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SUSTAINABLE DEVELOPMENT AREA OF ONSHORE LIQUEFIED NATURAL GAS (OLNG) IN EAST INDONESIA

(Pengembangan Wilayah Berkelanjutan Sekitar Kilang Gas Alam Darat di Indonesia Timur)

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ABSTRAK

Maksud studi ini dilakukan guna mendukung kawasan industri hilir migas yang aman dari bencana geologi, bertujuan menjembatani kebutuhan data geologi dan geomorfologi dalam pemilihan lokasi. Metodologi yang dipakai menggunakan analisis komparatif dan studi banding ke beberapa kilang. Optimalisasi potensi wilayah terintegrasi diupayakan secara berkelanjutan, yaitu aktivitas Onshore Refinery Natural Gas beserta pengembangan sektor lainnya. Direkomendasikan pemilihan lokasi pada pulau yang berdekatan, terintegrasi dengan beberapa kegiatan memanfaatkan sumberdaya yang tersedia. Data kewilayahan seperti; kawasan pantai dengan ketinggian pantai tertentu, wilayah potensial air tanah dan aliran air permukaan, relatif aman dari bencana geologi serta terintegrasinya pemanfaatan cadangan gas bumi untuk pembangkit listrik, pabrik pupuk, amoniak, dan lainnya. Indonesia timur mempunyai karakter geologi khusus ditinjau dari jenis batuan dan morfologi yang berkembang di wilayah ini. Hal ini menjadi pertimbangan penting dalam mengembangkan wilayah secara berkelanjutan berkaitan dengan kilang yang akan dibangun di wilayah ini. Kelebihan studi ini dengan optimalisasi fisiografi pantai untuk penentuan parameter terpilih kawasan Onshore Refinery Natural Gas. Muaranya sebagai upaya peningkatan Tingkat Komponen Dalam Negeri terkait pekerjaan geologi teknik dan geohazards pada pengembangan berkelanjutan dan pemilihan lokasi Onshore Refinery Natural Gas di Indonesia.

Kata Kunci: *Pengembangan wilayah, kilang darat gas alam, Indonesia Timur.*

ABSTRACT

This study is supporting the safety downstream oil and gas industrial area from geological disasters, intended to bridge the needs of geological and geomorphological data in Onshore Refinery Natural Gas site selection. The methodology is comparison analysis and comparative studies to several refineries. Optimization of integrated potential regions is pursued in a sustainable manner, its Onshore Refinery Natural Gas activities with the others development sector. It is recommended the selection locations based on adjacent islands, integrate with several utilizing resources. Regional data such coastal areas with certain coastal heights, potential groundwater and runoff area, are relatively secured from geological disasters and integrated utilization of natural gas reserves for power plants, fertilizer plants, ammonia and so on. Eastern Indonesia has specific geological character in term of rock types and morphology that developed in this region. It is an important consideration in sustainable development area related to refinery development. The advantages of this study is optimization of coastal physiography for determining the selected parameters of Onshore Refinery Natural Gas location. The goal is to increase the local content related to geological engineering and geohazards activities in the sustainable development and selection of Onshore Refinery Natural Gas locations in Indonesia.

Keywords: area development, onshore refinery natural gas, east Indonesia.

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I. INTRODUCTION

It's necessary to strive the gas production and derivative industries for domestic needs and interests. Therefore, infrastructure that's need to built, such Onshore Refinery Natural Gas that can improve local economic conditions. The consumption data energy of Indonesia has grown by 5.9 % in 2016, on the other hand starting from 2002 was dominated by gas production which expect to growth in a few years. The era of environmentally friendly natural gas energy utilization in Indonesia needs to pay attention to the results of studies on the development of the natural gas industry in an integrated manner with downstream industries carried out by several developed countries. The natural gas industry requires locations with certain requirements that support the achievement of security from natural disasters, continuity of production and transportation of products and economic benefits. The location of the natural gas industry is mostly located in coastal areas which allows the transportation of raw materials and gas products to take place economically using both pipeline and tanker facilities. Some important things related to the development of the natural gas industry in Indonesia include the experience of building an LNG refinery, refinery location on continental shelf and the effort to develop an integrated LNG industrial area. First, Badak LNG, located in Bontang, East Kalimantan, is a complete LNG industry, in addition to processing natural gas, it also implements education in the natural gas sector. Second, the location of the existing LNG industry lies in continental exposure, so that there is a large enough area to meet the needs of LNG production facilities. Third, there is an effort to encourage LNG industry companies to study the development of upstream - downstream oil and gas industries in integrated East Indonesia archipelago.

