DEVELOPING COAL BED METHANE GAS UTILIZATION PILOT PROJECT TO PRODUCE RESIDENTIAL ELECTRICITY

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ABSTRACT

Coal Bed Methane pilot project has produced around 80 m^3 CBM gas containing around 14,66% volume of CO_2 and 85,34% volume of CH_4. CO_2 has to be removed, the methane gas can be utilized to produce residential electricity applying the lattest technology.

Some equipment need to be installed in place at proposed CBM gas site plant to produce the electricity of around 150 KWe per day or 51,75 MWe per annum from which the pilot project can be scaled up to 1 x 55 MW gas fuelled power plant.

Keywords : Coal Bed Methane, residential electricity, pilot project .

I. INTRODUCTION

Coal Bed Methane (CBM) has been considered as one of domestic energy resources in Indonesia. CBM pilot project has been running since 2003 with CBM production target has been set to achieve around 100 MMSCFD in 2014. The project is now at dewatering stage, however, around 80 m^3 CBM gas has been flowing via wellhead simultaneously with the producing water.

This producing gas needs to be considered to be utilized in an economic way using natural gas based energy technologies available in the market. The concept map proposed by SINTEF Norway of Natural Gas Based Energy Transport Technologies is depicted in Figure 1. The concept shows for the gas production less than 1 $MMsm^3$/day, High Voltage Direct Current (HVDC) technology to produce electricity is considered to be applicable to transport the energy at the distance less than around 2,500 km. Therefore, existing CBM gas utilization is proposed to transform to residential electricity.

II. RESIDENTIAL CBM GAS FUELLED POWER PLANT DEVELOPMENT METHODOLOGY

Method of how to utilize low production CBM gas to convert to residential scale electricity is shown in Figure 2. This method includes:

- A CBM well produces water and gas, mainly methane, simultaneously. The water is sent to water disposal reservoir whilst the raw gas is delivered to CO_2 removal facilities. The components of this facilities will rely on gas composition. The facilities may comprise moisture removal, CO/CO_2 removal or acid gas removal. The size of the facilities depends on the magnitude of each impurities to meet gas users composition, safety or regulation such as Director General of Oil and Gas decree on CNG specification, for example.

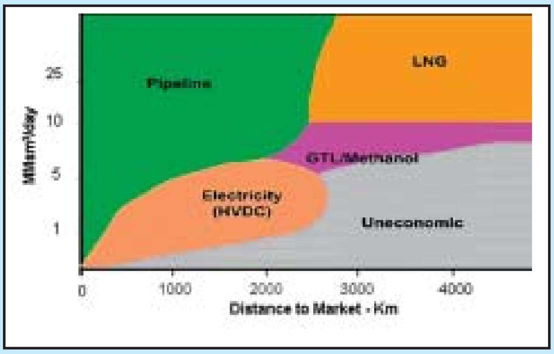

Figure 1
SINTEF's Concept Map Of Natural Gas Based Energy Technologies.

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- Having been purified, the production of clean gas is then compressed to be sent and stored in CNG Cascade for further utilization. Storage capacity of the cascade at 250 Bar working pressure varies according to its size. Storage capacity of existing CNG cascade in Lemigas is 1.000 LPE (Liter Premium Equivalent) or around 909 m^3 gas.
- The gas stored in the cascade can be used as fuel for gas engine prime mover. This fuel flows from Medium Pressure component of the cascade. While from Low Pressure cascade, the gas is piped to power generation set to produce electricity.
- The electricity prodused is then transmitted to the end consumers to provide their energy demand.

III. SITE SELECTION FOR THE CBM GAS FUELLED POWER PLANT

A Five Spot pattern had been selected in CBM pilot project, however, methane only produces from three wells i.e. Well-1, Well-2 and Well-3. Typical CBM gas composition is shown in Table 1. This gas contains around 85. 34 % volume of CH_4 and 14.66 % volume of CO_2.

