EXPLOITATION AND PRODUCTION OF COAL BED METHANE TO LIQUEFIED NATURAL GAS AS REPLACEMENT OF HSD (HIGH SPEED DIESEL) IN INDONESIA'S DIESEL POWER PLANT

Retno Gumilang Dewi
Chemical Engineering Department, Industrial Technology Faculty
Institut Teknologi Bandung
Email : gelang@che.itb.ac.id;

Utjok WR Siagian
Petroleum Engineering Department, Mining and Petroleum Engineering Faculty
Institut Teknologi Bandung
Email:

Bagus Arif Wisnuaji
Chemical Engineering Department, Industrial Technology Faculty
Institut Teknologi Bandung
Email : arif.bagus7@gmail.com

Zakiah Darajat Nurfajrin
Chemical Engineering Department, Industrial Technology Faculty
Institut Teknologi Bandung
Email : zakiahdarajat.zd23@gmail.com

ABSTRACT

In this century, CBM (Coal Bed Methane) in Indonesia is started to be look as one of energy which give high potential and high benefits. But, it still recorded as a research because of many high risk conducted in exploring CBM on both exploitation and production point of view. One of the benefits of CBM is converted into LNG which can be used as a substitute of HSD (High Solar Density) that nowadays used in the diesel power generation. After we studied the literature and made the simulation, from the exploitation point of view, each CBM wells in Indonesia can be determined on how the completion done and how to accelerate the dewatering process. From the production side, as a LNG product from feed of CBM is a big investment cost at first. In the other hand, it will give a good use in society and gives a profitable production based on the other point of economic.

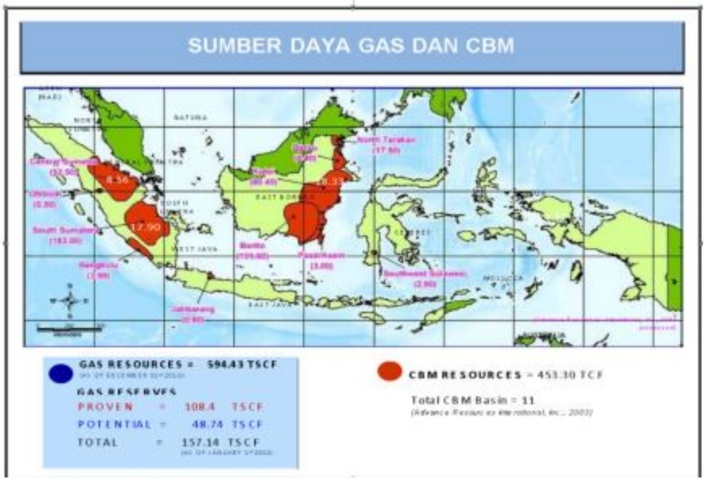
Keywords: CBM, Exploitation, Dewatering, Production, High Speed Diesel, Techno-economic

INTRODUCTION

CBM is one of the clean and eco-friendly to the environment fuel compared to crude oil, coal, or even other conventional gas. CBM has high potential economically because of lower depth of the well, if it's over 5,000 ft below the sea level, it will have loss of economic value. CBM project must consider many variables, such as thickness of coal, the amount of gas inside, permeability, hydrodynamic, quality of gas, quality of water, option of water disposal, depth of well, and completion process. With a good design and project evaluation based on those variables, stakes of CBM project success is high and, more importantly, profitable (Schulmberger, 2003; Dunn, et al 2015; Rao, et al 2014; Ayoub, et al 1991; Ojeifo, et al 2013; Brown, et al 2014, Golding, et al 2013).

Indonesia, as a nation, has another gas source besides from gas crude well and conventional natural gas well. That source named CBM (Coal Bed Methane) which based on the study, Indonesia have a CBM reserve of 453.3 TCF with the depth of source around 500 to 5,000 ft, with the assumption of CBM taken around 200 TCF (Ditjen Migas, 2010).

