BACHELOR THESIS & COLLOQUIUM
ME184841

MARKET ANALYSIS OF NATURAL GAS SUPPLY AND DEMAND IN EAST JAVA PROVINCE TO ENABLE A SUSTAINABLE SCENARIO USING SYSTEM DYNAMICS SIMULATION

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SUPERVISORS:
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A. A. Bagus Dinariyana Dwi P., S.T., MES., Ph.D.

DEPARTMENT OF MARINE ENGINEERING
FACULTY OF MARINE TECHNOLOGY
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DOUBLE DEGREE PROGRAM OF
DEPARTMENT OF MARINE ENGINEERING
FACULTY OF MARINE TECHNOLOGY
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2020

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SKRIPSI- ME184841

Analisis Pasokan dan Permintaan Gas Alam di Provinsi Jawa Timur Untuk Mempersiapkan Skenario Berkelanjutan dengan Simulasi Dinamika Sistem

Johanna Kusuma
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DEPARTEMEN TEKNIK SSISTEM PERKAPALAN
FAKULTAS TEKNOLOGI KELAUTAN
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
SURABAYA
2020

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APPROVAL FORM

MARKET ANALYSIS OF NATURAL GAS SUPPLY AND DEMAND IN EAST JAVA PROVINCE TO ENABLE A SUSTAINABLE SCENARIO USING SYSTEM DYNAMICS SIMULATION

BACHELOR THESIS

Submitted to Comply One of the Requirement to Obtain a Bachelor Engineering Degree

On

Reliability, Availability, Management, and Safety (RAMS)
Bachelor Program Department of Marine Engineering
Faculty of Marine Technology
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MARKET ANALYSIS OF NATURAL GAS SUPPLY AND DEMAND IN EAST JAVA PROVINCE TO ENABLE A SUSTAINABLE SCENARIO USING SYSTEM DYNAMICS SIMULATION

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ABSTRACT

In the last 5 years, Indonesia has seen an increasing amount of infrastructure development, from toll road, airports, and power plants. This will continue for a number years. As the economic and population growth, energy needs in Indonesia are also increasing every year. Indonesia has abundant natural gas reserves at 142.71 trillion standard cubic feet (TSCF) and the largest reserves in Southeast Asia. Indonesia is also Southeast Asia's biggest gas supplier, with exports accounting for roughly 45% of its production. Natural gas is an affordable energy source and very accessible. At the current rate of consumption and assuming no new discoveries, existing reserves would last around 50 years. In this study, there are two scopes of research, first determining the supply and demand of natural gas in Java Island, and then market analysis. A market study on gas supply and demand is done on various industry, from power plants, factories, and households needs. From the market study, the condition is analysed using system dynamics simulation, whether the gas supply meet the demand or not. Then, from the current condition, an improved and sustainable model of gas distribution system is proposed. The information will hopefully be useful for companies and government in developing the infrastructure and making decisions. The result of the simulation is the current supply and demand condition is inadequate. There will be deficit of supply every year except for 2023. The maximum daily deficit is 230.1 MMSCFD in the year 2022. Additional supply of 200 MMSCFD is required in year 2022. The viable option would be building a LNG Receiving Terminal with a capacity of 150-200 MMSCFD in Pasuruan area or to use the LNG Teluk Lamong facility.

Keywords: market analysis, natural gas distribution, system dynamics simulation

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ANALISIS PASOKAN DAN PERMINTAAN GAS ALAM DI PROVINSI JAWA TIMUR UNTUK MEMPERSIAPKAN SKENARIO BERKELANJUTAN DENGAN SIMULASI DINAMIKA SISTEM

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ABSTRAK

Dalam 5 tahun terakhir, Indonesia mengalami peningkatan pembangunan infrastruktur dalam jumlah yang massif, dan hal ini masih akan berlanjut dalam beberapa tahun ke depan. Seiring dengan pertumbuhan ekonomi dan populasi, kebutuhan energy di Indonesia juga meningkat tiap tahun. Indonesia memiliki cadangan gas alam yang melimpah, yaitu 142,71 trilun standar kaki kubik (TSCF), menempati peringkat pertama di Asia Tenggara. Gas alam adalah sumber energy yang terjangkau dan mudah diakses di wilayah Jawa Timur. Dengan tingkat konsumsi saat ini, dan apabila tidak ada penemuan cadangan baru, jumlah cadangan gas alam saat ini dapat bertahan sekitar 50 tahun. Dalam penelitian ini, ada dua lingkup penelitian, pertama penentuan penawaran dan permintaan gas alam di Provinsi Jawa Timur, kemudian simulasi dengan menggunakan simulasi dinamika system untuk memenuhi permintaan yang akan ada. Studi pasar tentang pasokan dari sumur-sumur dan sumber gas dilakdan permintaan gas dilakukan pada berbagai industri, mulai dari untuk bahan bakar pembangkit lsitrik, industri, dan kebutuhan rumah tangga. Selanjutnya, kemampuan pemenuhan permintaan gas dianalisis dan diusulkan system distribusi gas yang lebih baik dan berkelajutan. Dari kondisi tersebut ditemukan bahwa kondisi pasokan gas alam di Jawa Timur saat ini tidak mencukupi untuk permintaan di masa depan. Akan ada deficit pasokan setiap tahun kecuali pada tahun 2023. Defisit terjadi hingga 230,1 MMSCFD pada tahun 2022. Untuk mengatasi itu, diperlukan pasokan tambahan berjumlah 200 MMSCFD pada tahun 2022. Opsi yang dapat dilakukan adalah dengan membangun fasilitas terminal penerima dan regasifikasi LNG dengan kapasitas 150-200 MMSCFD di daerah Pasuruan atau menambah kapasistas Terminal LNG Teluk Lamong. Penelitian ini diharapkan dapat bermanfaat bagi pemerintah dan perusahaan dalam mengembangkan infrastruktur dan membuat keputusan.

Kata kunci: analisis pasar, distribusi gas alam, simulasi dinamika sistem

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PREFACE

This study titled “*Market Analysis of Natural Gas Supply and Demand in East Java Province to Enable a Sustainable Scenario Using System Dynamics Simulation*” analysed the market of natural gas, mainly in supply and demand of household, electricity, and industrial sector by using system dynamics. This work benefited immensely from the advice, criticism, and encouragement of many colleagues, family, and friends. I owe an immeasurable debt to my supervisors, Prof. Dr. Ketut Buda Artana, S.T., M.Sc., and A. A. Bagus Dinariyana Dwi P., S.T., MES., Ph.D., for their help, guidance, integrity, high standards, and passionate commitment. May I have the chance to thank you and prove myself in the future. To Dr. Eng. Dhimas Widhi Handani, S.T., M.Sc., my system dynamics teacher. To Raja Oloan Saut Gurning, S.T., M.Sc., Dr. Emmy Pratiwi, S.T., and Fadilla Indrayuni Prastyasari, ST., M.Sc. as the lecturers of RAMS Laboratory. Dr. Eng. M. Badrus Zaman S.T., M.T., as the Head of Marine Engineering Department (2015-2019) and Mr. Beny Cahyono, S.T., M.T., Ph.D., as the Head of Marine Engineering Department (2020-2024), Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember. Ir. Dwi Priyanta, M.SE., as the author’s supervisor lecturer and Dr.-Ing. Wolfgang Busse that had helped the author throughout the time of her study. I am thankful for all the lecturers and staffs in Marine Engineering Deparment, Institut Teknologi Sepuluh Nopember for the invaluable help and good assistance during my study.

In addition, the author would like to thank other students doing the Final Thesis in RAMS Laboratory, Hadyan, Christian, Trian, *Mbak* Nanda, and Ramirez, thank you for being such a good companion, for the late nights and the support. I hope they’ve learned as much from me as I’ve learned from them. Thank you to Mr. Firman, Mr. Thariq, Ms. Widhi, Ms. Hayy, Mr. Adam and Mr. Desta for the assistance. To Stanley, as a mentor who had assisted me in explaining the materials and a great discussion partner.

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A special acknowledgement to Tatyana, Jane, Ruth, Charra, Radifan, Shalmia, Fadel, Ardy, Kitto, Joey, Vira, Dinis, Aghi, Bella, Irvan, Frankie, Elisa, Ferrel, and Jonathan. Thank you for all the encouragement and comfort. Finally, the love and support of my family have been constant and essential. I would not be where I am today without your help. Thank you.

Author realize that this research is flawed and far from perfect. The author acknowledged her limitations and is expecting constructive criticism and suggestion for this research. The author hopes that this Thesis can be useful for the readers.

Surabaya, 2020
Johanna Kusuma

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CHAPTER 1
INTRODUCTION

1.1. Background

Indonesia has abundant natural gas reserves at 142.71 trillion standard cubic feet (TSCF) and the largest reserves in Southeast Asia. Indonesia is also Southeast Asia's biggest gas supplier, with exports accounting for roughly 45% of its production. The largest undeveloped gas reserves are located in the offshore East Natuna Block, which holds approximately 49.6 TSCF, there are also many high potential areas like West Papua and Maluku. At the current rate of consumption and assuming no new discoveries, existing reserves would last around 50 years.

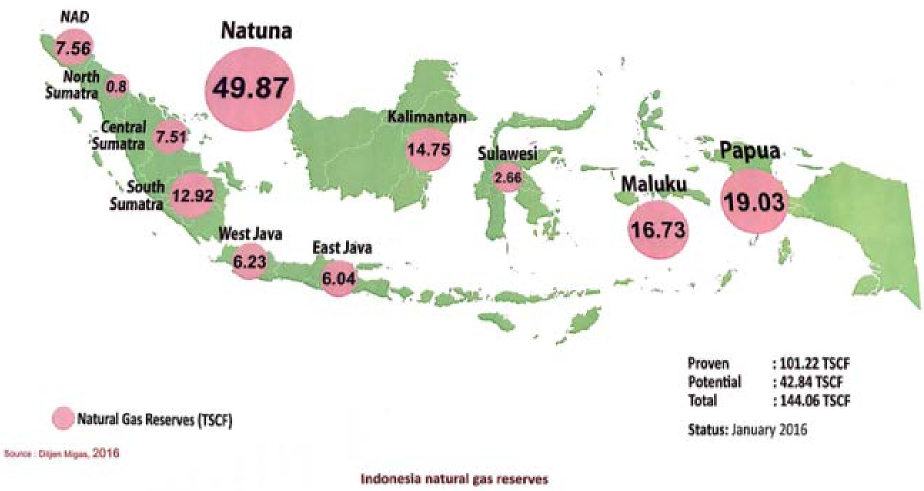

Figure 1.1 Indonesia Natural Gas Reserves (Source: Ditjen Migas, 2016)

Natural gas is relatively low-carbon (as compared to coal) and is generally medium-cost. Gas is therefore likely to remain a favoured fuel for at least the next decade especially given Indonesia's extensive gas reserves. While the electricity generated from natural gas in 2027 is expected to increase by over 80% from 2018 (in TWh) the share of gas in the energy mix in 2027 is expected to be only 20.6% representing a decrease from 24.8% of the energy mix in 2017. An oversupply of global and Asian (including Indonesian) Liquefied Natural Gas ("LNG") is likely to stimulate further consumption although the LNG market is expected to tighten over the next few years. Certainty over the upstream oil and gas investment climate and improved physical infrastructure (including pipelines and Floating Storage Regasification Units ("FSRUs")) as well as pricing for gas-for-power arrangements (currently under review again) are crucial to enabling a strong long-term role for gas in the Indonesian power generation mix. (PWC Power Guide in Indonesia 2018).

A draft assessment by the *Ministry of Energy and Mineral Resources* projects that Indonesia's national electricity demand will grow at an annual rate of

10.1% until 2031. In the *Indonesian Electricity Supply Business Plan 2019 (RUPTL)* it is also stated that an increase of 1.8 GW of installed renewable power capacity in the ten-year plan from 2019 to 2028, bringing new renewable capacity to 16.7 GW as compared to 14.9 GW in the previous RUPTL. The Minister also emphasized that the 0.4 percentage point cut in the demand growth forecast to 6.4% for the 2019 to 2028 period answers critics' concerns about the reliability of past RUPTL demand estimates.

In contrast to the 2000s, the current supply of natural gas for domestic market is greater than for export. Natural gas export is expected to continue to decline until the end of 2035 so that all natural gas production can be used for domestic demand. However, natural gas production will not be able to meet national gas demand in the future. To overcome the shortage in gas supply, it is necessary to consider non-conventional gas and import gas in form of LNG.

Energy demand and manufacturing activities are growing every day, with the government targeting an economic growth. The activities are creating investment opportunities in Indonesia's oil and gas sector. While in the past most oil and gas would be exported, strong economic growth and rapidly rising household spending mean the sector will focus more on self-consumption. A modernized, efficient and reliable energy supply system is needed to advance the economic development. Despite the availability of coal in Indonesia, the government's plan to rely more on cleaner burning gas and less on coal to fire new power plants is set to create stronger and stronger demand for gas.

Table 1.1 Natural Gas Demand for Industries in Indonesia

Industry	**2015**	**2020**
Fertilizer	791.22	1028.22
Petrochemical	295.00	708.00
Ceramics	133.95	134.68
Steel	80.00	120.00
Glassware	28.38	28.60
Glass	81.19	81.19
Cement	9.00	10.00
Rubber Gloves	4.67	4.70

* in metric standard cubic feet per day (MMSCFD)
(Source: *Forum Industri Pengguna Gas Bumi*)

With the growing energy demand, there is an absence of information on the integrated supply and demand. The gas distribution system already is hard pressed to maintain stable supplies in areas with high load densities, including Jakarta, Bandung, and East Java.

In order to overcome this condition and to fulfil the needs of gas in Java Island, it is considered necessary to improve the efficiency of natural gas distribution. To provide with an accurate recommendation, the historical data and forecasts will be analysed. The method that will be used is system dynamic simulation. System Dynamics is a computer-aided approach to policy analysis and design. It applies to dynamic problems arising in complex social, managerial, economic, or ecological systems—literally any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality.

Based on the circumstances above, author would like to analyse the supply condition of natural gas distribution in East Java. Currently, East Java Province has adequate natural gas field, but the supply decreased over the year while the demand increased due to economic and population growth. As mentioned above, the system dynamics will have two outputs, conceptual model and simulation model. The conceptual model is causal loop diagram while the simulation model is flow and stock diagram.