Taking into account the three matters above, conducted a study site selection for development of Onshore Refinery Natural Gas industrial estates with integration upstream - downstream area. The availability and qualifies land for Onshore Refinery Natural Gas is closely related to the geological and morphological conditions of the coast. This study reviews geology and geomorphology for determining selected parameters of upstream - downstream LNG industrial areas.

Maluku, specifically Southwest Maluku, is an archipelago that has slope to steep beaches because it's geologically composed by massive carbonate rocks raised in this region and part of Banda arc. This has an effect on the development area in presence of planned natural gas refineries on this area.

Another data: Maluku Province has the greatest impact of upstream and downstream development (54 – 60 percent); the increase of GDP of Maluku Province reaches 67 percent, and the increase of people's income reaches 54 percent when compared to that of Bussiness As Usual (BAU) scenario that occurs in the year 2025. The impact in the form of increased employment is also quite high, i.e., a rise of 150 percent when compared to that of BAU (Ariadji et al., 2018).

II. METHODOLOGY

The general assessment of the development Onshore Refinery Natural Gas consists of data collection, data processing, data analysis and ending preparation of the output report (Figure 1).

At the stage of data collection carried out simultaneously literature study of LNG industry processes and specifications, comparative studies to LNG refinaries in Indonesia and Malaysia, and secondary data collection related to geological and morphological conditions in refinery areas and islands in eastern Indonesia.

The data processing phase is carried out data management on a geographic basis, all related data are tied to geographic positions so that spatial analysis can be done quickly and accurately

A. Data

1. LNG Badak, Bontang

Badak Refinery is located in Bontang, East Kalimantan (Figure 1). This refinery began construction in 2014. Up to 2018 8 eight refinery / train units (A - H) have been installed, but only 5 refineries are actively operating.

Based on secondary data, it is known that the Badak LNG production facility is located in the clastic quaternary sediment, at an elevation of about 15 m. According to the earthquake prone map this area is located on the scale VII - VIII MMI (Center for Volcanology and Geological Disaster Mitigation, 2012).

2. LNG Donggi Senoro, Sulawesi Tengah

PT. Donggi Senoro LNG (DSLNG) is a liquefied natural gas processing company located in Central Sulawesi (Figure 1). DSLNG provides opportunities