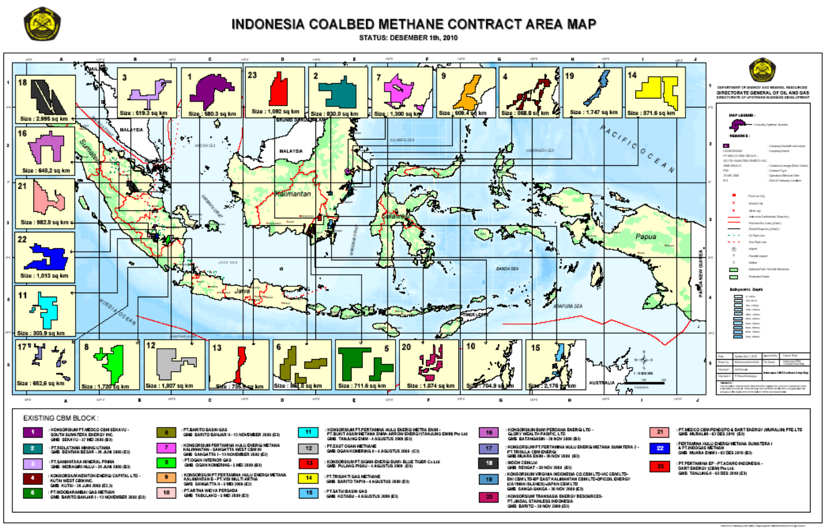
Figure 1: Map of Natural Gas and Coal Bed Methane Resources in Indonesia



Based on [8] at figure 1, the highest potential of CBM are in Borneo and Sumatera. In Borneo, the source spread into some regions such as Berau with the amount of 8.4 TCF, Pasir/Asem (3 TCF), Tarakan (17.5 TCF), Kutai (80.4 TCF) and Kabupaten Barito, Central Kalimantan (101.6 TCF). In the other hand, on Sumatera side, Central Sumatera (52.5 TCF), South Sumatera (183 TCF), dan Bengkulu (3,6 TCF). Lastly, the CBM potential located in Jatibarang, West Java (0,8 TCF) and Sulawesi (2 TCF). From figure 1 also shown that high CBM resources are located far from the market, in Java. Natural gas users are 80% located in Java, this condition as the same as conventional gas resources which located far from market location as shown in figure 1.

Until the year of 2012, government has 54 contract signs in CBM (Ditjen Migas, 2010). The development of CBM was ruled in Permen ESDM No 36 year of 2008 about the Coal Bed Methane business. Based on roadmap of CBM development in Indonesia, gas production from CBM will be 500 MMSCFD at 2015, 1,000 MMSCFD at 2020, and 1,500 MMSCFD at the year of 2025. CBM Contractors Cooperation nowadays are spread in 2 main territories, which is Sumatera and Borneo as shown by figure 2 (Ditjen Migas, 2010).

Figure 2: Maps of Cooperation Areas of Indonesia's CBM



In 2015, Indonesia should and able to produce around 500 MMSCFD CBM, but in reality, until now Indonesia still produce CBM at the amount of 0.5 MMSCFD. This shows that there are spans of reality to the ideal condition for utilization and development of CBM. Some problem including scarcity of operational equipment, overlapped area, price of CBM which are too low, longer time needed for dewatering, and low reservoir pressure.

According to Ex-Vice Minister of Energy and Mineral Resources (ESDM), Susilo Siswoutomo which quoted from (www.kompasiana.com, 2017), said that the scarcity of operational equipment was the main obstacles in development of CBM. The example is the amount of simple rig for CBM drilling was not many in Indonesia. As one of the solution, the research team of ESDM has a target to produce 20 simple rigs in every year. These simple rigs later will be used for CBM drilling. Ministry of Industry must be able to push domestic industries to help progressing in utilization of this unconventional energy sources.

Overlapped area also become one of obstacles in development of CBM, especially in overlapped area of the PKP2B/KP Batubara. Based on *Pedoman Pengembangan* CBM in this case PKP2B/KP Batubara have to exploit the land first, then CBM

Contractors can used part of exploited area for the exploration drilling, or pilot phase of CBM plant with the area of need based on technical standard, safety and environment.

Compared to natural gas, CBM has a longer period of production. Mostly, the highest production occurred in year 2 until year 7, then the production life happens in 10 or 20 years. In this case, CBM well is shorter the natural gas which have a production life for 30 until 40 years. If we compared the expense of exploration for each well, CBM well, with the amount of $ 400,000, is lower than the expense for crude oil or natural gas well, which can average over $ 1,000,000. In different with the conventional well, the production flow rate of CBM for one well is too low, so it will need more well to accommodate the amount of production which is more economic.