1.2. Problem Statement

From the description above, then we can determine the main issues that will be discussed more as mentioned below:

1. How to develop a gas distribution model based current and forecasted supply – demand in East Java Province?
2. How is the performance of the current gas distribution system in East Java Province?
3. How to develop a scenario to meet the gas demand based on supply capacity?

1.3. Research Objectives

Based on problems mentioned above, the goals of this research are:

1. Provide alternative options and scenario of supply gas to minimize the risk of natural gas deficit in industrial sector, household sector, and electricity generation in East Java Province using System Dynamics simulation.
2. Provide a gas supply and demand map for the current and forecasted condition in East Java Province.
3. Provide a map of current and future gas infrastructure in East Java Province.

1.4. Scope of Study/Research Limitation

This final project will be focused and organized with limitations on problem, which are:

1. Analysis will be done on gas supply in industrial sector, household sector, and electricity generation.
2. Analysis of supply and demand in East Java Province.
3. Scenario will be designed but the implementation will not be analysed.
4. Collecting historical data and information on the related aspect, and the gas availability from the past 10 years. Analyse the readiness of supply and infrastructure at the related sector for the substitution of energy sources in the future.

1.5. Research Benefits

This final project is expected to give benefits for various parties. The benefits that can be obtained are:

1. Present option plan about the distribution of energy (natural gas) in East Java Province, which can increase effectivity and efficiency in natural gas distribution.
2. Present recommendation and suggestion for gas supply and development plan along with the effort to overcome gas deficit or surplus by finding new alternatives.
3. Present a visualization of the current and forecasted national gas supply and demand in Java Island.
4. Present a visualization of current and future gas infrastructure in East Java Province.

CHAPTER 2
LITERATURE STUDY

2.1. Natural Gas

2.1.1. Natural Gas Characteristics

Natural gas is a vital component of the world's energy supply. It forms an important source for the production of both fuel and ammonia (the later being a vital component for the production of fertilizers). Similar to crude oil and coal, natural gas is a fossil fuel that emerged from the remains of plants, animals and microorganisms, stored deep underground for millions of years. But unlike other fossil fuels, gas is one of the cleanest (as it has low carbon intensity), safest and most useful of all energy sources.

Natural gas comprises gases occurring in deposits, whether liquefied or gaseous, consisting mainly of methane. It includes both “non-associated” gas originating from fields producing hydrocarbons only in gaseous form, and “associated” gas produced in association with crude oil as well as methane recovered from coal mines (colliery gas). Manufactured gas (produced from municipal or industrial waste, or sewage) and quantities vented or flared are not included. Data in million cubic metres are measured at 15°C and at 760 mm Hg, i.e. Standard Conditions. Natural gas data presented in terajoules are on a gross calorific basis. However, data expressed in tonnes of oil equivalent (toe, mainly for comparison reasons with other fuels) are on a “net” calorific basis. The difference between the “net” and the “gross” calorific value is the latent heat of vaporisation of the water vapour produced during combustion of the fuel. For natural gas, the net calorific value is 10% lower than the gross calorific value.

The typical properties of natural gas consists of 80-99% methane, and other hydrocarbon such as ethane, propane, N-butane, Iso-butane, Hexanes plus, and other gases such as nitrogen, carbon dioxide, hydrogen, and sulphur.

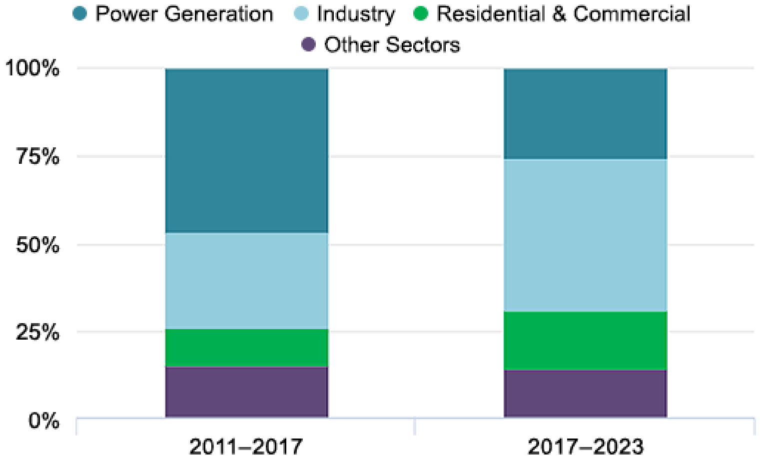

Figure 2.1 Worldwide Natural Gas Consumption Growth by Sector (Source: IEA)

2.1.2. Natural Gas Supply Chain

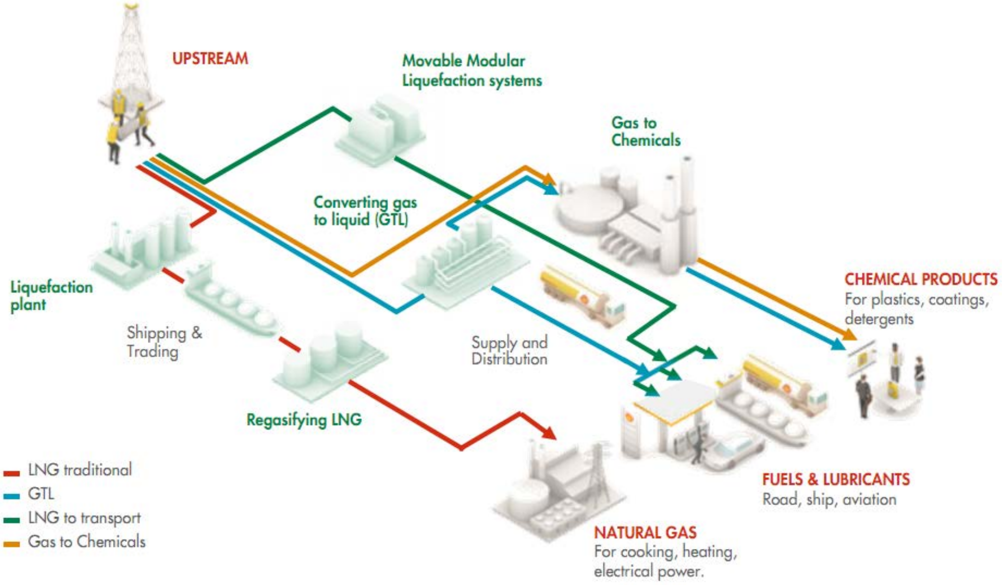

Figure 2.2 Natural Gas Supply Chain, from upstream, midstream, to downstream. (Source: https://www.2b1stconsulting.com/)

The natural gas supply chain is similar to other fossil fuel supply chain. It consists of exploration, exploitation, production, distribution – transportation, and consumption. The natural gas supply chain can be analysed through three different industry sectors: upstream, midstream, and downstream.

The oil and gas supply chain cannot be separated. The upstream sector is also known as the E&P (Exploration and Production) sector. It is consisted of processes and operations that involve searching for potential underground or underwater crude oil and natural gas fields, drilling of exploratory wells, and subsequently drilling and operating the wells that recover and bring the crude oil and/or raw natural gas to the surface. In recent years, there is an evident shift towards the inclusion of unconventional gas as part of the Upstream sector. This also affects the developments in processing and transporting Liquefied Natural Gas (LNG). The recent gas reserves exploration is the shale gas.

The midstream sector is usually combined in the literature with the downstream sector. This segment in the supply chain, involves the transportation, storage and marketing of various oil and gas products. Transportation options can vary from small connector pipelines to massive cargo ships making trans-ocean crossings, depending on the commodity and distance covered.

When we are discussing the transportation of oil and natural gas, most oil can be transported in the current state, while the natural gas must be liquefied or compressed.

When it comes to the downstream sector, it encompasses the refining, processing, distillation and purification before turning it into usable, sell-able and consumable products e.g. fuels, raw chemicals and finished products etc. All the afore-mentioned services transform crude oil into usable products such as gasoline, fuel oils, and petroleum-based products. Retail marketing activities help move the finished products from energy companies to retailers or end users.

In general, natural gas transportation required more expense and technical aspects compared to crude oil, oil products, and coal.

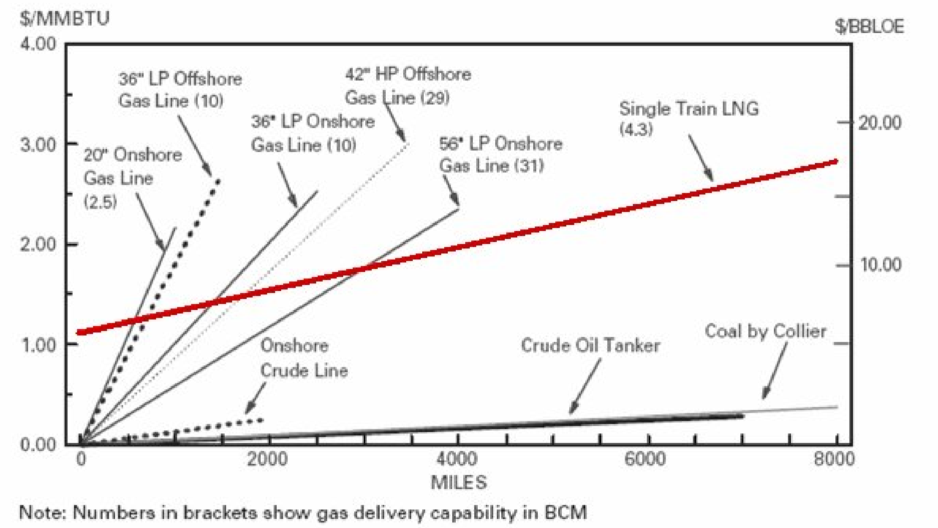

Figure 2.3 Costs of gas, oil, and coal transportation (Source: Anne Neumann, 2006)

2.1.3. Natural Gas Reserves in Indonesia

Table 2.1 Asia-Pacific Natural Gas Trade Balance (BCM)

	Domestic Production (2012)	Domestic Consumption (2012)	LNG Imports (2012)	LNG Exports (2012)	Pipeline Imports (2012)	Pipeline Exports (2012)	Natural Gas Trade Balance			
							2012	2015	2020	2025
Asia Pacific Importers										
China	107.20	146.60	20.00		24.20		(39.40)	(48.42)	(67.15)	(91.63)
India	40.30	54.60	20.50				(14.30)	(17.73)	(24.65)	(33.71)
Japan		116.70	118.80				(116.70)	(132.69)	(164.36)	(203.58)
Singapore		8.30			9.50		(8.30)	(9.44)	(11.69)	(14.48)
South Korea		50.00	49.70				(50.00)	(56.85)	(70.42)	(87.22)
Taiwan		16.30	16.90				(16.30)	(18.53)	(22.96)	(28.44)
Thailand	41.40	51.20	1.40		8.50		(9.80)	(12.54)	(18.31)	(25.94)
Asia Pacific Exporters							-	-	-	-
Australia	49.00	25.40		28.10	10.90		23.60	25.18	27.91	30.70
Brunei	12.60	35.80		9.10			12.60	13.90	16.37	19.29
Indonesia	71.10	33.30		25.00		10.20	35.30	37.74	41.98	46.39
Malaysia	65.20			31.80	2.30		31.90	34.07	37.83	41.72
Myanmar	12.70					8.50	12.70	14.00	16.50	19.44
Supply-Demand Balance							(138.70)	(171.31)	(238.95)	(327.46)

Notes: Supplies increase based on projected regional production and consumption growth rates from BP Energy Outlook 2013. Data for China include Hong Kong.

(Source: BP, BP Statistical Review of World Energy June 2013 (2013); BP, BP Energy Outlook 2035 (2013).

Indonesia has abundant natural gas reserves at 142.71 trillion standard cubic feet (TSCF). The larges undeveloped gas reserves are located in the offshore East Natuna Block which holds approximately 49.6 TSCF. Other areas with high potential are West Papua and Maluku. Assuming no new discoveries, existing reserves would last around 50 years at the current rate of consumption.

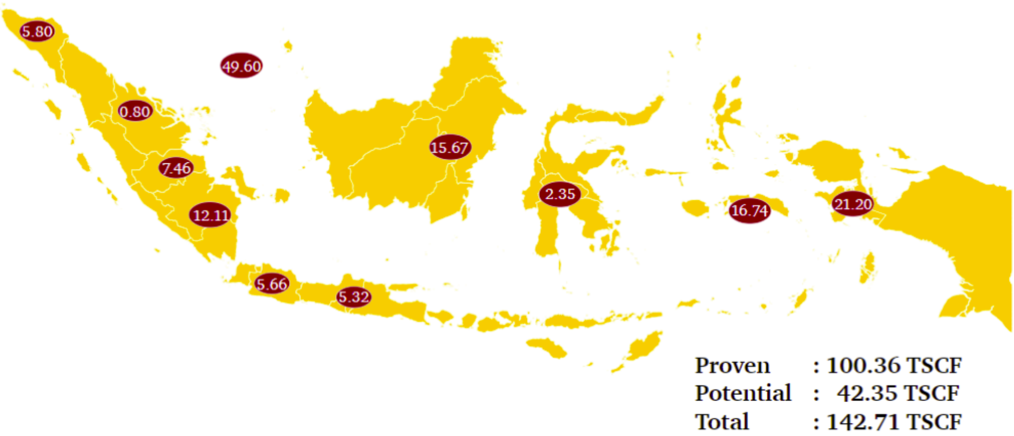

Figure 2.4 Map of Indonesian gas reserves per January 2017 (Source: LAKIN DJMGB 2017)

Indonesia has experienced a gradually narrowing surplus of gas production over domestic consumption over the past five years, as seen in Figure 2.5. But the difficulties associated with improving production in mature oil fields, the lack of exploration in the recent past and the unattractiveness of fiscal regime are though In contrast to the decreasing gas production, the domestic gas consumption in Indonesia has increased by more than 8% over the same period.

