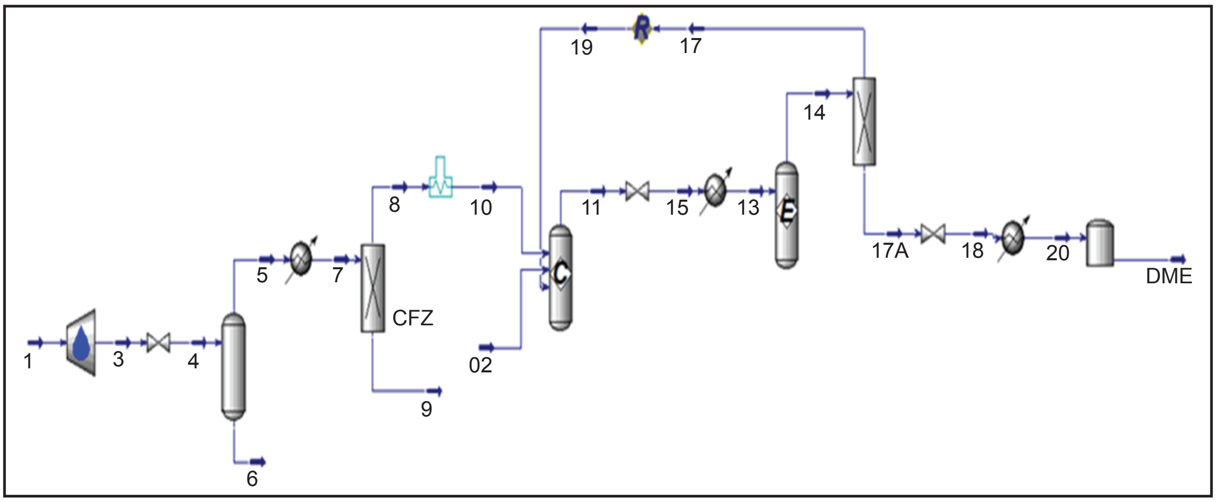

Figure 2
Process flow diagram.

Table 1
Mass and energy balance process simulation

Name	1	7	8	10	11	02	14	17	17A	DME
Vapour fraction	1	-	1	1	1	1	1	1	1	-
Temperature (F)	250	5	30	851	260	851	273	200	3,453	89
Pressure (psig)	4,000	1,490	1,490	1,480	1,400	1,580	1,400	1,400	1,400	142
Molar flow (MMSCFD)	1,835	1,859	807	807	24,604	225	24,004	23,854	150	150
Mass flow (tonne/d)	78,132	78,637	24,068	24,068	621,632	12,984	621,632	613,371	21,245	21,245
Composition (% mol)										
Methane	30.00	29.61	68.19	68.19	12.82	-	13.14	13.23	-	-
CO2	70.00	69.07	31.81	31.81	40.11	-	41.74	42.00	-	-
di M-Ether	-	-	-	-	-	-	0.62	-	100.00	100.00
H2S	-	-	-	-	-	-	-	-	-	-
H2O	-	1.32	-	-	-	-	-	-	-	-
Hydrogen	-	-	-	-	45.23	-	44.49	44.77	-	-
CO	-	-	-	-	1.83	-	0.00	0.00	-	-
Oxygen	-	-	-	-	-	100.00	-	-	-	-
Methanol	-	-	-	-	-	-	-	-	-	-

the process simulation as a dividing factor. In general, investment costs for the development of the East Natuna field consist of capital costs and non-capital costs. Capital costs are estimated with the following forming components:

- Development costs of 26 wells with a production capacity of each well of 350 MMSCFD: 11.37 US \$ / MT (Guo, et al., 2007)
- CPF development costs outside of CO_2 separation facilities: 37.12 US \$ / MT (Yong, 2010)
- Cost of developing CO_2 separation facilities with CFZ technology and injection facilities: 53.64 US \$ / MT (Parker, et al., 2011)
- Construction cost of onshore facilities is 2.83 US \$ / MT (Guo, et al., 2007)
- Development DME Plant: 16.89 US\$/MT (Prabowo, et al., 2017)
- While non-capital costs are estimated with the following components:
- Acquisition, licensing, and land: 0.40 US\$/MT
- Exploration costs consist of drilling, well lodging, geological and geophysical analysis: 6.59 US\$/MT (Partowidagdo, 2009)
- Project management costs: 8.03 US\$/MT (Guo, et al., 2007)

- The total investment cost for the development gas field, including DME Plant, is 136.50 US$/MT and 119.52 US$/MT excluding DME Plant. Operating costs in this study outline consist of 2 types:
- Operating Costs from production facilities: 71.71 US$/MT (Seddon, 2006)
- Operating Costs from DME Plant: 30.56 US$/MT (Prabowo, et al., 2017).