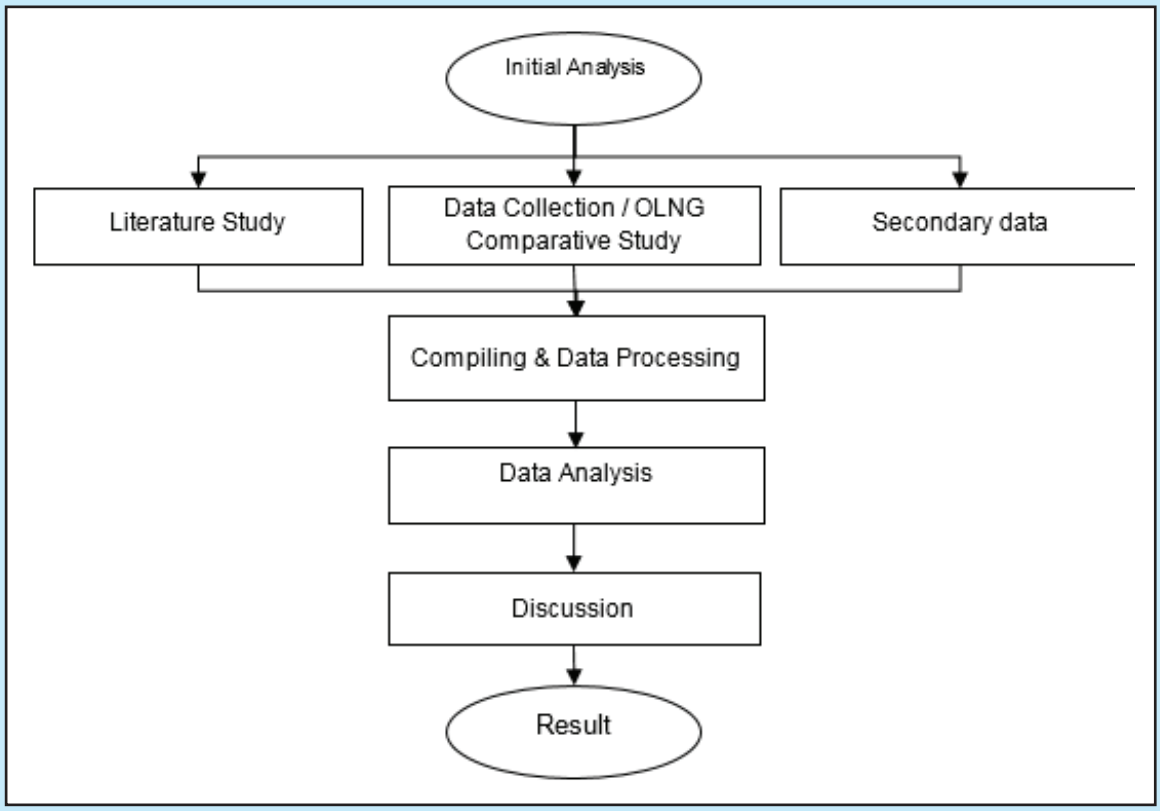

Figure 1
Workflow and method.

Table 1
Some selected Onshore Refinery Natural Gas Production Facilities in Indonesia

No.	Components	Badak LNG	Donggi - Senoro LNG	Tangguh LNG
1	Slope	Plain (1-3)%	Undulation (3-15)%	Undulation (3-15)%
2	Ground elevation	> 10 meter	> 35 meter	> 35 meter
3	Shoreline types	Deltaic shoreline	Straight shoreline	Straight shoreline
4	Ground water depth (deep well)	> 40 meter	> 30 meter	30 meter
5	Surface water source	Bontang river	Small rivers	Big and small rivers
6	Year construction	1974	2010	2001
7	Number of train	8 trains	1 train	3 trains
8	Design capacity	22.5 M tones/year	2 M tones/year	-
9	Recent production/year	22.5 M tones	2 M Tones	7.6 M tones/year
10	Coverage complex are	2.010.00 Ha	300 Ha	404 Ha
11	LNG transportation	Ship tanker LNG	Ship tanker LNG	Ship tanker LNG small scale

for processing small-scale natural gas reserves. The DSLNG refinery was built in 2011, on an area of 300 hectares (Energy World, 2017). The DSLNG facility stands on quaternary limestone, at an elevation of about 25 meters that forms a cliff with a seashore. According to the earthquake prone map this area is located on the scale VII - VIII MMI (Center for Volcanology and Geological Disaster Mitigation, 2012).

3. LNG Tangguh, West Papua

The Tangguh refinery is operated by BP Berau which began operations in 2009. The addition of one refinery (Tangguh Train 3) is planned to be operational