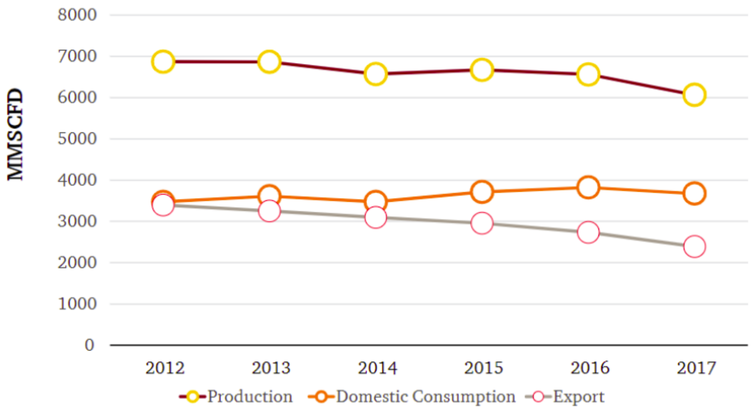

Figure 2.5 Indonesia Natural Gas Production, Domestic Consumption, and Export (in MMSCFD) for 2012-2017 (Source: LAKIN DJMGB 2017)

2.1.4. Gas Business Process

The oil and gas industry can be separated into three sectors: upstream, midstream, and downstream. The upstream sector includes the subsurface resource, its production to the surface, and the basic facilities at the well location. The midstream sector connects the upstream and downstream sectors, and it encompasses the transportation and storage of oil and gas between upstream production operations and downstream refining and processing operations. In the case of the two-sector system, the midstream sector is part of the downstream sector. A natural gas processing plant purifies natural gas and converts it into products such as LPG, liquefied natural gas (LNG), and fuel gas for residential, commercial, and industrial use.

Indonesia has been active in the oil and gas sector for more than 130 years, after the first oil discovery in North Sumatra in 1885. The declining oil production and increased consumption have resulted in Indonesia being a net oil importer since 2004. This factor, along with high oil prices before 2015, led the Government to gradually but substantially scale-back the domestic fuel subsidy during 2009-2014.

Investment in the oil and gas industry in Indonesia was around US$ 10.9 billion in 2018, as the rise in oil and gas prices triggered some investment interest from the previous US$ 10.3 billion in 2017, which was the lowest in decades. However, the industry’s contribution to the state revenue has fallen sharply from 14% in 2014 to 2.8% in 2016, before recovering to 4.9% in 2017 and 7.4% in 2018. The Government also set a target of 7.4% for 2019.

Indonesia is ranked 11th in terms of global gas production, with proven reserves of 96 trillion cubic feet (TCF) in 2018. On a reserve basis, Indonesia ranks 13th in the world and the second in the Asia-Pacific region (following China). Indonesia’s relevance in seaborne Liquefied Natural Gas (LNG) is more critical.

Table 2.2 Natural Gas Components

Component	Number of C Atoms	Natural Gas	LNG	Residential Gas	LPG	NGL
Methane	1	X	X	X		
Ethane	2	X	X	X		X
Propape	3	X	X		X	X
Butanes	4	X			X	X
Pentanes	5	X				X
Natural Gasoline	5+	X				X
Non-hydrocarbon		X				
Water		X				

2.2. Energy Consumption

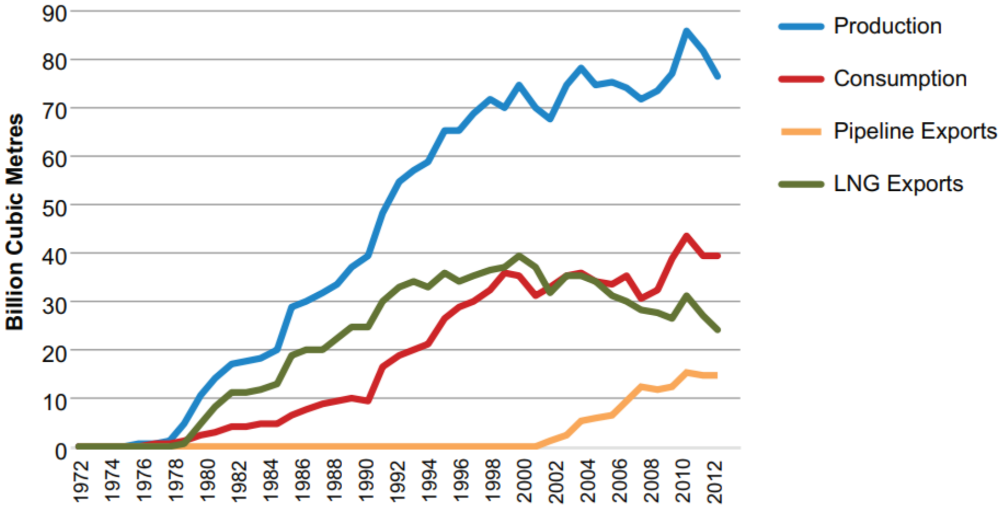

Figure 2.6 Indonesia's Natural Gas Production and Consumption (1971-2012) (Source: "World-Natural Gas Statistics," IEA Natural Gas Information Statistics (database) 2013, DOI: 10.1787/data-00482-en.)

Indonesia has been developing and producing natural gas since 1976. It was one of the biggest LNG exporter in 1980 until 2000. Yet, Indonesia have been importing oil and coal as an energy source. As seen in the graph above, the natural gas consumption is low compared to the production number, only about 30-40% maximum. To overcome energy shortage, the government issued several regulation such as the MoEMR Decree No. 1790 K/20/MEM/2018 which stated that the Minister of Energy and Mineral Resources is empowered to allocate some or all of the natural gas previously allocated to the power sector if it cannot be utilised by PLN or is not followed up with a natural gas purchase agreement within a year. The planned natural gas allocation for the power sector until 2027 is also included in the decree.

2.2.1. Energy Demand

The natural gas energy demand is mainly use for energy generator for national use and industrial use. It is also used for production in industry such as fertilizer, petrochemical, cement mill, steel mill, and other industry. The sector of gas consumer is divided into *wilayah usaha/*industrial, electricity generation, and household use.

1. Wilayah Usaha

At the end of 2017 the Government had issued 42 Wilayah Usaha, including the Wilayah Usaha of PLN, with a breakdown of 27 Wilayah Usaha already in operation and 15 Wilayah Usaha not yet operating. The distribution of Wilayah Usaha can be seen in Figure 2.7.

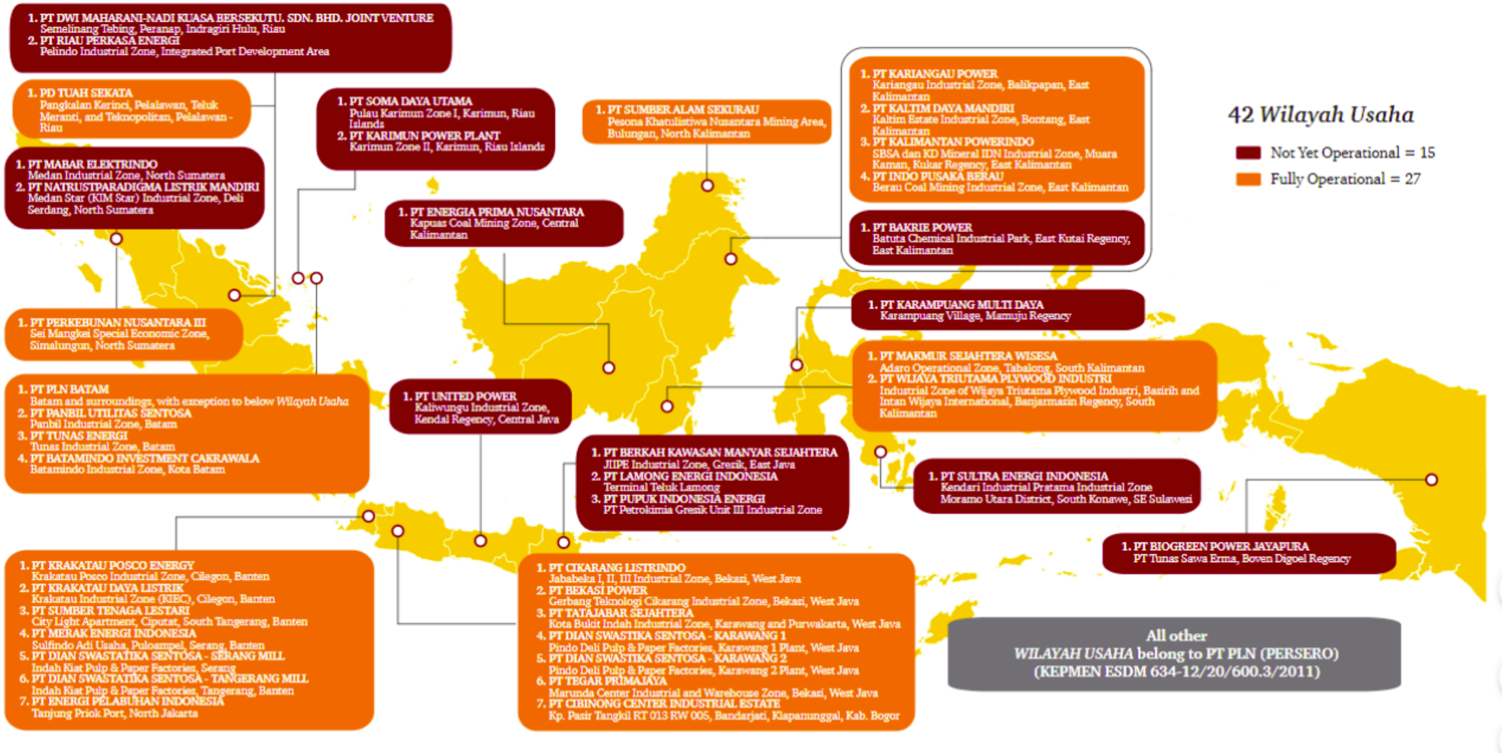

Figure 2.7 The holders of Wilayah Usaha in 2017 (Source: DGE; I Warsito, “The Availability of Reliable Electricity to Improve the Competitiveness of Industrial Area”, 18th July p. 12.)

2. Power Generation

At the end of 2017 the total installed capacity was 60.7 GW divided between: PLN and its subsidiaries which accounted for 41.7 GW (69%); IPPs accounting for 14.2 GW (23%); PPUs, accounting for 2.4 GW (4%), and the remaining 2.4 GW (4%) belonging to the holders of non-fossil fuel operating licences (IO Non-BBM). As such the majority of power-generating assets in Indonesia are controlled by PLN including its subsidiaries such as *Indonesia Power, Pembangkit Jawa Bali ("PJB")* and *PLN Batam*.

Private sector participation is allowed through IPP or PPP arrangements. IPP appointments are most often granted through competitive tenders although IPPs can be directly selected or directly appointed in certain circumstances under GR No. 14/2012 (as amended by GR No. 23/2014). A similar situation applies for PPPs under PR No. 38/2015 and its implementing regulation of LKPP (Lembaga Kebijakan Pengadaan Barang dan Jasa Pemerintah - Government Procurement of Goods and Services Policy Board) No. 19/2015.

Investors who generate electricity for their own use rather than for sale to PLN are known as PPUs. PPUs with a capacity greater than 200 kVA must hold an operating licence (Izin Operasi) to generate, transmit, and distribute for their own use or to their own customer base (such as tenants on an industrial estate). PPUs with a capacity between 25-200 kVA must obtain approval from the relevant Minister, Governor, or Mayor. PPUs with a capacity lower than 25 kVA are only required to report to relevant Minister, Governor, or Mayor. The PPU may sell excess capacity to an IUPTL holder, such as PLN, or directly to end customers subject to approval of the relevant Minister, Governor, or Mayor.

Table 2.3 Fuel type for Electricity Generation from 2018 to 2027 based on 2018 RUPTL in tWh

Fuel Type	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Hydro	19.0	17.6	18.0	19.8	20.0	23.7	28.0	43.1	44.4	46.7
Geothermal	14.7	16.6	17.5	19.3	22.4	23.6	26.2	50.8	50.0	49.2
Other	0.4	2.5	2.9	3,2	3.2	3.3	3.6	6.3	6.6	6.6
Gas (incl. LNG)	57.1	68.1	76.1	73.5	80.0	83.7	85.7	96.6	98.1	103.5
Oil	11.6	11.4	7.1	3.6	1.7	1.7	1.8	1.8	1.9	2.0
Coal	169.6	176.5	194.2	220.1	234.5	248.6	264.6	236.8	264.4	293.9
Import	1.4	1.6	0.9	0.6	-	-	-	-	-	-
Total	273.8	294.3	316.7	340.1	361.8	384.6	409.0	435.4	465.4	501.9

2.2.2. Gas Consumption Growth

As stated above, as the population growth increase in Indonesia, the industrial sector and energy needs is also being developed. It is why there will be a steep increase in energy needs and gas, as one of the abundant source that Indonesia has will be exploited for national use. Figure 2.8. below show the forecast of energy use in Indonesia based on the population growth by BAPPENAS and outlook report from the Ministry of Energy and Mineral Resources.

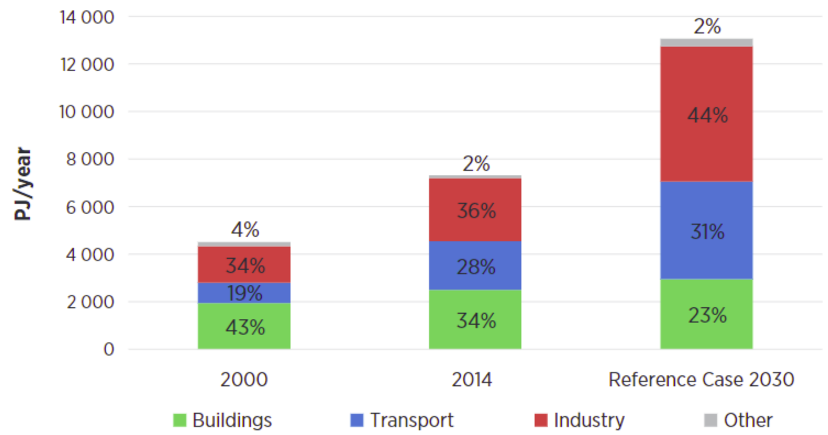

Figure 2.8 Breakdown of total energy consumption in Indonesia in 2000, 2014, and in the Reference Case of 2030 (Source: irena.org)

2.3. Infrastructure Development

2.3.1. Natural Gas Infrastructure in Indonesia

In the upstream sector, Indonesia has several gas terminals. Indonesia is also one of the pioneer of LNG export. The liquefaction terminal in Indonesia are PT Arun Natural Gas Liquefacton in Sumatra, PT Badak Natural Gas Liquefaction in Kalimantan, LNG Tangguh in Papua, and LNG Donggi Senoro in Sulawesi. Other natural gas producers in Indonesia can be seen in the table below:

Table 2.4 Indonesian Gas Production in 2011 (Source: Ditjen Migas ESDM)

No	Company	Volume (MSCF)
1	Res Canada (Camar)	1,019,170
2	Hess (Ujung Pangkah)	21,190,224
3	Kangean Energy	59,864,453
4	Kodeko (Poleng)	9,201,292
5	Lapindo Brantas	2,261,552
6	ExxonMobil (Cepu)	775,732
7	PHE WMO	49,226,084
8	PetroChina (Tuban)	3,633,984
9	Santos (Madura)	30,476,533
10	Santos (Sampang)	27, 635,078
	Total	205,284,102

As for the distribution pipeline in Indonesia, it is mostly owned and operated by Perusahaan Gas Negara (PGN), a state-owned company. The pipe is centralised in Java Island. In 2018, the total pipe length in Indonesia is 7,481 kilometre. Some pipes are very old. That is why in the graph below there is a decrease of pipeline length from 2019 to 2020.