Beside those problems, long dewatering process, which can occurs in 2-7 years, can make the development of CBM project not getting interested for the investor's point of view. Long dewatering process, for nowadays, has a solution with using Enhancing Recovery Process using gas of CO_2 and N_2. These gases can increase the diffusive coefficient of coal matrices in order to produce faster.

Shallow of reservoir makes well's radius of curvature becoming smaller and making this hard to execute. Too low of pressure coming from CBM reservoir, which near atmospheric pressure, will increase the compressing expenses into bigger number. Because of that condition, for the efficiency of compressor usage, productive well reaching into certain amount of production will only need one compressor.

The usage of LNG in fulfilling the domestic demand is for energy source of PLN's power plants is to replace HSD which most power plants in Indonesia used as their power plant's fuel. Here below are the data of LNG demands in 2014 with various area based on (www.pln.go.id, 2017), for the energy source supply in Indonesia's PLN power plant in 2014.

Table 1: List of LNG Demand for PLN Power Plants in Indonesia

Area	LNG Demand (MTPY)	Electricity Demand (MW)
Aceh	0.16	113.37
North Sumatera	1.84	1287.75
Riau	0.25	173.79
West Sumatera	0.10	72.66
South Sumatera, Jambi, and Bengkulu	0.94	655.17
Lampung	0.08	57.70
North Sulawesi, Central Sulawesi, and Gorontalo	0.47	330.30
South Sulawesi, South East Sulawesi, and West Sulawesi	0.83	579.16
Maluku	0.13	92.32
Papua	0.32	223.50
NTB	0.25	174.99
NTT	0.21	144.40
DKI Jakarta	3.92	2740.70
West Java and Banten	1.96	1040
Central Java and Yogyakarta	2.41	1689
Bali	0.62	432.70

Based on those problems, the study will answer 3 main problems that Indonesia will face in CBM development which are dewatering process, low reservoir pressure, and price of CBM. Hope with this study, later Indonesia have a solution in determining good CBM price and be able to decrease the time need for dewatering process in CBM wells.

METHODOLOGY

In this study, it will be divided with 2 stage of studies with the boundaries of dewatering process, low reservoir pressure, and low price of CBM. For dewatering process and low reservoir pressure, which included in exploitation process, the author will use literature studies based on journals published in the last 5 years, then make the matrices of advantage and disadvantages of each applied technology, and later will be picked the technology used based on the condition occurs in Indonesia

In the other hand, in price of CBM, this will be simulated as a plant design of CBM using Aspen Hysys 8.8 with the sample comes from well X in Muara Enim, South Sumatera with the composition as shown below at table 2.

Table 2: Composition of CBM

Component		% Mol
Methane	CH4	84,68
Ethane	C2H6	3,79
Propane	C3H8	1,63
Iso-Butane	i-C4H10	0,40
n-Butane	n-C4H10	0,38
Iso-Pentane	i-C5H12	0,24
n-Pentane	n-C5H12	0,17
Hexanes	C6H14	0,71
Nitrogen	N2	0,3
Carbon dioxide	CO2	5,64
Hydrogen sulfide	H2S	0,00

The assumption used in this study is shown at table 3.

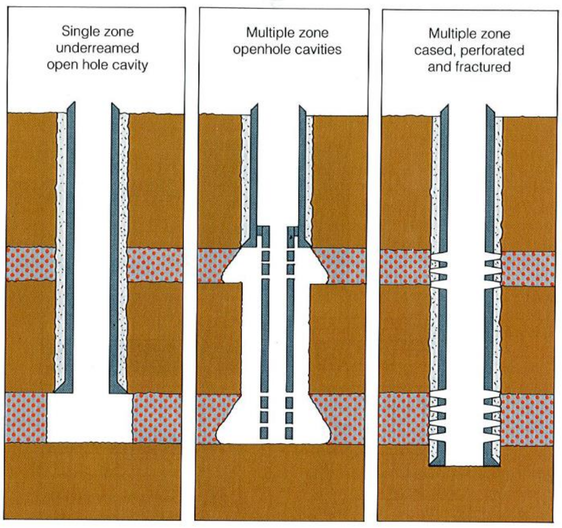
Table 3: Assumption in Process Simulation CBM to LNG plant design

Assumption	Information
Production	106,5 MMSCFD
Calculation of Mass and Energy Balance	Peng-Robinson
Operation Days	330 days
Feed Pressure	2 bar
Feed Temperature	30^0C
Equipment Price Calculation	Marshall and Swift
Construction Time	2 years
Operating Year	2020