Table 1
Typical CBM Gas Composition

Well	Average Flowrate (m^3/day)	Average Well Head Pressure (Bar)	Original Sample		Mixture	
			CO_2, % vol	CH_4, % vol	CO_2, %vol	CH_4, % vol
Well-1	25	1.97 - 4,60	67,77	424,14	13,78	86,22
Well-2	25	1.97 - 4,60	57,55	239,46	19,38	80,62
Well-3	30	2.37 – 5.53	28,052	229,31	10,90	89,10
Total	80	-	153,372	892,91	14,66	85,34

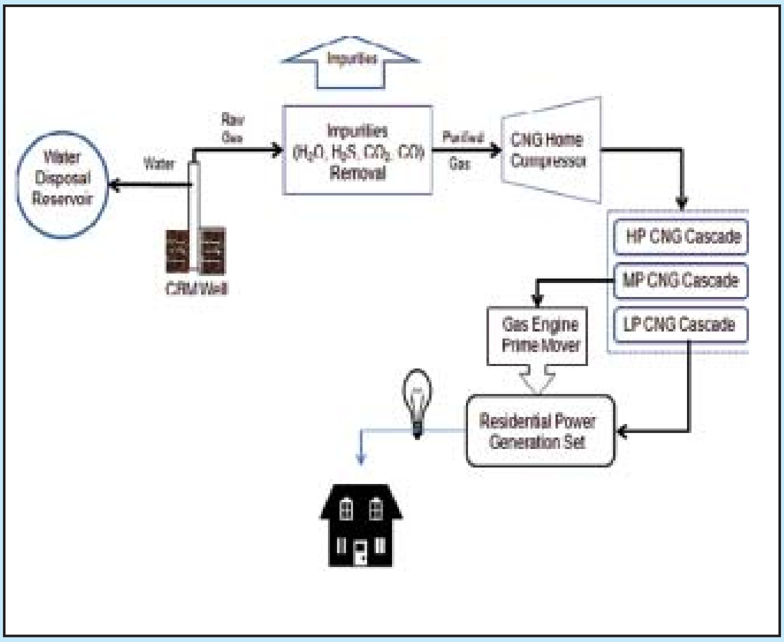

Figure 2
Residential CBM Gas Fuelled Power Plant Development Method

Based on original wells location, a schematic proposed CBM gas utilization site plant has been plot in Figure 3. The site plant is proposed to be laid next to country road-1.The distance of the site from Well-1 is around 290 m, around 450 m away from Well-2. While the distance of the site from Well-3 is less than 280 m. On the site plant will be constructed CNG cyllinder header, portable CNG Cascade as a gathering station of the gas from all wells, portable CNG compressor and portable residential cogeneration to produce electricity or portable filling unit to store the gas in Residential Adsorbed Natural Gas modules. A CO_2 removal unit, preferably carbon active based, will be required to be installed close to each well.

IV. PRELIMINARY CO_2 REMOVAL DESIGN

The decree of Director General of Oil and Gas on fuel gas specification allows CO_2 content maximum 5 % volume. Therefore, almost 10 % volume

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of CO_2 should be separated from the gas in order that the gas can meet the decree to be commercially used in Indonesia. If CBM gas flowrate from the well is 80 m^3/day, then around 8 m^3/day of CO_2 should be removed from the gas.

At standard temperature and pressure, the density of CO_2 is around 1.98 kg/m^3, therefore around 8 m^3/Day is equivalent to 15.84 kg/Day of CO_2 or around 5. 78 ton in 365 working days per annum. Simply CO_2 in CBM gas can be removed by flowing the gas through carbon active bed because the affinity of CO_2 is more higher compared to CH_4 affinity.

Typical carbon active characteristic to adsorp CO_2 from the flowing gas is depicted in Figure 4. If CBM wellhead pressure is around 200 psi (13.6 atm or 13.2 Bar), the carbon active adsorption capacity will be in the range of 20 – 60 g CO_2 / 100 g carbon active (200-600 g CO_2/ kg carbon active), depend on type of carbon active will be used. To adsorp 15,84 of kg CO_2/day will require 26,4 to 79,2 kg carbon active per day. If the price of type G carbon active is affordable, 15,84 kg of CO_2/day can be stored in 26,4 kg/day or 9.64 ton of type G carbon active per annum.