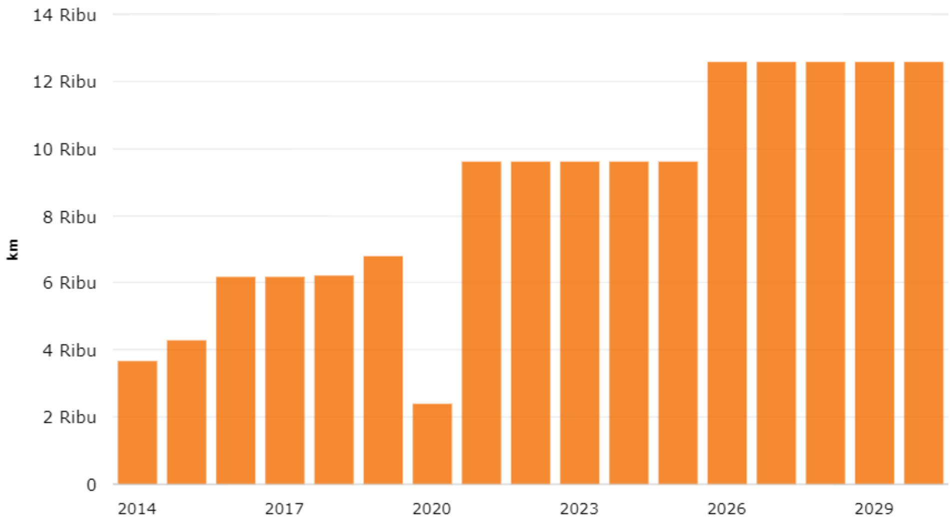

Figure 2.9 Open Access Gas Pipe in Indonesia 2014-2030 (Source: Bank Indonesia, 2015)

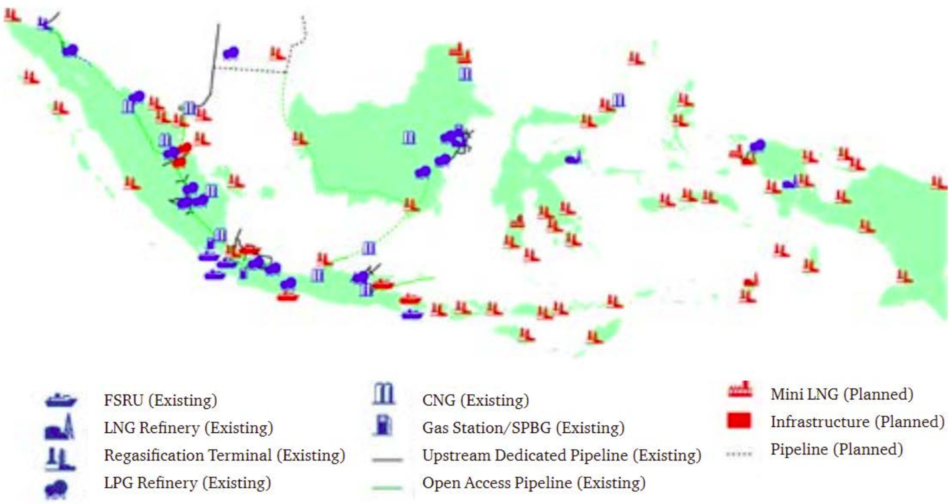

Figure 2.10 Indonesian gas infrastructure - current and concept (2016-2035)
(Source: Neraca Gas Bumi Nasional 2016-2035)

2.3.2. Natural Gas Transportation via Pipelines

To transport or move something solid, liquid or gas, the well established transportation system should be set up for perfect supplying, importing and exporting factors. The natural gas transportation is the most important activity to move gas from one point to another. Several types of transportation can be used to transport gas in natural gas industry, but the most effective, economical and efficient way to do this transportation is in pipelines with their complex networks. Currently, offshore and onshore systems are using pipelines, even though there are differences in terms of security, terrorist attacks and construction prices. For building pipeline network systems under the sea or over the sea is very costly and technically complex. Because of this, generally the companies that are working on pipeline systems are setting the onshore systems in an area where the demand of gas is high to decrease the cost of construction.

Pipelines are especially used in gathering systems, transmission systems and transmission systems. The diameters of pipelines range between 4 inches and 48 inches(EIA). Raw natural gas is gathered from production wells by the gathering pipeline systems. The mission of these three pipelines are to transport natural gas across the world, to bring natural gas from storage facilities to distribution systems, and to distribute natural gas to homes and to industry. The main differences among these systems are types and characteristics of pipelines such as diameters, materials, lengths and maximum and minimum pressures. For instance, gathering and transmission lines are constructed from steel pipe, whereas distribution lines can be constructed from steel or modern plastic pipe.

A. Gathering pipelines

Gathering line is one of the major three types of pipelines. Low pressure and small diameter pipelines compose the gathering system to help transportation of natural gas from wellhead to the processing plant. Flow lines are composed of narrow pipelines typically buried 4 feet underground and working at an approximately 250-psi pressure (naturalgas.org).

B. Transmission pipelines

A second type of pipelines is transmission line. A transmission line is a pipeline that especially used to transport natural gas across long distances from a gathering, processing or storage facility to a distribution system. Transmission pipelines are made of steel, but it can be specialized according to its function and area. Transmission pipelines` diameter measure are generally 6 to 48 inches in diameter, which can vary according to function and task. Mainline transmission pipes are generally between 16 and 48 inches according to diameter sizes while they are between 24 and 36 inches in diameter in major interstates (naturalgas.org).

C. Distribution pipelines

A third and last type of pipelines is distribution lines, which represent the final step in delivering natural gas to households or industrial customers. They are part of a pipeline network system located downstream of a natural gas transmission line. Because of this, they are the middle step between high-pressure pipelines and low-pressure pipelines. Natural gas distribution systems` pipelines are small- to mid-size pipelines, which are ranging from 2 inches to 20 inches in diameter. Distribution pipelines generally operate below their capacity and their working pressure is approximately between 0.5 psi and 200 psi (naturalgas.org).

2.3.3. Natural Gas Transportation via LNG

Liquefied Natural Gas (LNG) has the same distribution concept as natural gas via pipeline with one additional step, liquefaction. As seen in Figure 2.11 below, the value chain begins with the process of bringing natural gas to market by safely drilling wells to bring the gas and other reservoir components to the surface, where it may be processed on site or transported to a facility for treating and processing. Natural gas extracted from subsurface reservoirs can contain non-hydrocarbons, including Hydrogen Sulphide, Nitrogen, Carbon Dioxide, and Water. The treatment processes remove these components from the natural gas, a solvent is used to absorb Carbon Dioxide, Hydrogen Sulphide, and Water. Heavier liquids are removed from the lighter gas for separate processing. Water is removed and the remaining natural gas is ready to be cooled into a liquid. The liquefaction plant cools the gas to negative 162 degrees celcius. As the gas cools it is reduced to 1/600th hundredth of its previous volume. The resulting liquefied natural gas is clear, colourless, and ready for transport. The liquified natural gas (LNG), is stored in large insulated tanks until it is ready for shipment. Pipes connect the storage tank to a loading jetty. Regardless of outside temperatures the LNG inside the tanks and loading facility remains at negative 162 degrees celcius. The LNG is then pumped into specially designed LNG ships. When the LNG ship arrives it is guided to the receiving terminal, where the LNG is unloaded, and stored in insulated tanks. The LNG is then pumped into a regasification plant, where it is warmed and converted back into a gaseous state. A network of pipelines delivers the natural gas to power plants, where it is used to generate electricity for urban areas, to industrial facilities for the manufacturing of steel, cars, and chemicals. And also to homes and office buildings for heating, cooking, and drying clothes

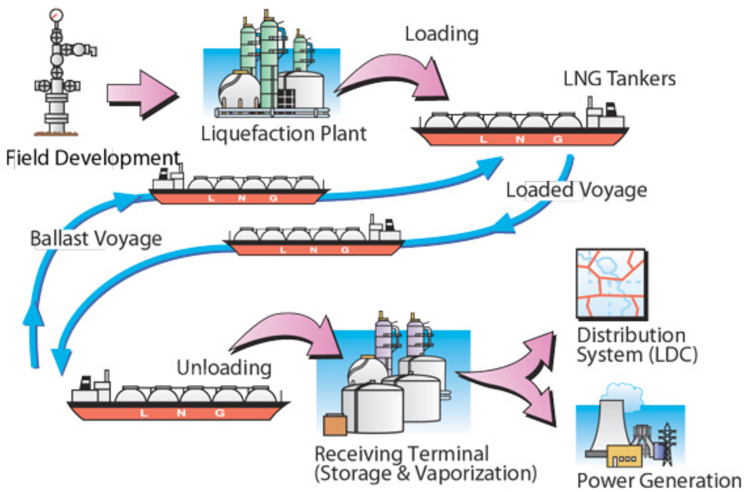

Figure 2.11 LNG Value Chain from Upstream to Downstream
(Source: ihdrc.com)

2.4. System

System is a collection of several components or elements that operate simultaneously in order to achieve a goal. A system consists of elements that are observed in the system. The state of the system is defined as a collection of variables used to describe the system at any time.

2.5. Model

Model is a result of interpretation of a real system consists of logic combination and mathematics that takes into account. Those factors are influenced by the problem beforehand. The model itself must be done carefully and in detail, in order for the simulation model that obtained to be very similar with the real one. In order to create a good model, the criteria are easy to understand, having clear objectives, conation clear problem solving, and easy to be controlled and manipulated by model users.

Modelling is the process of producing a model that is a representation of the structure and system that works. Verification and validation also needed to be done to find out that the model has no different with the real system. Verification is the process of checking the data, ensuring the model is suitable with the logic of the flow chart. Verification needed to check the translation of conceptual models into programming languages correctly (Law & Kelton, 1991). On the other hand, validation is the determination process of whether the model that has been made is in accordance with the real system being modelled (Law & Kelton, 1991).

2.6. Simulation

Simulation will be used to improve the performance of dynamic and complex system like the natural gas supply chain. The simulation will help imitate the supply and demand behaviour and provide predictions of the demand coverage. Various scenarios will be made in order to analyse the baseline for improvement and recommendation.

2.7. System Dynamics Method

System is a collection of several components or elements that operate simultaneously in order to achieve a goal.

Similar to agent-based modelling, system dynamics is a simulation technique that links “components” of the model via pre-defined functions. System dynamics models include a “growth function” of their variables that allows for a “dynamic” modelling of processes over time. It also assumes that the system is functioning continuously as defined by the input data which implies that possible disequilibria in the system are maintained. This is a major difference to the neo-classical paradigm (the framework for this thesis) where the existence and convergence to an equilibrium state is a central concept. Another drawback from an industrial economics point of view is that system dynamics can not represent imperfect markets as we find them in the natural gas sector today and the studies using this approach generally predefine a perfectly competitive market.

System dynamics has traditionally been used for the analysis of management processes. As a tool for energy systems analysis, system dynamics has been used for more than 30 years. The system dynamics approach is suitable for modelling complex environments, such as ecosystems and human activities, on a multi-dimensional scope with time-dependent variables. The system dynamics modelling helps more clearly demonstrate the interactions of the environment and socio-economic variables, and also helps to identify the key factors that significantly alter a dynamic system.

As a review of the research on the dynamic model of the natural gas industry, the present paper develops a system dynamics model to analyze the factors influencing upstream behaviour.

The established natural gas system dynamics model can clearly reveal all kinds of production process aspects of gas company exploration and development, and the relationship between production process input factors and output factors. The system dynamics model is a combination of qualitative and quantitative methods; the most prominent feature of this method is its ability to handle non-linear, high-level, multiple feedback, complex time-varying system problems. Indonesia’s upstream gas companies often have insufficient data. In this situation, the system dynamics (SD) model can be used to carry out the calculation and research.

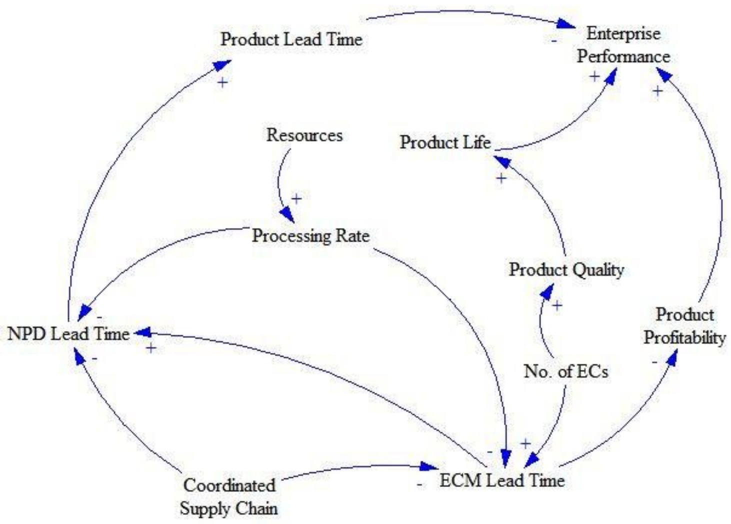

Figure 2.12 Example of causal loop diagram

The system dynamics model uses causal loop diagram to help making the model. The current system of gas supply and distribution is transformed into causal loop diagram so the simulation can be done.