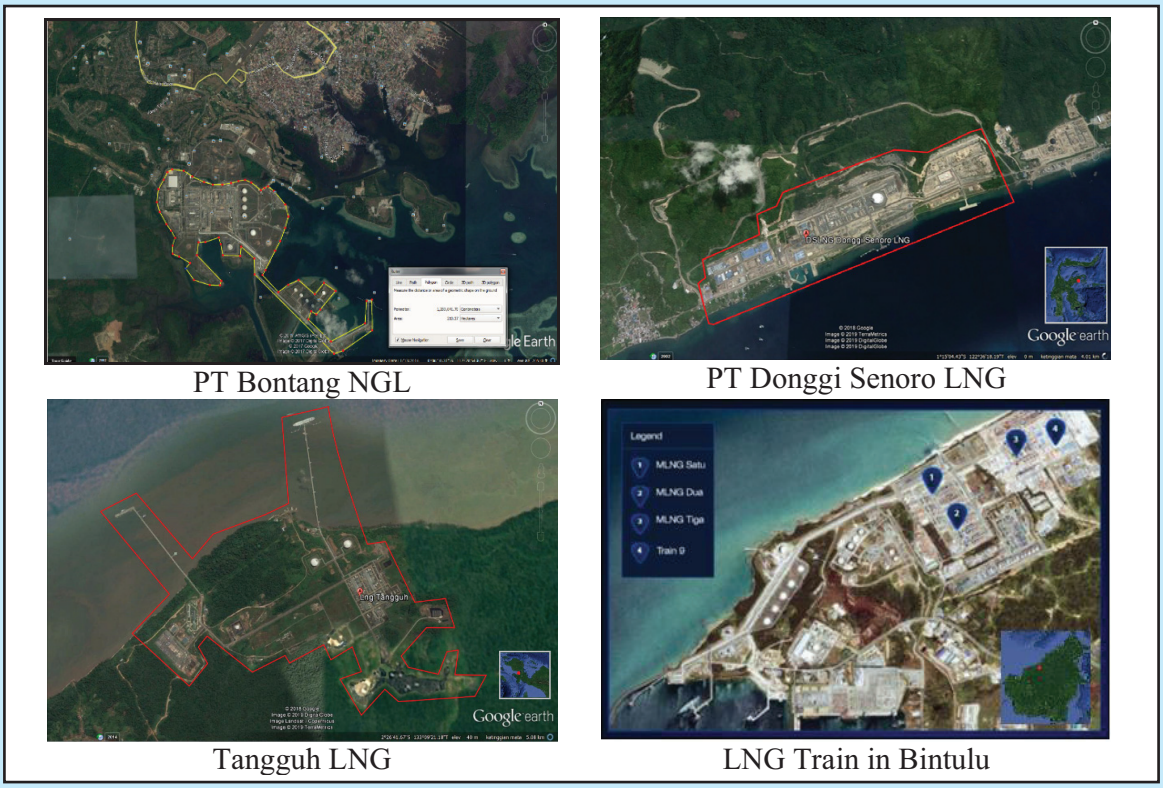

Figure 2
Existing Natural Gas Refinery in Indonesia and Malaysia.

starting in 2020 (BP Indonesia, 2014). This production facility is located in Bintuni Bay, Papua with a land area of around 350 hectares (Figure 1). The Tangguh Pant facility is built on quaternary and late Tertiary sedimentary rocks, at an elevation of about 30m meters. According to the earthquake prone map this area is located on the scale of V - VII MMI (Center for Volcanology and Geological Disaster Mitigation, 2012).

4. Development of LNG, Bintulu

In 1971, PT. Shell discovered a large natural gas reserve on Luconia Field which is located off the coast of Sarawak Malaysia. Shell with reserves of up to 33 tcf was able to meet the needs of nine trains for 20 years with gas production of 1.200 MMcfd. This production facility was built on the west coast of Sarawak, at an elevation of around 25 meters (Figure 2).

Important information related to the Badak LNG refinery, Donggi Senoro LNG and Tangguh LNG is shown in table 1. The important information is land slope, land height, beach type, groundwater depth, water source, and year of construction, number of trains, design capacity, current production, the area of refinery complexes, and other transportation facilities.

B. Limitation

This paper outlines the results of a study focused on site selection for Onshore Refinery Natural Gas development in Eastern Indonesia, while issues related to EIA and Environmental Management Efforts / Environmental Monitoring Efforts are not discussed.

III. RESULTS AND DISCUSSION

Masela Block, a gas block, was discovered by Inpex more than a decade ago, is located in Laut Timor Basin, east of Timor Island just on along the border line between Indonesia and Australia. The discovery has been seen as a driver of economic development in all sectors in the surrounding region which has long been suffering from very limited infrastructure. In this area there is a good management of upstream and downstream oil and gas in a surrounding region (Baik 2015 in Sunarjanto et al, 2016). However, oil and gas industry development would likely face some constraints, such as greater distance from the capital city, a deep sea situation,

high sea floor slope towards closest islands, a lack of infrastructure and facilities, and possibly a border dispute with neighboring countries (Sunarjanto, et al., 2016).