V. Commercial Portable CNG Compressor Specification

The CNG Compressor is a natural gas compression equipment that is mainly used to compress and fill the family-use natural gas to cars. Normally it will take 3-6 hours to compress the family-use natural gas to 20 MPa and fill up the CNG every time. It has small dimension and light weight with great performance It is a green environment product, safe and reliable for operation, durable and economic. Typical Portable CNG Compressor specification available in the market is shown in Table 2 and Figure 3. The compressor features indicate that the 1st stage compression ratio is in the range of 127 to 223, the 2nd stage and the 3rd stage compression ratio are betwen 17 to 18 and 1 to 3, respectively.

[13]Polyethylene (PE) tubes have been used for more than 40 years, but the material is used only at low pressures below 7 Bar for the limitation of its mechanical resistance and therefore PE will be suitable to be used for existing CBM wells flowline. As a rule of thumb, based on 6 inches gas pipeline simulation, a pressure drop of around 0.3 Bar (5 psi) will

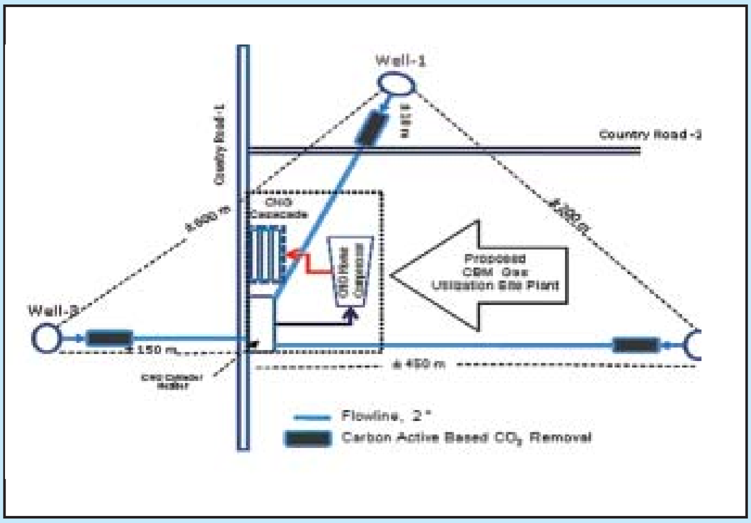

Figure 3
Proposed CBM Gas Utilization Site Plant Schematic

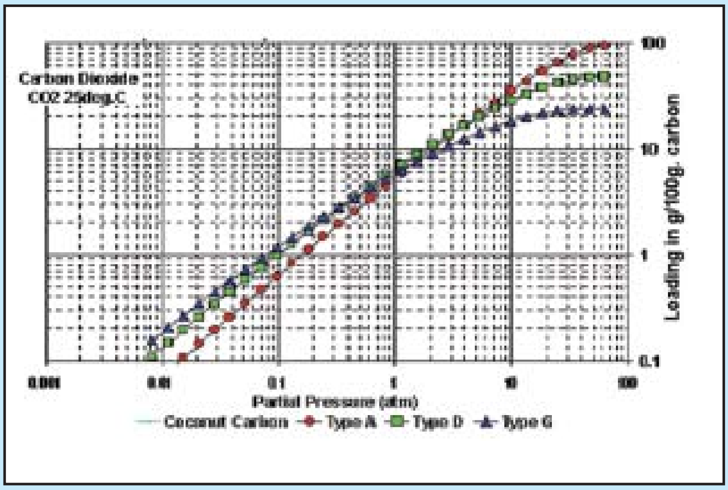

Figure 4
Typical CO_2 Isotherm Adsorption

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take place along 1000 meter distance. The experiences indicates a pressure drop gradient of around 0.00005 Bar/inch/meter gas pipeline. Proportionally (see Figure 1 and Figure 2), the ultimate pressures using two inches flowline of High Density Polyethylene (HDPE) SDR-11 from each well at the proposed site are pointed out in Table 3.

Based on each ultimate pressures, it seams the typical CNG compressor specification in Table 2 will be suitable to be in place on site but an overpressure protection needs to be installed to maintain a proper intake pressure to the second stage compressor. The pressures become input to the stage, compresses the gas and around 200 Bar pressure arrives at CNG Cascade.