CHAPTER 3
METHODOLOGY

3.1. Research Scheme

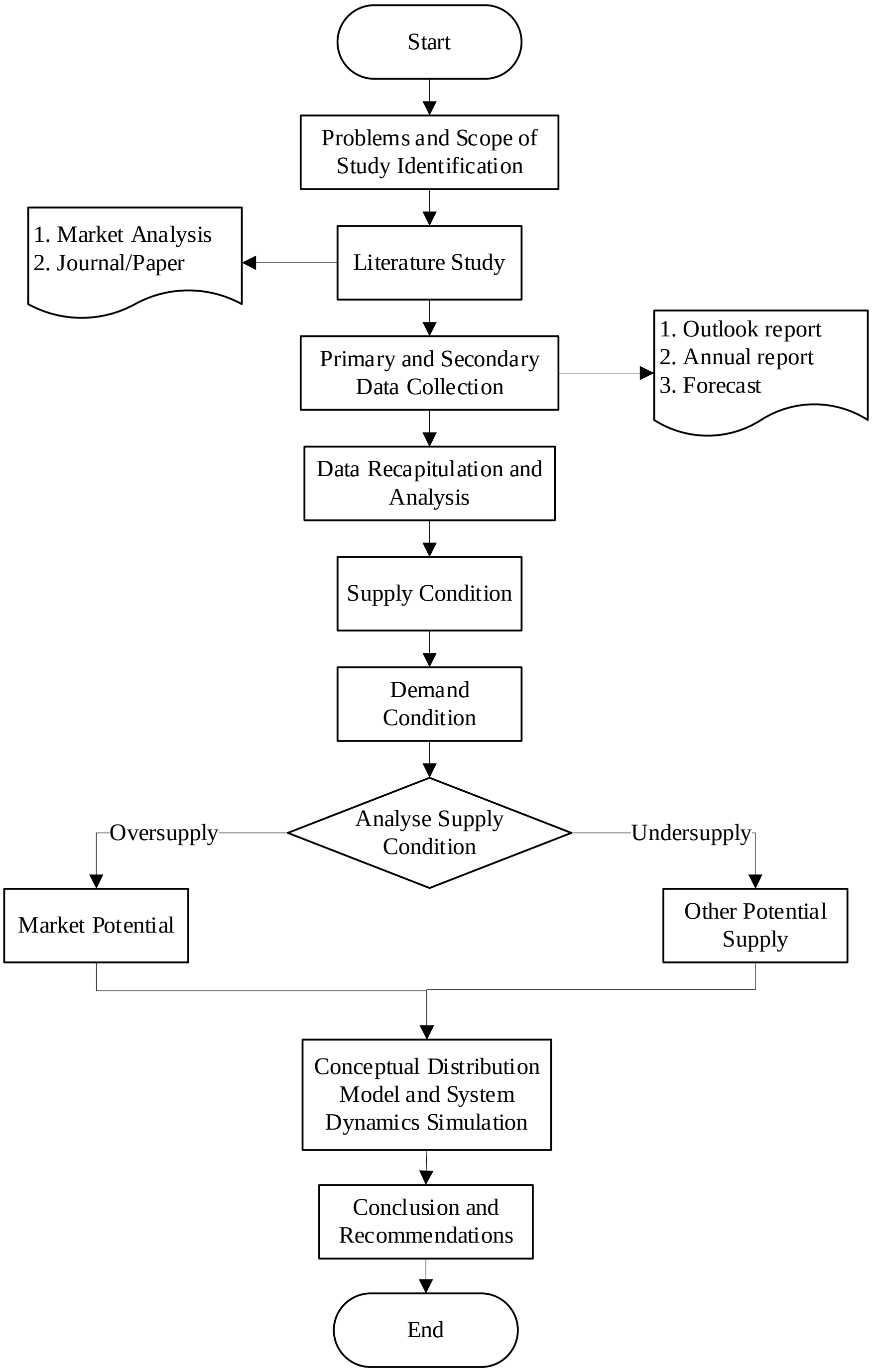

Figure 3.1 Research Scheme

3.2. Methodology Identification

The methodology identification is an explanation regarding on analysis method that will be conducted in order to encounter the problem of this research. The problem analysis in this research is the market analysis of natural gas supply and demand in Java Island. Supply data from existing gas field, and field that are being developed will be combined with other natural gas source such as floating storage and regasification unit (FSRU). Natural gas demand from three main sectors: electricity generation, industries, and households are gathered. By analysing the supply and demand data of the historical and current market, then the natural gas market will be known. The surplus – deficit condition will affect the gas price and the energy distribution. To determine the condition, the system dynamics simulation will be used. For the supply and demand forecast, the data from government bureau will be combined with trend linear project.

A non-experimental, quantitative, cross-sectional, retrospective method will be used in order to obtain the essential outcomes and achieve the specific objectives of this research project. As the goal of this thesis is to provide alternative of natural gas distribution, a system dynamic simulation will be conducted for several scenarios. The best scenarios will be picked based on its performance from the simulation.

To provide a comprehensive picture, both technically and empirically, descriptive analysis and system dynamics modelling are used in this study.

Descriptive Analysis

The descriptive analysis method in this study was used to describe the various actual conditions that occurred in the supply and utilization of national gas

3.3. Research Flow

The research will be based on a various steps to achieve its result and goals. Hereby are the further explanation of methodological flow from the beginning of the process, data collecting, until the final process resulting the objectives of this research:

3.3.1. Problem and Scope of Study Identification

In the initial step of this research, the researcher will conduct a direct observation about the current natural gas distribution in Java Island. The research process will be based on literature, observation, and discussion with lecturers. From the initial identification, then the parameter, data analysis, research method, and limitation of this research will be determined.

3.3.2. Literature Study

The next step of this research is study literature. The study shall be related to the existing problems and in accordance with the purpose of the study. The aim of literature study is to have a better understanding for the author about the supporting information and problem related to this research. Literature-related issues can be used as a reference to understand the problem.

3.3.3. Data Collection, Data Processing and Analysis

At this stage, an analysis of gas distribution in Java Island will be carried out based on the current model. A map of current supply and demand will be created to understand the distribution system better.

3.3.4. Supply and Demand Condition

At this stage, an analysis of natural gas distribution in the Java Island was carried out by mapping the supply and demand throughout the island. The function of mapping is to help visualize and understand the flow of natural gas, especially to the end customer.

Data collection is done parallel with the literature study. All data which is related to the research, such as oil and gas reserves, oil and gas consumption, and also oil and gas production are collected for supporting the research. In this phase, dynamic hypothesis is conducted to conceptually modelling the system using Causal Loop Diagram to map the problem and understanding the relation between stakeholders. Furthermore, the alternative scenarios for oil and gas management in Indonesia must be determined as comparison for the system improvement.

From the data, the researcher can determine the natural gas supply condition in Java Island whether it is oversupplied or undersupplied, and how big the number difference is. If there is an oversupply of natural gas, the researcher will give a recommendation on potential market for the natural gas. If there is an undersupply, a recommendation for natural gas resource will be given, possibly from a LNG or CNG terminal.

3.3.5. Modelling and Simulation

At this stage, several scenarios for gas distribution will be made and tested using the system dynamics simulation. Model verification is performed simultaneously with the model simulation process. The simulation is done to determined the best and plausible scenarios.

The Causal Loop Diagram (CLD) that has been made in previous phase can’t be simulated directly to produce the result. CLD elements must be transformed into stock, rate, and converter to convert the CLD into Stock and Flow Diagram. STELLA is one of the system dynamics modelling software. Stock and Flow Diagram furthermore needs to be simulated to gain the result.

Simulation model must be credible in order to represent the real system correctly. Every model used in simulation must be verified and validated to test the credibility of the model. Verification is the process to check whether the operational logic of the model compatible with the logic in flow diagram. Meanwhile validation is the process to determine whether the model is the accurate representation of the real world. Validation is done through 5 methods, those are model structure testing, boundary sufficiency testing, model parameter testing, mean comparison testing, and extreme condition testing.

3.3.6. Scenario Development

After verifying and validating the simulation model, as the improvement of the system, the better resulted scenario must be developed. Scenario will be developed through financial valuation that will assess the value of each scenario in achieving the goals of energy independence, energy security, and energy equity.

3.3.7. Conclusion and Recommendations

The last stage is to conclude the whole process that had been done. Conclusion and recommendations will be assessed after the result from the simulation. This stage contains a short answer to the problems of this research. From conclusions, there will be recommendation that can be given based on the results so that the next project will be better.

3.4. Source of Data

The source of data in the thesis are divided into two parts, which are:

3.4.1. Primary Data

The primary data is data that will be received rom the original source. The data will be obtained through a resource or expert that are capable in their field. The information will be directly send towards stakeholders inside the chain, in this case the reliable source will be coming from the background of Ministry of Energy and Mineral Resource, Directorate of Oil and Gas, National Energy Council, and government authority. Through interviews the author will received the information that will be used for data processing of this thesis.

3.4.2. Secondary Data

The secondary data is obtained through indirect source. The definition of indirect source is through data of documentation, journals, and books as references. The secondary data act as a support for primary data.

3.5. Data Collection Method

3.5.1. Literature Study

Literature study is an information research on related data, methods, and problems that are raised in the research, through internet, journals, papers, and books

3.5.2. Simulation

Several scenarios will be developed based on the current condition and then the system dynamics simulation will be done. The purpose of this process is to develop a scenario with better performance. The distribution system will be represented using various tool: model boundary diagram, causal loop diagram, and system dynamics

CHAPTER 4
DATA COLLECTION AND PROCESSING

4.1. Data Collection and Processing

In this thesis, the analysis is done by calculating the supply and demand of natural gas. This chapter will explain the data collection and analysis of the supply and demand of natural gas. All production field and developing field will be considered.

East Java is now a producer of oil and gas. As many as 30 percent of 800 thousand Barrel of Day (BOD) of national production, donated of oil and gas field production from East Java. While for gas, also very important. East Java is able to contribute 10 to 12 percent of the total gas supply in the country. Currently, in the working area of SKK Migas Java Bali Nusa Tenggara (Jabanusa), there are 32 cooperating contractors (KKKS) operating companies. And, 16 KKKS companies already in production.

The data collection will be conduct by performing an identification action in the current gas distribution of East Java Province. The process of this data collection is done by secondary data collection. The main data is obtained from the following sources:

1. Natural gas production rate, well reserves, prospective resources from *Neraca Gas Bumi Indonesia 2018-2027* published by Ministry of Energy and Mineral Resources Indonesia.
2. Infrastructure of natural gas pipe, pipe capacity and utilisation from *Rencana Induk Jaringan Transmisi dan Distribusi Gas umi Nasional tahun 2012-2025* based on *Keputusan Menteri Energi dan Sumber Daya Mineral Nomor 2700 K/11/MEM/2012*
3. Natural gas demand for household, electricity generation, and industrial and demand forecast from *Neraca Gas Bumi Indonesia 2018-2027* published by Ministry of Energy and Mineral Resources Indonesia.
4. Natural gas for electricity demand and future projection from *Rencana Usaha Penyediaan Tenaga Listrik PT PLN (Persero) 2019-2028.*

4.2. Supply Condition

Indonesia has a diversity of geological basins that continue to offer sizeable potential for oil and gas exploitation. Indonesia has 60 sedimentary basins, including 36 in Western Indonesia that have already been thoroughly explored. Fourteen of these are producing oil and gas. In under-explored areas of Eastern Indonesia, 39 tertiary and pre-tertiary basins show rich promise in hydrocarbons.

About 75% of exploration and production is located in Western Indonesia. The four oilproducing regions are Sumatra, the Java Sea, East Kalimantan and Natuna. The three main gas-producing regions are East Kalimantan, South Sumatra and Natuna. Further demonstrating the importance of gas, Indonesia’s gas production represents 60% of total oil and gas production in the country. This portion is estimated to increase to 70% in 2020 and 86% in 2050.

The supply of natural gas in East Java mainly came from fields in Madura, operated by Husky-CNOOC Madura Limited, Kangean Energy Indonesia, and Pertamina Hulu Energi West Madura Offshore. The production target is set by the company and the ministry. The forecast of supply will be determined by the historical data and the field capacity.

The gas is imported to East Java in two ways, in the gaseous form via pipelines from other field in Java island, and as Liquefied Natural Gas (LNG) from other region in Indonesia.

It is assumed that natural gas is imported only when the total domestic gas production is not adequate to cover the total annual demand. Only the imports of natural gas that is used domestically for either power generation, household, and industrial use are taken into account as 'import'. Also, only the domestically produced natural gas is assumed to be exported, as long as there is surplus not used in the domestic market.

Several system dynamics models that investigate natural gas or petroleum resources exploration and production have been described in the literature (Davidsen et al., 1990; Dyner e al., 1998; Olaya and Dyner, 2008; Chi e al., 2009; Eker and van Daalen, 2015), which originate form an early model of Naill (1974). He model developed in this study is similar to these models, in terms of the relation between the exploration and production activities and the corresponding investments, and the factors that affect investments such as price and demand. However, this model is different from those in terms of three main aspects: Firstly, a more detailed lifecycle structure of natural gas fields is implemented in this model, as will be explained further below, in order to test policies specific to Indonesia and to different steps of extraction process. Secondly, this model includes the profitability of natural gas production and its effects on investment, due to the recent economic growth in East Java Province. Lastly, having the general purpose of focusing on uncertainties to generate a large number of future scenarios, this model includes several parametric and structural uncertainties, i.e. the model formulations representing different assumptions that could be made for the same phenomenon.

Table 4.1 List of Natural Gas Fields in East Java Region

No	Field	Field No	Notes
1	Kangean Energy Indonesia Ltd	Field 1	Existing Supply
2	PHE WMO	Field 2	Existing Supply
3	Husky CNOOC	Field 3	Existing Supply
4	Ophir - Santos Sampang Pty	Field 4	Existing Supply
5	Ophir - Santos Madura Offshore Pty	Field 5	Existing Supply
6	Saka Pangkah	Field 6	Existing Supply
7	Pertamina EP Poleng	Field 7	Existing Supply
8	Husky CNOOC (MAC and MDK Field)	Field 8	Project Supply
9	Husky CNOOC (MDA and MBH Field)	Field 9	Project Supply
10	Jambaran Tiung Biru	Field 10	Project Supply
11	PHE WMO 1	Field 11	Project Supply
12	PHE WMO 2	Field 12	Potential Supply

(Source: *Neraca Gas Bumi Indonesia 2018-2027*)

The technical subsystem of natural gas production is modelled based on the field lifecycle which is composed of exploration, appraisal, development, and production phases (Jahn et al, 2008).The oil and gas resource base is divided into four types, which are *Prospective Resources, Contingent Resources, Undeveloped Reserves,* and *Developed Reserve*. Some research also divided the resources into two categories, as discovered and undiscovered resources. The supply is divided into several category because the delay from discovery to production that can strongly affect the producible volume, and the actions that should be taken at different at different stages to keep the volume high.