RESULT AND DISCUSSION

This study will separate the result into two parts, there are about how the exploitation is and the result techno-economic from LNG plant design by CBM as substitution HSD in Indonesia diesel power plant. On the other hand, in the exploitation process will separate into 2 case, there are how proper CBM well structure and then how to speed up the dewatering process that has been difficult to do. For the CBM well structure, according to (Levienem, et al 1987), generally the development of CBM wells will be divided into 3 sections as shown in Figure 3

Figure 3: Completion for CBM Well (Levienem, et al 1987)



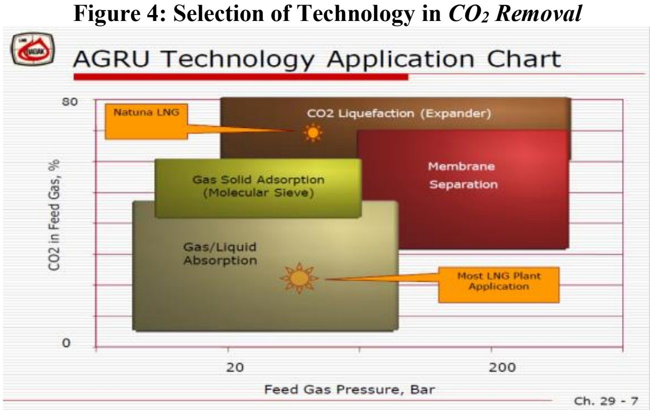
The first position is the single zone open hole completion, wherever, later after the drilling, the direct installation of the well pipe, production packer, and x-mas tree on the top of the well. it can consequence in a cost to one well if compared to the other will be cheaper, nevertheless, the disadvantage of this completion is the amount of impurities contained in the gas, including sand, coal, and others. The second is multi-zone open hole cavities, in this process after the drilling and installation of the first casing, will be done the installation of casing with a smaller size. Expected by the installation of casing with more zones, will increase the production of gas itself, on the contrary, has a weakness that is with the size of the zone and the absence of control of impurities will lead to more diverse gas coming out of the well. The third are multi-zone, cased, perforated, and fractured. In this process, drilling and installation of the casing up to the bottom hole, cementing, and eventually will be perforation and cracking. Perforation here is a hole using a gun that will provide the aperture gas exit. The advantage of this completion is to get a large production but the outer impurities will be little due to screening through a small perforation so that the impurities do not come out. Instead, the disadvantage of this completion is the very expensive cost of perforation and cracking (Leviene, et al 1987; Logan, 1989; Kamal, 1989; Jeffrey, 1989; Holdtich, 1988; Szabo, 1981).

Meanwhile, in accelerating the process of dewatering, according to (Wang, et al 2015; Xu, et al 2017; Tang, et al 2017), there are three things to note in the acceleration that is, first is to calculate the time required for a good interruption. Well the interference from the relation between the well model, the well permeability, and the well part. Each well has different characteristics. Second is the calculation of pressure drop from the well. After knowing the interference time, will be done the calculation of pressure drop with the principle of the bottom hole flowing pressure that will decrease with the process of dewatering process. Third is the usage of artificial lifts. According to [20], the use of artificial lifts is highly biased to enhance the dewatering process.

Generally, the use of artificial lifts will follow how much Net Positive Suction Head (NPSH) is needed on a well. Artificial lifts, in this case pumps. Such as, progressive cavity pumps, pumps that have advantages under abrasive well conditions and very viscous water conditions but have weaknesses in less economical pumps at lower NPSH and lower production rates. Rod pump is an artificial lifts option that has the advantage of maintenance that all users are able to do quick reparation, in contrast, that has a disadvantage to the needs of NPSH higher than other tools with the same distance and does not have the ability to fluctuate production. Jet pump is a very good theoretical pump but has a weakness in the application. With solids in water entering the pump, the jet pump is unable to adapt well to the well, and has a high NPSH. The final artificial lift is the Electric Submersible Pump (ESP) which has the advantage of being well adapted to vertical or horizontal wells and lower NPSH values for the same depth distance. The weakness of ESP is the ability of low solid handling and the need for cooling fluids in ESP motors (Bassett, 2016; Merwr, et al 2012).