In general the activities (Figure 3) carried out in the oil and gas field development projects which are located offshore and built on land refineries are:

- Carry out oil and gas production from offshore fields,
- Flow to oil and gas processing facilities (FPSO),
- Flow condensate to tankers and gas to gas refineries on land,
- Processing gas into LNG for domestic and export needs

Geohazards must be considered seriously in the area of Onshore Refinery Natural Gas development, especially in Eastern Indonesia that have potential tectonic activity. Geohazards are important things in the area of Onshore Refinery Natural Gas development in Eastern Indonesia because, (1) Eastern Indonesia is on the plate boundaries of Asia, Pacific and Australia with active and high earthquake zones. (2) The existence of an Onshore Refinery Natural Gas on the coastal is expected not to be disturbed by the earthquake and tsunami disaster. (3) There are several troughs and active faults that affecting the selection routes of pipelines from the wellhead to the Onshore Refinery Natural Gas production facilities.

The comparative analysis of coverage area for Onshore Refinery Natural Gas facilities in Indonesia concluded that when the area used is getting narrower, this opens opportunities for Onshore Refinery Natural Gas to be built in eastern Indonesia consisting of islands with the potential of low to moderate geohazard level.

The development of the Onshore Refinery Natural Gas area consists of several stages, including the determination of the area, planning of refinery design and development of supporting industries. In the selected area detailed studies of natural disasters prone to work were carried out by national and local experts. Material selection in Onshore Refinery Natural Gas facility planning is directed to be able to use material that can be produced by domestic industries. At the stage of physical development it is directed to utilize local experts and labor. Thus the construction of the Onshore Refinery Natural Gas area will have a fairly high local content value.

Disaster study activities are directed towards national and local experts. The design of the LNG plant is designed to involve national experts, so that the technology transfer process occurs and the ability of national experts is increased. In the process of development it is directed to the maximum extent possible to employ local workers by supervising national experts and foreign experts. At the planning stage of the LNG refinery it is necessary to consider the use of materials that can be produced by the national industry.

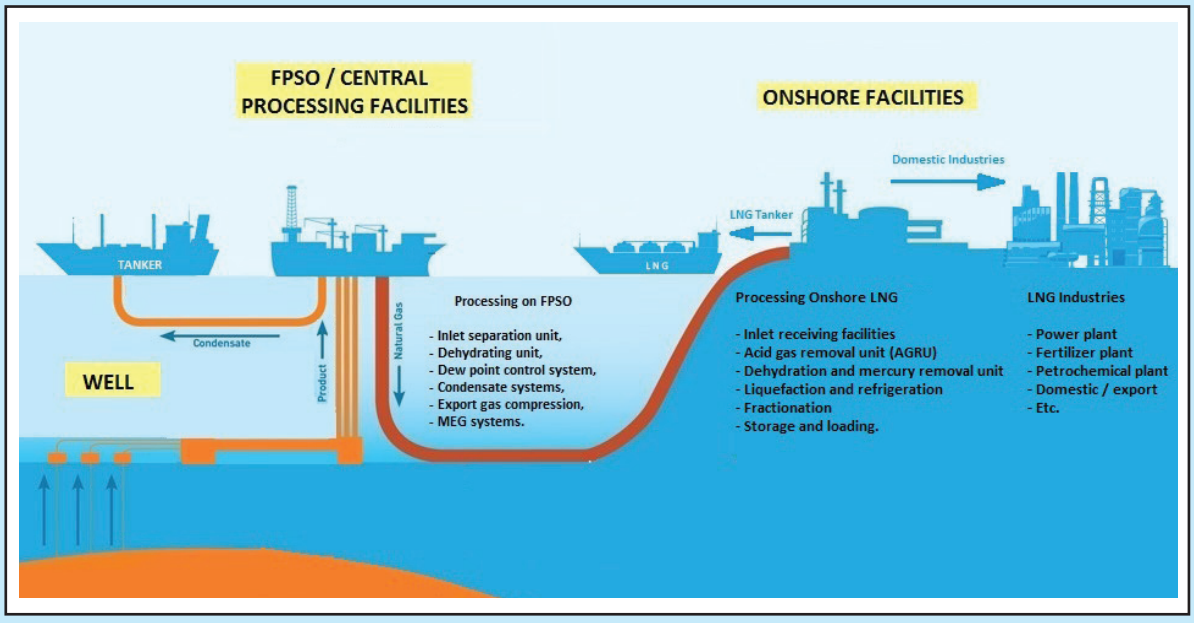

Figure 3
Activities on Onshore Refinery Natural Gas (Source: LNG Journal, 18 January 2012, Modified).