Natural gas is extracted from several offshore fields in Madura, and in Cepu area. These two types of natural gas production is taken into the same account in the model. Being a natural gas type with different technological characteristics and cost values, the two types is assumed to have the same model representation as the other two types of natural gas. The total *Production Rates* (PR) are the total gas production rate in the East Java area.

Table 4.2 Supply Data

No	Description	Year	MMSCFD	Year	MMSCFD
1	Kangean Energy Indonesia Ltd	2018	201.77	2022	99.19
2	PHE WMO	2018	140.00	2022	80.00
3	Husky CNOOC	2018	100.00	2022	100.00
4	Ophir - Santos Sampang Pty	2018	33.00	2022	-
5	Ophir - Santos Madura Offshore Pty	2018	47.00	2022	-
6	Saka Pangkah	2018	23.96	2022	11.74
7	Pertamina EP Poleng	2018	14.44	2022	10.26
8	Husky CNOOC (MAC and MDK	2019	-	2022	120.00
9	Husky CNOOC (MDA and MBH	2019	-	2022	72.70
10	Jambaran Tiung Biru	2018	-	2022	171.79
11	PHE WMO 1	2018	19.82	2022	-
12	PHE WMO 2	2018	-	2022	-
13	LNG Teluk Lamong	2018	-	2023	40.00
	Total		579.99		705.68

(Source: *Neraca Gas Bumi Indonesia 2018-2027*)

Table 4.3Supply Data (Continued)

No	Description	Year	MMSCFD	Year	MMSCFD
1	Kangean Energy Indonesia Ltd	2027	10.31	2032	-
2	PHE WMO	2027	35.00	2032	
3	Husky CNOOC	2027	100.00	2032	100.00
4	Ophir - Santos Sampang Pty	2027	-	2032	
5	Ophir - Santos Madura Offshore Pty	2027	-	2032	
6	Saka Pangkah	2027	-	2032	
7	Pertamina EP Poleng	2027	-	2032	
8	Husky CNOOC (MAC and MDK	2027	75.50	2032	
9	Husky CNOOC (MDA and MBH	2027	5.15	2032	
10	Jambaran Tiung Biru	2027	171.79	2032	
11	PHE WMO 1	2027		2032	
12	PHE WMO 2	2027	40.55	2032	10.00
13	LNG Teluk Lamong	2027	40.00	2032	40.00
	Total		467.99		150.00

(Source: *Neraca Gas Bumi Indonesia 2018-2027*)

4.3. Demand Condition

The demand analysis will considered the current demand and the development plant from the Government. The data is concluded from the following source:

The demand and supply analysis will determine the correct action for the gas distribution. If there is a surplus of supply, the prospectus market and new customer will be analyse. If there is a deficit of natural gas, the author will determine the best way to add new supply of gas to East Java.

The total gas demand variable has a negative effect on the fulfilment ratio because the more demand the less fulfilment ratio if supply does not increase. Based on the results of interviews conducted with the company, there are two variables that affect the fulfilment ratio, namely the supply and demand variables. The demand variable is divided into three, namely household demand, industry demand, and electricity demand.

The gas demand for household, industry, and electricity have a positive effect on the fulfilment ratio because the increase of demand means the fulfilment ratio decreases if the supply does not increase.

Table 4.4 Demand Data

No	Description	Year	MMSCFD	Year	MMSCFD
1	Industrial	2018	153.62	2022	161.57
2	PT Petrokimia Gresik	2018	150.00	2022	150.00
3	Power Generation (PLN)	2018	305.80	2022	331.51
4	Household Use (*Jargas Rumah Tangga*)	2018	1.10	2022	1.34
	Total		610.520		644.417

(Source: *Neraca Gas Bumi Indonesia 2018-2027*)

Table 4.5 Demand Data (Continued)

No	Description	Year	MMSCFD	Year	MMSCFD
1	Industrial	2027	169.52	2032	177.47
2	PT Petrokimia Gresik	2027	150.00	2032	150.00
3	Power Generation (PLN)	2028	357.22	2032	382.93
4	Household Use (*Jargas Rumah Tangga*)	2027	1.71	2032	2.18
	Total		678.450		712.578

(Source: *Neraca Gas Bumi Indonesia 2018-2027*)

4.4. Model Formulation

After the required data has been obtained, the next step is to make a model of the natural gas existing system conditions by using the variables indicated by the causal loop diagram. These variables must be determined first because it is required to formulate the diagram. Then the causal loop diagram will be the guideline for making a base model. The base model is a model that already represented the existing system. To find out if the Base model is in accordance with the real system, verification and validation need to be done.

4.4.1. Causal Loop Diagram

The price variable is also used in the demand sub-model since consumer demand changes as the price changes. The demand volumes determined in this sub-model are used in the market sub-model for price-setting in return, to indicate the effect of the supply/demand balance. Between the supply and demand sub-models, the demand volumes determined in the later are major factors used in the supply sub-model to determine production rates or import volumes. From the supply sub-model to the demand sub-model, the link is the societal acceptance of natural gas production and the fulfilment ratio, which determines the demand flow between natural gas via consumer preference.

This system dynamics model concentrates on the total or average values of system variables at a high aggregation level. For instance, the production rate of natural gas does not represent the production from a single natural gas field based on a single natural gas field based on a decision of a single producer, but the total production rate from all such field based on a decision of a single producers, assumed to be a homogenous group. With this homogeneity assumption, this model include the actions and decisions of several actor groups in addition to the system components mentioned above, as the drivers of change in the system.

Figure 4.1 depicted the main causal relations and loops governing the natural gas production mechanism in the model. In this diagram, an arrow denotes a causal link between two variables, and the sign next to it signifies the polarity of that causal link. If a change in the first variables changes the second variable in the same direction, then the polarity is positive, otherwise, it is negative. The depletion loop is the main loop in the field lifecycle, implying that increased *production rate* depletes the volume of the *developed reserves*, which reduces further production. Regarding the investment of producers to stimulate production and new discoveries. The Economies of Depletion is a reinforcing loop, which means that depletion due to increasing *Production rate* increases the *unit cost*, leading to a price increase which makes the investments in production more attractive. The Economies of Scale loop, however, is a balancing loop which describes the increased production reducing price, which further reduces the investments, and hence the production rate. Lastly, the Market Development loop summarizes the supply-demand relation in the market, where high production decreases the price, and hence increases the demand, which further increases the production.

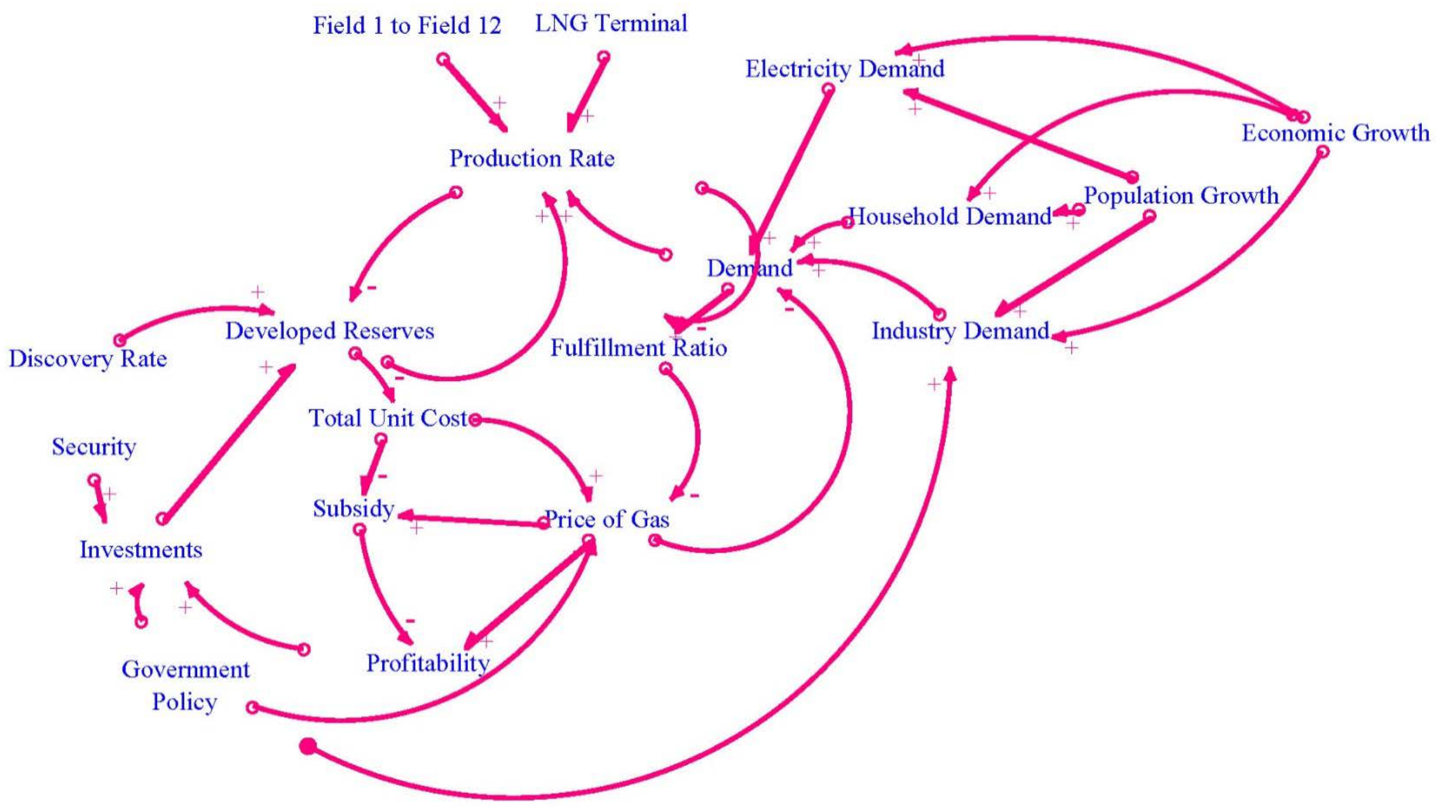

Figure 4.1 Causal Loop Diagram

4.4.2. Stock and Flow Diagram

After creating a conceptual model, the next step is to create a flow base model diagram that represents the real system in the gas distribution process. Figure 4.2 is the base model of gas distribution. To better understand this flow diagram, it is divided into several sub-models, for each demand and supply variables. Each of the sub-models below will explain the formula for each variable.

Stock variables in the systems dynamics methodology are mathematically the integrals of the summation of the flows that affect them.

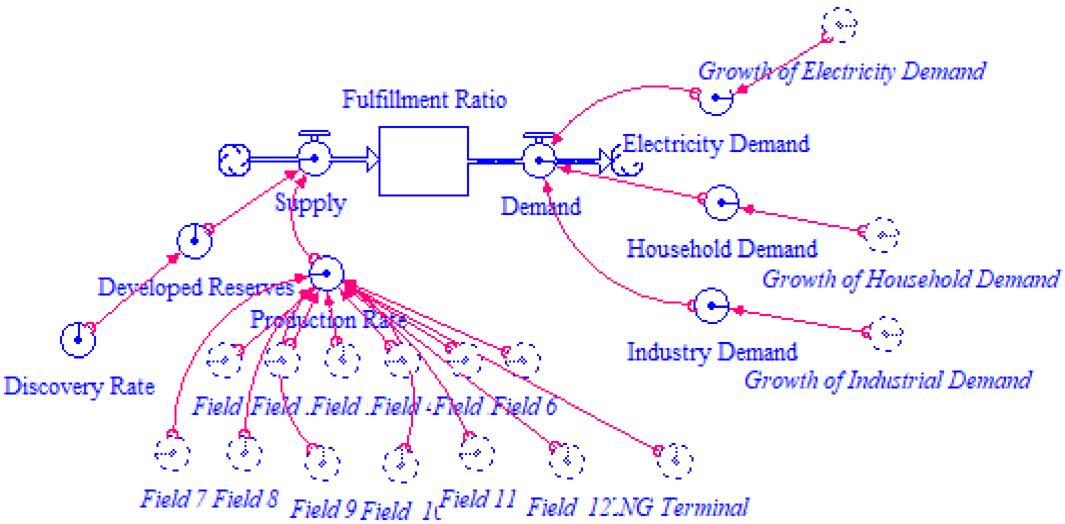

Figure 4.2 Flow Diagram of Natural Gas

The Figure 4.2 shows the main flow diagram use to simulate he fulfilment ratio the main variable fulfilment ratio, which is influenced by supply and demand. The higher the supply, then more demand can be covered.

$$Fulfilment\ Ratio = \frac{Supply}{Demand} \quad (4.1)$$

$$Supplu = Produciton\ Rate + Developed\ Reserve \quad (4.2)$$

$$\begin{aligned} Total\ Gas\ Production\ Rate \\ &= Field\ 1 + Field\ 2 + Field\ 3 + Field\ 4 \\ &+ Field\ 5 + Field\ 6 + Field\ 7 + Field\ 8 \\ &+ Field\ 9 + Field\ 10 + Field\ 11 \\ &+ Field\ 12 + \ LNG\ Terminal \end{aligned} \quad (4.3)$$

$$\begin{aligned} Total\ Demand &= Electricity\ Demand \\ &+ Household\ Demand \\ &+ Industry\ Demand \end{aligned} \quad (4.4)$$

The main stock and flow diagram consisted of several sub-diagram from different supply sources and demand.

1. Supply of Field 1

Sub-model of Field 1 is used to calculate the supply from each field. The variable supply of Field 1 is the production rate from the field. The depletion rate is modelled from the forecast in *Neraca Gas Bumi Nasional 2018-2027*, which is different for each field. Field 1 is ran by Kangean Energy Indonesia Ltd., located in Kangean Island, Sumenep, Madura, East Java Province.

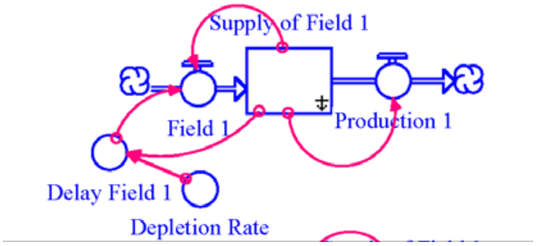

Figure 4.3 Flow Diagram of Field 1

The formula for the model are the initial supply times the depletion rate, because the data of remaining reserve and production planning are confidential data of the field owner.

$$Supply\ of\ Field\ 1\ (t) = Supply\ of\ Field\ 1(t-dt) + (Field\ 1 - Production\ 1\ )dt \quad (4.5)$$

$$Delay\ Field\ 1 = DELAY(Supply\_of\_Field\_1 * Depletion\_Rate, 365) \quad (4.6)$$

It is assumed that as long as there is no surplus, all the gas is used in the domestic market. The formula and the stock and flow diagram is the same for Field 1-12.