D. Revenue Estimation Result

- Estimated DME Price: 600 US$/MT (Equal to LPG Price)
- DME Product: 21,245 MT/day
- Revenue: 4,206,537,734 US$/year

E. Economic Simulation Result

Based on the Table 2, it can be seen that the Integrated Natuna to DME development scenario has a better economic result. This is because DME has a very high economic value so that it will improve the economy from the upstream, which is in line with the application of Value Engineering (Berawi, 2014).

However, the Integrated Natuna to DME development scheme is constrained by government regulation, in article no 24 stated that the processing of natural gas becomes LNG, LPG, and Gas to Liquefied (GTL), including in and/or is Downstream Business Activities as long as it is intended for obtain profits and/or profits and not a continuation of Upstream Business Activities. Therefore, special treatment is needed for the government regulation that allows integration between upstream and downstream to develop the Natuna gas field. The allowance of upstream and downstream integration is facilitated in the form of tax incentives from the downstream side consisting of tax holidays and tax allowances. Therefore, this study also conducts economic simulations with tax incentives scenarios such as tax holidays and tax allowances, as shown in the Table 3.

Based on Table 3, it can be seen that tax incentives can increase project ROI to 7.94% in the scenario with additional tax holiday incentives and tax allowances. However, considering the government revenue, the tax holiday incentive scenario is the most optimal scenario for developers and the government. This is similar to other mega infrastructure development projects, the Sunda Strait Bridge Development Project (Berawi, 2015).

CONCLUSIONS

The Natuna Gas Field is technically feasible to be developed into a DME product with a capacity of 1,800 MMSCFD, resulting in 21,245 MT/day DME.

Table 2
Economic simulation result

In Thousand US$	With DME Plant	Upstream gas
Description	**Total**	**Total**
Project cashflow		
Investment	28,710,167	25,139,000
Profit after tax	36,158,636	2,549,384
Depreciation	28,710,167	25,139,000
Cashflow	36,158,636	
Cumulative cashflow		
ROI	6.34%	0.63%
POT Project (Years)	14.00	28.00
NPV Project @10%	(5,687,051.22)	(10,908,454.21)
Government Take		
Gross split share	27,763,149	12,303,522
Tax	12,052,879	849,795
Total	39,816,028	13,153,317

Table 3
Economic simulation result with integrated scenario

In Thousand US$	Base case	+Tax Holiday 15 years	+Tax Allowance 15 years	+Tax Holiday 15 years +Tax Allowance 15 years
Description	**Total**	**Total**	**Total**	**Total**
Project cashflow				
Investment	28,710,167	28,710,167	28,710,167	28,710,167
Profit after tax	36,158,636	42,185,075	40,377,143	46,403,583
Depreciation	28,710,167	28,710,167	28,710,167	28,710,167
Cashflow	36,158,636	42,185,075	40,377,143	46,403,583
Cumulative cashflow				
ROI	6.34%	7.64%	7.24%	7.94%
POT Project (Years)	14.00	12.00	12.00	12.00
NPV Project @10%	(5,687,051.22)	(3,599,872.45)	(4,226,026.08)	(3,250,114.64)
Government Take				
Gross split share	27,763,149	27,763,149	27,763,149	27,763,149
Tax	12,052,879	6,026,439	7,834,371	1,807,932
Total	39,816,028	33,789,588	35,597,520	29,571,081

Upstream and downstream integration economic scheme produces a better economic result (ROI: 6.34%) compared to an upstream economic scheme (ROI: 0.63%). Special treatment of government regulations for the Natuna's cases is needed so that upstream and downstream integration can be worked.

Tax incentives on the downstream scheme can increase project economy, and the scenario of tax holiday is the most beneficial for developers and the government.

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GLOSSARY OF TERMS

Symbol	Definition	Unit
LPG	Liquefied Petroleum Gas	
DME	Dimetil Eter	
TCF	Trillion Cubic Feet	
ROI	Return of Interest	
EOS	The Equation of State	
CPF	Central Processing Facilities	
CFZ	Controlled Freeze Zone	
TPD	Tons Per Day	
MT	Metric Ton	
GTL	Gas to Liquid	

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