Table 2
Typical Portable CNG Compressor Main Features

Parameter	Magnitude
Nominal Volumetric Displacement	2.0 – 5,0 Nm3 / hour
Flow rate	2000-5000L/hour
Intake Pressure: a	0.0017-0.0035 Mpa (0.017 – 0.035 Bar)
Discharge Pressure:	20 MPa (3000 Psi, 200 Bar)
Compression Medium: Natural gas	No sulfur, water, solid particles < 20µm
Compression Stages	Four
Gas Feeding Temperature	Ambient temperature +10 ºC
1st Stage Discharge Pressure	0.38-0.48 MPa (3.8 – 4.8 Bar)
2nd Stage Discharge Pressure	. 7.0-8.2 MPa (70 – 82 Bar)
3rd Stage Discharge Pressure	8-25 MPa (80 – 250 Bar)
Cooling Mode	Air-cooled
Motor Power:	1.5 KW
Voltage	110V\240V\220V
15) Frequency	60HZ\50 HZ
16) Noise Level:	55 dBA
Weight	65 – 100 kg
Overall Dimensions	650 x 810 x 660mm

VI. PORTABLE CNG CASCADE SPESIFICATION

Total methane production from the three wells is shown in Table 4. This production account for 68.44 m^3/day. Whilst the existing CNG Cascade lowest capacity is 1000 Liter equivalent Gasoline (909 m^3) per unit at 200 Bar Pressure. Therefore, only one unit CNG Cascade per day required to gather the gas from all wells.

Moreover, around 10 – 15 per cent of the gas will be used as fuel for the portable gas fuelled prime mover. This bring about net volume of CBM gas around 58 – 61,5 m^3/Day, which leads to the CNG Cascade Full Capacity (909 m^3) at 200 Bar pressure will be filled in around 15 days.

There will be two options for the CBM gas utilization. The first option (if ANG manufacture is available in Indonesia) is to distribute the gas via Residential Adsorbed Natural Gas (RANG) modules. If the modules can store around 4.15 m^3 gas at 15 Bar pressure, It will require around 220 RANG modules per day to distribute the gas to residential gas end consumers.

Table 3
The Ultimate Calculated Pressures
At Proposed Site.By Well

Well	Distant to CNG Storage, m	Pressure Drop, Bar	The Ultimate Pressure, Bar
Well-1	265	0.0265	1.94 – 4.57
Well-2	440	0.044	1.93 – 4.55
Well-3	160	0.016	2.35 – 5.51

Figure 5
Typical Portable CNG Compressor[14]

The second option is to carry the 909 m^3 CBM gas in the cascade to a residential cluster. Connect the cascade to residential cogeneration to produce electricity. As an estimate, a 1000 MW power plant will require around 135 MMSCFD (3.823 MMm^3/day) natural gas. The 909 m^3 CBM gas in the cascade will be able to produce about 202 KWe (Kilo Watt equivalent) electricity. If transmission loss account for 25 %, the net elecricity produced from the pilot CBM gas for surrounding people will account for 150 Kwe per day or 51.75 MWe at 345 working days per annum. Therefore, LEMIGAS' CBM pilot project can be scaled up to 1 x 55 MW CBM gas fuelled power plant to increase percentage of village electrified ratio in South Sumatera province.

VII. PORTABLE GAS ENGINE PRIME MOVER

Prime mover is a machine that transforms energy from thermal or pressure form to mechanical form typically an engine or turbine. A gas fuelled turbine is an internal combustion engine consisting of a compressor, a combustion chamber and a gas turbine, where the turbine mechanically powers the compressor. In the market, the prime mover can be integratedly with a compessor or separately in a different package. The typical portable CNG compressor is integratedly built-in with the compressor. This is shown in Table 2 as Motor Power of 1.5 KW.

VIII. Portable Residential Co-Generation Set

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) defines cogeneration as the simultaneous production of electrical or mechanical energy (power) and useful thermal energy from a single energy source such as oil, coal, or natural gas. In some cases the energy can be provided by a renewable energy source. Technologies currently most suitable for the residential market include:

- Reciprocating internal combustion based cogeneration systems
- Fuel cell based cogenerations systems
- External combustion Stirling engine based systems

These residential/light commercial cogeneration technologies vary in capacity from 1-100 KW. An average of 14 KW is needed to meet both the electrical and heating demands for a single North American home while 5 KW is more than enough to satisfy the electrical requirements.