2. Household gas Demand

Sub-model of Demand is used to calculate the average demand in East Java. The variable is the current household gas demand with the projected demand growth and growth percentage. The demand growth percentage is obtained from by comparing from *Badan Pusat Statistik* 2010-2017 annual data and *Neraca Gas Bumi Nasional 2018-2027.*

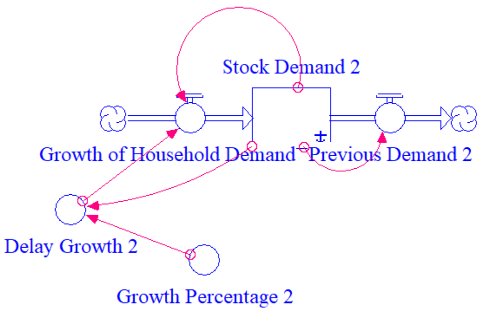

Figure 4.4 Flow Diagram of Household Demand

The formula for the household demand model are the initial demand times the growth rate, as seen below;

$$Growth\ of\ Household\ Demand = DELAY(Stock\_Demand\_2 + Stock\_Demand\_2 * Growth\_Percentage\_2, 365) \quad (4.7)$$

3. Power Generation Gas Demand
Sub-model of Demand is used to calculate the average demand in East Java. The variable is the current electricity gas demand with the projected demand growth and growth percentage. The demand growth percentage is obtained from by comparing from *RUPTL PLN 2018-2027* and *Neraca Gas Bumi Nasional 2018-2027.*

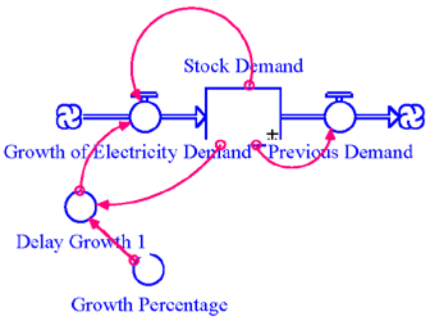

Figure 4.5 Flow Diagram of Electricity Demand

The formula for the electricity demand model are the initial demand times the growth rate, as seen below;

$$Growth\ of\ Electricity\ Demand = DELAY(Stock\_Demand + Stock\_Demand * Growth\_Percentage, 365) \quad (4.8)$$

4. Industrial Gas Demand
Sub-model of Demand is used to calculate the average demand in East Java. The variable is the current electricity gas demand with the projected demand growth and growth percentage. The demand growth percentage is obtained from by comparing from *RUPTL PLN 2018-2027* and *Neraca Gas Bumi Nasional 2018-2027.*

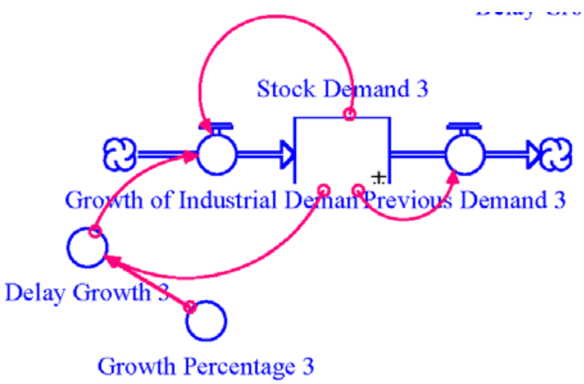

Figure 4.6 Flow Diagram of Industrial Demand

The formula for the industrial demand model are the initial demand times the growth rate, as seen below;

$$Growth\ of\ Industrial\ Demand = DELAY(Stock\_Demand\_3 + Stock\_Demand\_3 * Growth\_Percentage\_3, 365) \quad (4.9)$$

5. Result

The flow diagram helps to model the future supply and demand of natural gas in East Java. The variable is growth percentage, for demand, and field depletion for the gas supply. The running time is set for 15 years. The result of the simulation is concluded in the Table 4-6 bellow. The flow diagram helps to model the future supply and demand of natural gas in East Java. The variable is growth percentage, for demand, and field depletion for the gas supply. The running time is set for 15 years. The result of the simulation is concluded in the Table 4-6 bellow.

Table 4.6 Simulation Result

Year	Days	Fulfilment Ratio	Average Daily Total Supply (MMSCFD)	Average Daily Total Demand (MMSCFD)	Average Daily Deficit (MMSCFD)
2018	0	0.95	579.99	610.52	-30.53
2019	365	0.85	523.33	619.27	-95.94
2020	730	0.85	523.33	619.27	-95.94
2021	1095	0.73	458.97	628.19	-169.22
2022	1460	0.64	407.17	637.28	-230.11
2023	1825	1.36	878.72	646.55	232.17
2024	2190	1.22	802.26	656	146.26
2025	2555	1.16	772.03	665.63	106.4
2026	2920	1.06	719.29	675.44	43.85
2027	3285	0.99	678.62	685.45	-6.83
2028	3650	0.99	686.89	695.65	-8.76
2029	4015	0.94	660.65	706.05	-45.4
2030	4380	0.89	638.88	716.66	-77.78
2031	4745	0.85	620.57	727.46	-106.89
2032	5110	0.82	604.98	738.48	-133.5

Table 4-6 shows the result of simulation. The simulation is done each day for 15 years, and the table show the summary per year. Fulfilment ratio is the value of supply divided by demand. The Average Daily Total Supply is the total of field production. It can be seen that the supply decreased each year, except for year 2023, because there will be additional supply from several fields; PHE WMO, Husky-CNOOC, Jambaran Tiung Biru, and increase of capacity in LNG Teluk Lamong, from 30 MMSCFD to 180 MMSCFD. The Average Daily Total Demand is the total natural gas consumption in industrial, electricity, and household gas usage. There result is made into a graph form, as seen in Figure 4.7 below.

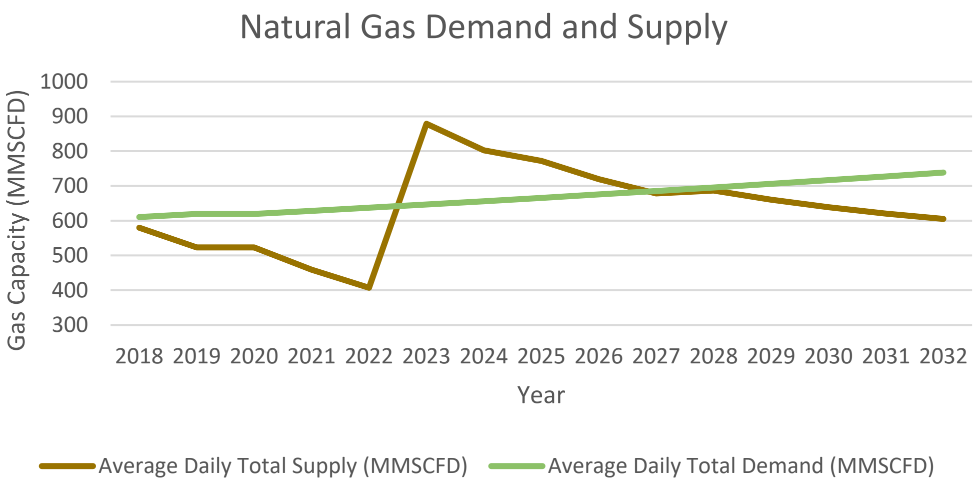

Figure 4.7 Natural Gas Demand and Supply Forecast

Figure 4.7 shows the natural gas demand and supply under normal condition. The *Average Daily Total Demand* (MMSCFD) increased over the year. The value is the total of natural gas from household demand, electricity demand, and industrial demand. The demand increased steadily based on the projected population and economic growth.

The *Average Daily Total Supply* (MMSCFD) shows the total of natural gas produced and supplied in East Java Province. In 2018, the supply came from Kangean Energy Indonesia Ltd., PHE WMO, Husky CNOOC, Ophir – Santos Sampang Pty., Ophir – Santos Madura Offshore Pyt., and Pertamina EP Poleng. With the current condition, with no new field discoveries, the supply will decrease. In 2023, there will be an increase of supply because threeo new sources of supply will operate, LNG Teluk Lamong will increase their capacity from 30 MMSCFD to 180 MMSCFD, Husky CNOOC, and Pertamina EP Cepu's Jambaran Tiung Biru, with capacity of 170 MMSCFD.

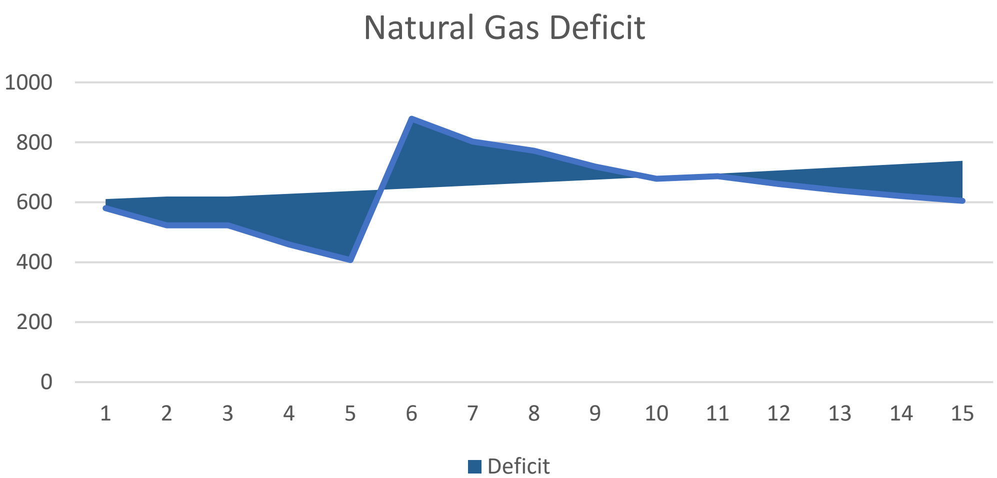

Figure 4.8 Natural Gas Discrepancy

Figure 4.8 shows the discrepancy of natural gas supply and demand in East Java Province from year 2018 to 2033. The demand increased each year while the supply is decreasing, except for year 2023 because there will be 3 new sources, from Husky CNOOC (MAC, MDK, MDA, and MBH Field), PT Pertamina EP Cepu (Jambaran Tiung Biru Field), and Terminal LNG Teluk Lamong, which means that from 2019-2022 and 2028-2033 there is a deficit and from 2023-2027 there is a surplus of supply.

The Figure 4.7 and 4.8 show that here are shortage in the gas supply from the year 2020. To fulfil the demand, there are several alternatives to choose, such as increasing the capacity of LNG Terminal Teluk Lamong, and increase exploration of gas sources in East Java Region.

4.5. Model Verification and Validation

4.5.1. Model Verification

Verification is done to ensure that the conceptual simulation model (flow charts and assumptions) of the real-life is accurate. simulation models. verification is done by calculating the error rate, to minimize the model from errors. This stage aims to examine the simulation model whether the model represents the concept correctly or not. Model verification is conducted during the running process of model simulation using Stella. If there is no error notification, then the model is considered as verified (error free).

Model verification and validation has a purpose as to whether the model is working or there is an error in it, also to compare whether the model is composed already represent a real system (Barlas, 1996). Verification is done by updating the formulation and rotating the unit (unit) variable model. If an error occurs in the model, it means that the model is not verified. Verification confirms whether the model runs according to logic research. While validation is recommended for evaluation of simulation models and determine whether the simulation results are acceptable and represent the real system. Method validation is twofold, white box and black box, white box is by the way enter all variables and relationships between variables in the model, then justification will be done by experties, while black box validation compares actual data with simulation results. The model is considered valid if there is no significant difference between the observation model and the real system.

Figure 4.9 shows the simulation result for the fulfilment ratio of natural gas demand base on the base model. The graph shows that the model simulation ran with no errors.

The verification and validation test is available in software Figure 4.10 to Figure 4.11 showing the results of the consistency test and verification of all variables in this simulation model. Verification is a process to ensure that the computer program that has been implemented is correct (Eriyatno, 1998). Figure 4.10 is the result of verification from the stock and flow diagram. This test is available in the STELLA software Figure 4.10 to Figure 4.11 show the results of the consistency test and verification of all variables in this simulation model.. Figure 4.10 is the result of verification from the stock and flow diagram.