The results from regional comparison analysis and development of Onshore Refinery Natural Gas areas;

- Utilizing natural gas sources from several locations, became integrated Onshore Refinery Natural Gas development area. Example, in Donggi Senoro LNG, Central Sulawesi, utilizing gas from the Senoro gas field and the Donggi-Matindok gas field.
- Due to limited area, several islands can be utilized for the development of the Onshore Refinery Natural Gas industry. For example, development plan of Masela gas field in on several islands in Maluku Barat Daya and Maluku Tenggara Timur.

Table 1 shows the development of Onshore Refinery Natural Gas development in Indonesia since 1974 until present. Amount of trains affected the area, also the production capacity and facilities from each Onshore LNG refineries. For information, recent Onshore LNG is located in Eastern Indonesia.

The development of Onshore Refinery Natural Gas supporting sectors, such as agriculture, plantations, fisheries, tourism and other supporters that are characteristic and / or are the main commodities of the area need optimal attention and support.

Optimization of the potential use of natural gas in the Onshore Refinery Natural Gas business can be grouped into three, namely:

- Natural gas is used as fuel. Natural gas is used as fuel which replaces the use of petroleum. Some industries that have the opportunity to use gas fuel include power plants, heavy to light industries, motorized vehicles in the form of CNG and NGV, restaurants, hotels, households and so forth. LPG (Liquefied Petroleum Gas), is a mixture of various hydrocarbon elements derived from natural gas. By increasing the pressure and lowering the temperature, the gas turns liquid. Its components are dominated by propane (C_3H_8) and butane (C_4H_{10}). LPG also contains other light hydrocarbons in small amounts, for example ethane (C_2H_6) and pentane (C_5H_{12}). The use of LPG in Indonesia is primarily as household fuel.
- Natural gas as raw material. Industries that use gas as raw material are fertilizer, petrochemical, methanol, LDPE (Low Density Polyethylene) plastic raw materials, LLDPE (Linear Low Density Polyethylene), HDPE (High Density Polyethylen), PE (Poly Ethylene), PVC (Poly Vinyl Polyethylene) Chloride), C3 and C4 can be used for LPG, CO2 can be used as raw material for soft drinks, dry ice, food preservatives, artificial rain, cast iron industry, welding and light fire extinguishers.
- Natural gas as an energy commodity for export. Most natural gas producing countries in the world sell gas as a commodity for countries that are in dire need of natural gas. The biggest mode of transportation of natural gas used for export commodities in the world is LNG (Liquefied Natural Gas). LNG is natural gas that has been processed by removing impurities and heavy hydrocarbons and then condenses it into liquid at atmospheric pressure by cooling it to around -160° Celsius. LNG is transported using specially designed vehicles in tanks that are also specially designed.

Some important things as data in the development of the Masela Onshore Refinery Natural Gas area are general data (DJMG, 2017): the depth of the sea between 400 m s.d. 800 m, Abadi field gas reserves estimated at 10.73 TCF (Lemigas-SKK Migas, 2017).

Another important thing is about geohazards in the Onshore Refinery Natural Gas development area, Eastern Indonesia is known as a region that has high tectonic activity, so it is necessary to update bathymetry and geohazards data. Presidential Regulation no 33 of 2015 CONCERNING STATE BORDER PLANNING PLAN FOR THE MALUKU PROVINCE; developing an area for offshore oil and gas mining that is environmentally friendly and based on disaster mitigation and adaptation.

Geohazards become very important in the Onshore Refinery Natural Gas development area due to 3 (three) things: (1) Eastern Indonesia is on the boundary of the Asia, Pacific and Australia plates which are active and high earthquake zones. (2) The existence of Onshore Refinery Natural Gas areas in coastal areas requires active monitoring. (3) The existence of a number of active trenches and faults, thus affecting the selection of routes and natural gas pipeline from the wellhead to the Onshore Refinery Natural Gas production facility.