Reciprocating Internal Combustion (IC) Engine Based Cogeneration Systems of less than 30 KW for the residential sector are spark ignited engines based on the Otto cycle during which a mixture of air and fuel is compressed in each cylinder before ignition is caused by an externally supplied spark. These systems are mostly run on natural gas, although

Table 4
Total Methane Produced From The Three CBM Wells

Well	Average Flowrate (m3/day)	Average CH4, % vol	Average CH4, (m3/day)
Well-1	25	86.22	21.55
Well-2	25	80.62	20.15
Well-3	30	89.10	26.73
Total	80	85.34	68.44

Table 5
Capital Investment Estimation

Component	Cost Reference	Capital Investment per Annum, IDR
Carbon Active Based CO_2 Removal (3 packages @ 26.4 Kg)	IDR 19,000/Kg (Indonesia price market, functional group modification and installation cost)	769.272.000
Two inches HDPE Flowline SDR 11 (865 m or around 2,600 feet)	Total of around AUS$ 10.840. Assuming 2 joints per day for 14 working days including installation cost	81.300.000
CNG Home Compressor (Two packages)	US $ 4,500 FOB Shanghai	128.250.000
CNG Cascade	Available in Lemigas	-
Gas Cogeneration (5 x 30 Kwe Capacity)	JPY 213,000 (ECOWILL Osaka Gas, including installation cost)	159.750.000
CNG Cylinder as Header to prevent pressure surge to the compressor	IDR 7.000.000, available at Indonesia market plus installation cost	9.800.000
Total Capital Investment		1.148.372.000

Note : 1 US $ = 9,500; 1 JPY = IDR 100; 1 AS $ = IDR 7500 they can be set up to run on propane, gasoline or landfill gas. The mechanical power derived from the engine turns the generator to produce electrical power. Heat provided from hot exhaust gases, cooling water and engine oil is recovered to meet the thermal requirements of the facility.

In gas cogeneration, city gas (methane dominated content) is used to power engines, turbines and fuel cells to generate electricity. Gas cogeneration systems are used for a variety of purposes, including residential power production process.

Gas cogeneration systems reach total energy efficiency up to 70% to 90%, and achieve high energy and cost saving performance. They are also as a clean, environmentally friendly gas cogeneration systems since they are fuelled by city gas which is clean energy. Since gas engine cogenerations for residential use are expected to deploy, cogeneration systems have become available for many purpose of gas users.

Residential micro-cogeneration systems act as an alternative or supplement to provide electricity and heat to a home by burning fossil fuels with net efficiencies of up to 90%. The energy obtained from these methods, will have lower greenhouse gas emissions than that from typical fossil fuel electricity generating stations running at an average of 30 – 35% efficiency.

IX. CAPITAL INVESTMENT ESTIMATION

Based on Figure-2, capital investment calculation for CBM gas utilization is indicated in Table-5. The total capital investment required for the utilization account for IDR 1.148.372.000.

X. CONCLUSIONS

Having the above discussion, the following important points can be summarized :

- Having been separated from CO_2, the 68.44 m^3/day of methane gas produced from LEMIGAS' CBM pilot project can be utilized for domestic gas supply or to produce residential electricity.
- Preliminary equipment identification for CBM gas utilization comprise of Carbon Active Based CO_2 Removal, Two inches HDPE Flowline SDR 11, CNG Home Compressor, CNG Cascade, Gas Cogeneration and CNG Cylinder as Header to prevent pressure surge to he compressor.
- The electricity transformed from the CBM gas is around 150 KWe per day or 51.75 MWe at 345 working days per annum.
- LEMIGAS' CBM pilot project can be scaled up to 1 x 55 MW CBM gas fuelled power plant to increase percentage of village electrified ratio in South Sumatera province.
- Total capital investment required for CBM gas utilization to produce residential electricity account for IDR 1.148.372.000.

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