For the techno-economic results of LNG plant design from CBM will be divided into 2 things, there are from technological and economic. For the technological aspect, LNG design process from CBM will be divided into 3 process stages, such as, Acid Gas Removal Unit (AGRU), Dehydration Unit, and Refrigeration and Liquefaction Unit. In the Acid Gas Removal Unit (AGRU) section, the chemical absorption process is selected based on the graph from PT. Badak NGL, that the gas feed with the above CBM composition is suitable to use the amine absorption method.

Figure 4: Selection of Technology in *CO_2 Removal*



In the amine absorption system, PROSERNAT AdvAmine technology is selected. PROSERNAT is a licensed amine system technology developed by SNEA (P) and ELF now owned by TOTAL. This technology has been used as many as 150 units for 50 years. This technology has 3 types based on the type of solvent, for instance HiLoadDEA, MDEAmax, and EnergizedMDEA. The selected type is HiLoadDEA due to the following considerations:

- DEA price is lower than MDEA. DEA cost is $ 3.25 per kg, equal to MEA but lower than MDEA solution is about $ 4.25.
- CO_2 loading DEA is greater than MDEA, because MDEA is more selective against H_2S
- Nonselective, can separate both H_2S and CO_2 contaminants

In the dehydration stage this unit is selected by adsorption process because this process is able to remove H_2O until the maximum limit of less than 1 ppm. This is in accordance with the desired product specifications.

Table 5: Comparison *Dehydration* Process

Condition	Absorption	Adsorption
Max Limit of Water	10 ppm	< 10 ppm
Kind of Solvent	liquid	solid
Corrosion	Tend to corrosion	No

Foaming	No	No
Example	EG, DEG, TEG, TREG	Alumina, Silica Gel

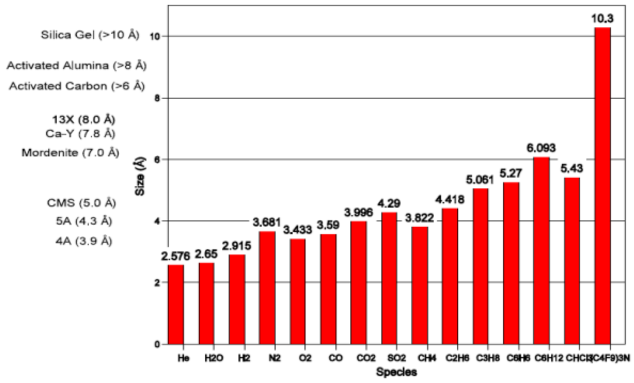
The adsorbent used in this process is molecular sieve. Compared to other adsorbents that can only remove water content of less than 10 ppm, molecular sieve can remove water content up to less than 1 ppm. The molecular sieve type used is molecular sieve 3A, because it is able to bind H_2O which has a particle size of 0.265 nm (2.65Å).

Table 6: Comparison of Adsorbent Types

Adsorbent	Water Content	Regeneration Ability	Regeneration Temperature	Active pH
Alumina	<10 ppm	Hard	Very high	Alkali
Silica Gel	<10 ppm	Easy	High	Acid
Molecular Sieve	< 1 ppm	Easy	high	Alkali

One of kind adsorbent is molecular sieve. That type commonly is used molecular sieve type 3A, the reason for selecting 3A size can be shown in Figure 5:

Figure 5: Size of Pore and Effective Size per Molecule



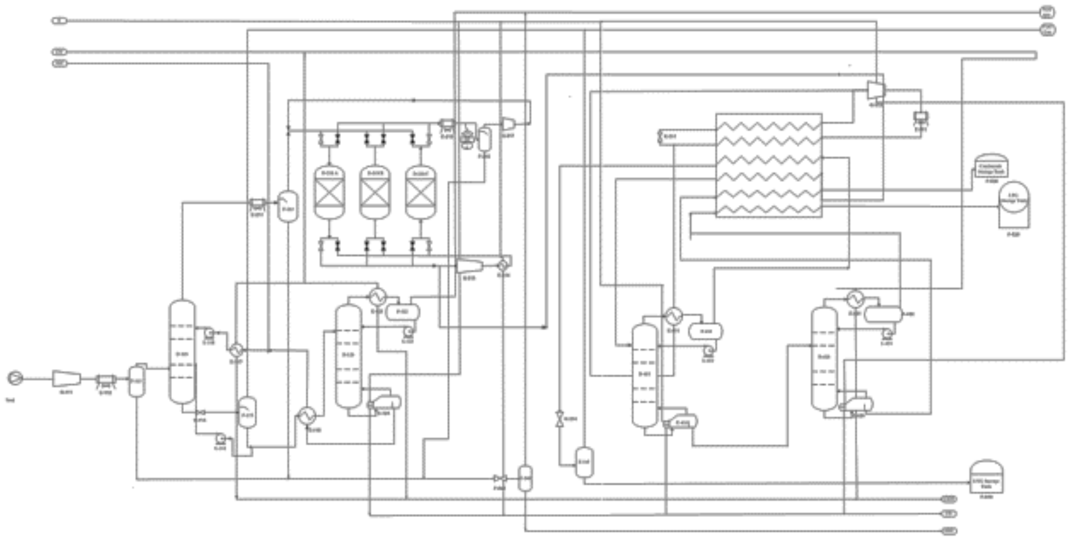
Liquefaction and refrigeration process side, matrix comparisons have been made for technologies that have been used in the industry and the following results are obtained as shown in Figure 6

Figure 6: Comparisons of Liquefaction and Refrigeration Process

	C3-MR	Cascade	SMR	DMR	MFC	N2 Expander	Krypak EXP
Thermal Efficiency	High	High	Medium	High	High	Low	Low
Equipment Count	Medium	High	Low	Medium	Medium	Medium	Low
Precooling Exchanger	Kettle	Core-in-Kettle	Plate-fin	Spiral Wound	Plate-fin	Kettle	Plate-fin
Liquefaction Exchanger	Spiral Wound	Core-in Kettle Plate-fin	Plate-fin	Spiral Wound	Spiral Wound	Plate-fin	Plate-fin
Hydrocarbon Refrigerant Storage	Large	Large	Medium	Medium	Medium	None	None
Capital Investment	Medium	Medium	Low	Medium	Medium	High	Low
Offshore Suitability	Medium	Medium	High	High	High	High	High
Compactness	Low	Low	Medium	Medium	Low	High	Medium
Motion Impacts	High	Medium	Medium	Medium	Medium	Low	Low

Based on figure 6, will be used SMR Liquefaction Process from Prico B & V with refrigerant in the form of Single Mixed Refrigerant. If the three main processes are combined, then the design of the LNG plant from CBM will be as shown in Figure 7.

Figure 7: The result of LNG from CBM plant design



The simulation result, 130.8 MMSCFD CBM will produce 0.71 MTPA LNG, 0.027 MTPA LPG, 1,363 bpd condensate and 244,61 tpd of fuel gas. Efficiently, this technology is included both with the conversion of 81% LNG from CBM feeds. After looking technologically, for the economic aspect, the calculation has been calculated based on the solution of equipment price and the age of the factory for 10 years so that the following results (Coulson, et al 1957; Geankoplis, et al 1997; ITS-DSME, 2010; Kern, et al 1965; Kidnay, et al 2006; Ludwig, et al 1947; McCabe, et al 1985; Perry, et al 2010; Peters, et al 2003; Poling, et al 2001; Smith, et al 1955; Syukran, et al 2007) are obtained with the sale of LNG to PLN to Sumatera, Java and Bali, LPG to Pertamina, and condensate to PT Chandra Asri.

Table 7 Calculation of Economy in Plant Design of LNG into CBM

No	Parameter	Unit	Value
1	Total Investment Cost	MUSD	287,79
2	Interest	% per year	12
3	NPV 10 Years	MUSD	189,93
4	IRR	%	32,75
5	Payback Period	Year	3,38
6	BEP	%	35,1
7	CBM Price	US$/mmbtu	0,09
8	LNG Price	US$/mmbtu	0,162
9	LPG Price	US$/ton	7,49
10	Condensate Price	US$/barrel	0,75
11	Project Life	Year	10

CONCLUSION

Based on the result above, this study get a conclusion which are many steps prepared in order to exploit the CBM well. In accelerating the dewatering process, the usage of artificial lift and the amount of pressure drop in CBM wells gives the most effect compared to other. Last, based on techno-economic calculation, plant design of LNG from CBM is a good investment although having a high total investment cost. It was shown by the value of BEP, IRR, and POT that are good in the eye of investor for 10 year

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