The LNG refinery area needs to be sought free from high-level geohazards. Geoharzards, such as the earthquake, tsunami, mud volcano and flood disaster. The selection of the initial level of potential areas for LNG plant development can be done using regional maps that have been issued by the relevant agencies. For selected regions for the construction

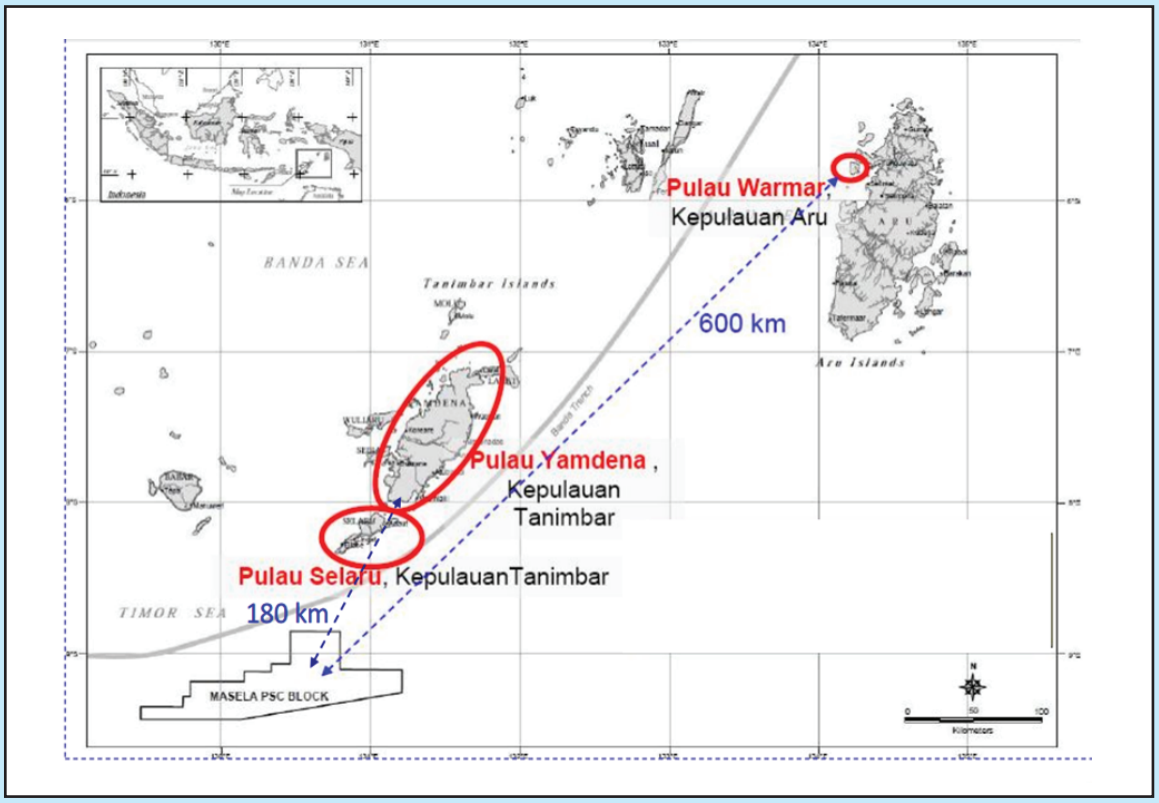

Figure 4
Masela PSC block in south west Maluku area (Ditjend Migas, 2017).

of the LNG refinery, further studies are carried out related to earthquakes, tsunamis, land movements, mud volcano and floods.

The development of Onshore Refinery Natural Gas refinery is related to location of the source, processing location and user location. Till the middle year of 2019, in East Indonesia have been built two LNG refineries that is Tangguh LNG in Bintuni Bay, West Papua and Donggi Senoro LNG in Central Sulawesi. Based on the collected data, the two LNG refineries located in natural coastal areas with clearly siltation, at the 20 meters topographic elevated above sea level. Based on the earthquake-prone map, both LNG refinery are located in low-to-moderate disaster zone, with scale V - VIII MMI.

Considering the location of the two LNG refineries toward the eastern Indonesia region, Donggi Senoro Refinery can represent Sulawesi, Tangguh Refinery represents Papua, then one region that hasn't been represented is Maluku which is become the focus study of potential development LNG refinery.

Referring from region earthquake hazard map released by Center for Volcanology and Geological Hazard Mitigation, coastal morphology and sedimentation processes that occurred some islands have the potential to develop the LNG industry. The expected areas are Wetar Island, Yamdena Island, Aru Islands, and Seram Island. The expected areas are Wetar Island, Yamdena Island, Aru Islands, and Seram Island. (Selaru Island, Yamdena Island and Warmar Island (Figure 4).

Another potential that must be considered is the water resources that must be sufficient for Onshore Refinery Natural Gas construction and operation. According to the Geological Agency (2009): Yamdena area in Southwest Maluku has the possibility of groundwater prospects that can be developed. The possibility of developing and utilizing ground water in the area of investigation can be stated as follows:

1. Unconfined groundwater

   Unconfined groundwater is found in local small productive aquifer areas, namely in the plains and hilly ground water zones in coastal areas such as Wertamrian, Wermaktian Batuputih, and Kormomolin areas. Aquifer productivity is generally small with a well discharge of less than 5l / sec. Unconfined groundwater resources which prospects for development are also found in the

areas of moderate productive aquifers and local areas of productive aquifers, which are found in plains formed by coral limestone, such as in Saumlaki, southern Tanimbar; Adaut, Selaru; and Larat, North Tanimbar. Ground water levels are generally shallow 1 - 5 m, locally in the Sifnana area the depth reaches 13 m BMSL. Utilization of unconfined ground water can be done in a simple way, namely by making dug wells or hand drilled wells

2. Confined Groundwater

   The prospect of developing and exploiting groundwater in study area is unlikely, because this area is generally composed of compact rocks so that groundwater is only limited to weathered and fractured zones. Confined groundwater can still be expected in the hills and terrain groundwater zones, in areas with relatively sloping morphology, and areas of rock breakage or destruction.

   In karst groundwater zones, a limited amount of Confined groundwater can still be expected in fracture zones in relatively sloping areas, such as found in Yamdena Island, namely in the South Tanimbar area including Saumlaki and Olilit, and North Tanimbar in Larat Village. In Selaru Island, confined aquifers are possible in Adaut, Namtambung, Abat, Lingat, and Bulat Village. This is indicated by the presence of springs from underground rivers in Adaut Village which never drie.

3. Water springs

   The emergence of springs is mainly found in karst ground water zones compiled by coral limestone, in general the flow is small - medium, the measured discharge at the Bomaki spring in Sifnana Village reaches 15 l/sec, some has been used for the supply of clean water to the surrounding population . These springs arise through fractures or faults of solid sedimentary rocks and limestone.

Based on groundwater potential data, it can be seen that groundwater resources in Yamdena, in certain regions have sufficient potential to be developed, meanwhile some regions have limited groundwater potential. Initiatives from local governments and stakeholders are needed to play a role in seeking the use of mutual support between surface water and ground water, to meet the needs of raw water sources for the provision of clean water for residents and later to support the construction and operation of Onshore Refinery Natural Gas in Yamdena and surrounding areas.

IV. CONCLUSION

Monitoring the geohazard and mitigation efforts continuously for site selection and the development of Onshore Refinery Natural Gas areas. Recommendation;

Development of Onshore Refinery Natural Gas areas is on the several adjacent islands. (especially on Yamdena Island). The determination location of onshore Gas Refinery from Masela Field is mostly determined by the distance and situation of the location toward geological disaster conditions or regional stability and supporting facilities (layout, ground water and so on).

Potential groundwater and surface water flow need to be, the river can be used as an alternative source of water for Onshore Refinery Natural Gas production. The study of engineering geology needs to be more detailed, aligned with the principle of high-costs in planning to construction, but is low-cost on maintenance.

Promote the use of mutual support between surface water and ground water for the needs of raw water sources for the supply of clean water for the population as well as to support the construction and operation of Onshore Refinery Natural Gas in Yamdena and surrounding areas. It is necessary doing the geohazard studies of Onshore Refinery Natural Gas areas, specifically related to flood, earthquake, tsunami, liquefaction, mud volcano and other natural disasters potential.

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