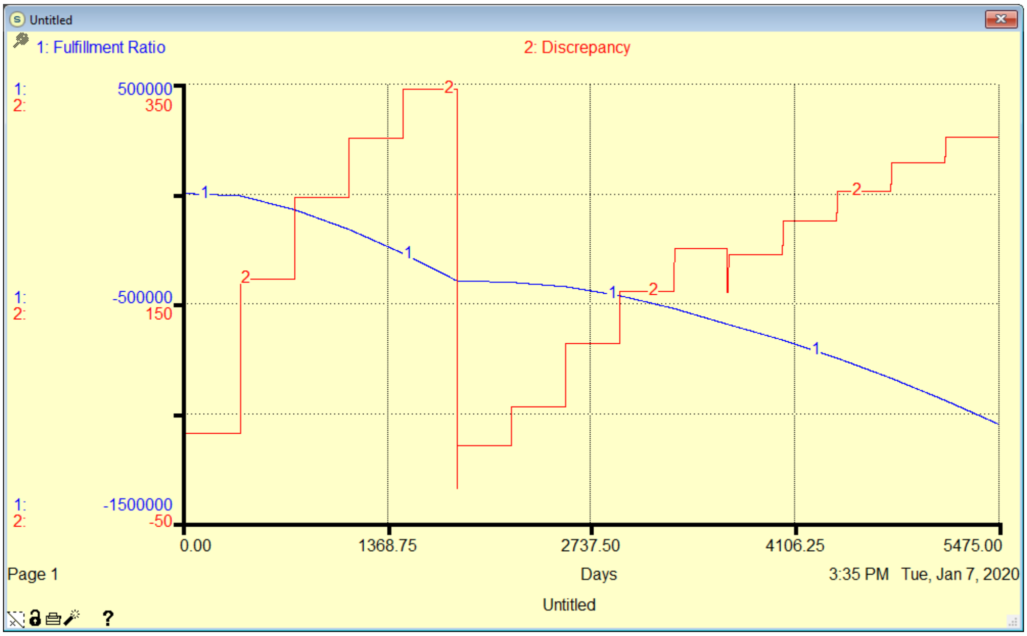

Figure 4.9 Fulfilment Ratio Graph

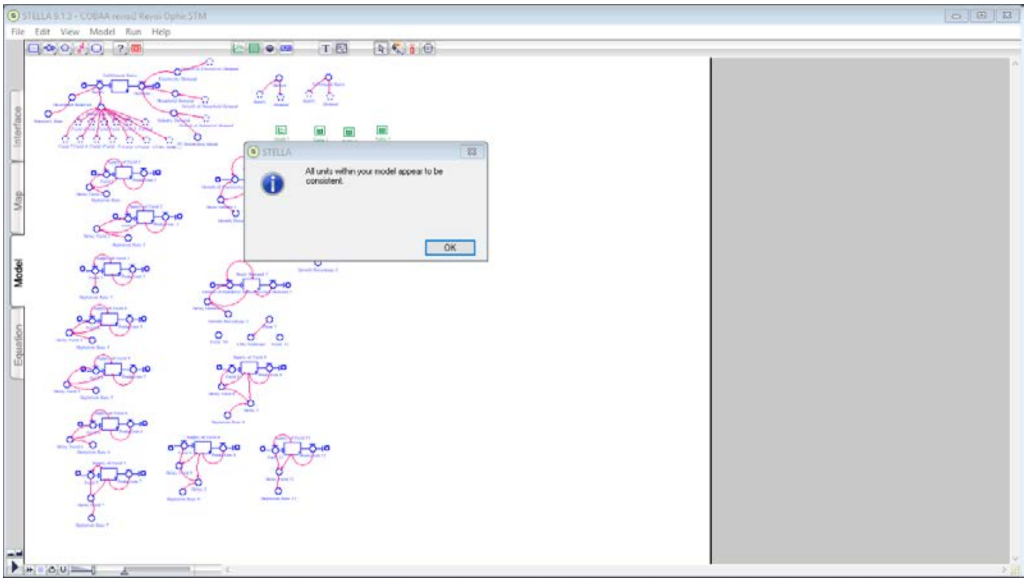

Figure 4.10 Consistency Test Stock and Flow Diagram

Figure 4.10 is the result of Consistency test of Stock and Flow diagram. In this test, units of equations were tested to ensure that they are dimensionally consistent with the units on the right hand side of the equation corresponding to those on the left hand side. Most of the information from the real system is used to check the consistency of model behaviour. The model structure is observed. A consistent model will look like a real system. A reasonable fit exist between the feedback structure of the model and the essential characteristics of the real system. All of the parameters and their numerical values should have real system equivalents. The parameters corresponded conceptually and numerically to the real life. The model can be stated as consistent if the values selected for the parameters and the test information available consistent. The action box states "*All units within your model appear to be consistent*" shows that all the variables are tested and consistent.

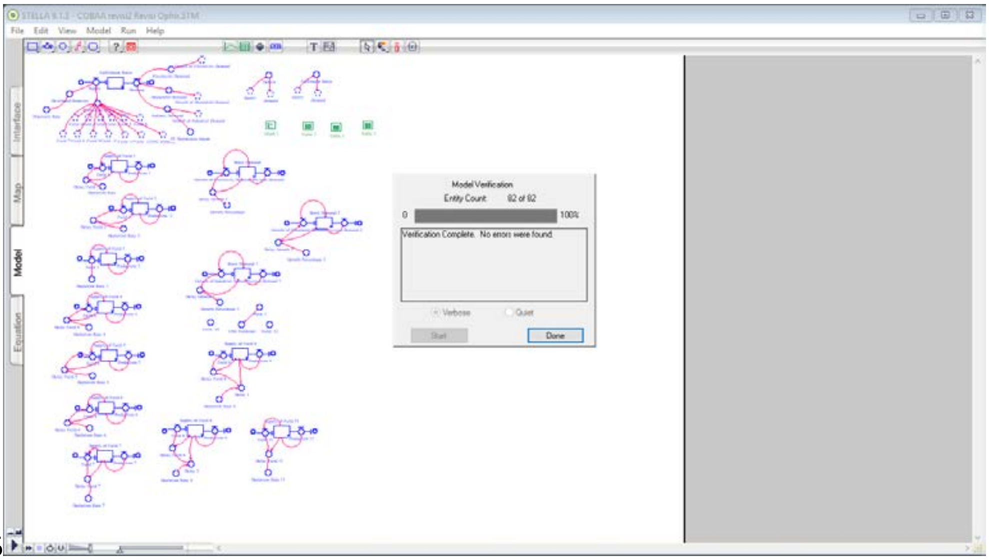

Figure 4.11 Verification Test Stock and Flow Diagram

Figure 4.11 shows the check error of all simulation diagram units where in the verification. While verification was performed to ensure that the model is technically correct, validation was performed to make certain that the model structure and assumptions met the purpose for which it was intended. All variables and equations of the model were documented and referenced. The model was tested to ensure that the outputs, such as the graphical behaviour and results, were realistic and comparable to historical graphs. The action box stated that "*Verification Complete. No errors were found.*" shows that all units meet the verification phase in the error checking and next step in the simulation can be carried on.

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CHAPTER 5
SCENARIO FORMULATION AND RESULT ANALYSIS

5.1. Scenario Development

Scenario development was done to get the best scenario to be applied as an improvement to the existing distribution model. Scenario development was done by changing the conditions or developing a model in order to get different output from the existing conditions. After that, an observation on the change in output between the previous condition and after the improvement scenario will be done, whether the change is significant or not.

In this study, the scenario that will be carried out will focus to improve the supply of natural gas, because the purpose of this study is for the energy security of natural gas in East Java. This is strongly related to gas supply to meet demand in East Java.

In this study, scenarios are made for the next 15 years horizon, because the dynamic system is more accurate if it is in the shorter-term, because when the time span is very long, its accuracy will decrease. Actual data starts in 2018, so the timeframe for scenario improvement is 2018-2033. The data used are historical data and forecast data from the government. in each scenario, add a new model to the main model to find out the system behaviour. the model in each scenario is the main model with improvements.

Based on the model in Chapter 4, Figure 4.1 and the flow diagram, Figure 4.2, several scenario will be made in order to meet the demand in East Java area. Then, an analysis on the scenario will be done.

5.1.1. Supply and Demand Mapping

After the base model is valid and verified, the next step is to create a simulation scenario. Before a scenario is made, first we need to make a geographical distribution of the supply and demand in East Java, as seen in Figure 5.1.

The map is divided into four layer. The first layer is the supply, colored in blue. The supply layer does not show the field, but the receiving area of natural gas with the gas metering station. For example, Pertamina Hulu Energi West Madura Offshore has an Onshore Receiving Facility (ORF) in Gresik, Husky-CNOOC with ORF in Pasuruan, and Kangean Energy ORF in Porong. The location of Onshore Receiving Facilities affected the customer coverage.

The second and third layer is the consumer, which are electricity demand and industrial demand. The natural gas demand for electricity is colored in orange. It is based on the government development plan. Currently, only one gas-power plant is operating, PLTGU Grati, while the other two, PLTGU Gresik (Jawa 3) and PLTGU Madura are still in development. The natural gas demand for industrial is based on the location of industrial estates.

The fourth layer is the pipeline. There are transmission pipeline, coloured in green, underground gas pipelines arranged in a network for the transportation of natural gas between LNG Terminals, upstream pipelines, storages and distribution networks and end users. Then there are distribution pipeline, coloured in red. Distribution pipeline is small-diameter and low-pressure underground gas pipelines arranged in a network for the transportation of natural gas from the transmission network to end consumers. Upstream pipeline, coloured in black. Upstream pipeline is underground or undersea gas pipelines used for the transportation of natural gas from production fields to transmission networks.

From the Figure 5.1, it can be concluded that the supply and demand mainly came from two area; Gresik and Pasuruan.

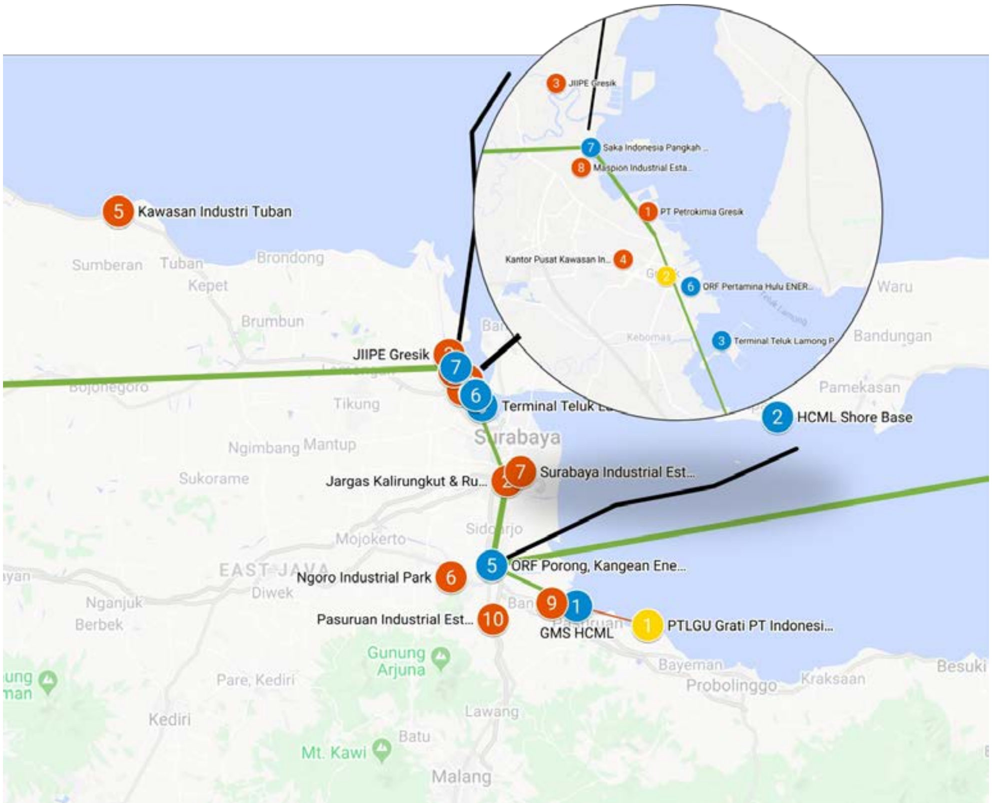

Figure 5.1 Natural Gas Supply and Demand Distribution in East Java

Legend Entry:

No	Industrial Demand
1	PT Petrokimia Gresik
2	JIIPE Gresik
3	Kawasan Industri Gresik
4	Ngoro Industrial Park
5	Surabaya Industrial Estate Rungkut
6	Maspion Industrial Estate
7	Pasuruan Industrial Estate 1
8	Pasuruan Industrial Estate 2

No	Supply
1	HCML
2	Kangean Energy Indonesia
3	PHE WMO
4	Saka Indonesia Pangkah Limited
5	Terminal Teluk Lamong LNG

No	Power Generation Demand
1	PLTGU Grati
2	PLTGU Gresik (Jawa 3)
3	PLTGU Madura

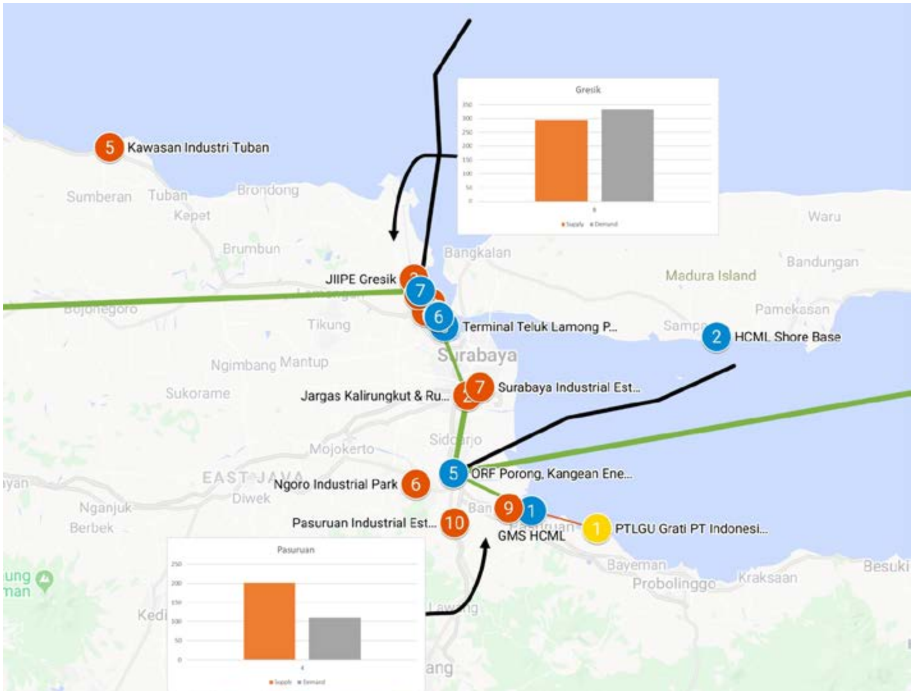

Figure 5.2 Gas Supply and Demand Map of East Java Region in 2019

Figure 5.2 above shows that there are two heavily populated area for gas supply and demand. In Gresik, the supply came from PHE WMO, Pangkah Indonesia Saka Limited, Husky-CNOOC Madura Limited, and LNG Terminal Teluk Lamong with a total of 293.96 MMSCFD The demand came from PT Petrokimia Gresik with the amount of 150 MMSCFD, industrial area with the amount of 83 MMSCFD, and PLTGU Jawa 3 with the amount of 100 MMSCFD. The total of demand in Gresik area is 333 MMSCFD.

In Pasuruan, the supply came from Kangean Energy Indonesia, from four of their operating fields, which are Terang, Sirasaun, and Batur Field. The total supply is 201.77 MMSCFD. The current demand are from PLTGU Grati, with the amount of 40 MMSCFD and industrial estates, with the amount of 70 MMSCFD. The total current demand is calculated at 110 MMSCFD.

5.1.2. Supply and Demand Forecast

Based on the stock and flow diagram simulation result, the supply and demand is then forecasted for the condition in year 2032. The condition can be seen in Figure 5.3.

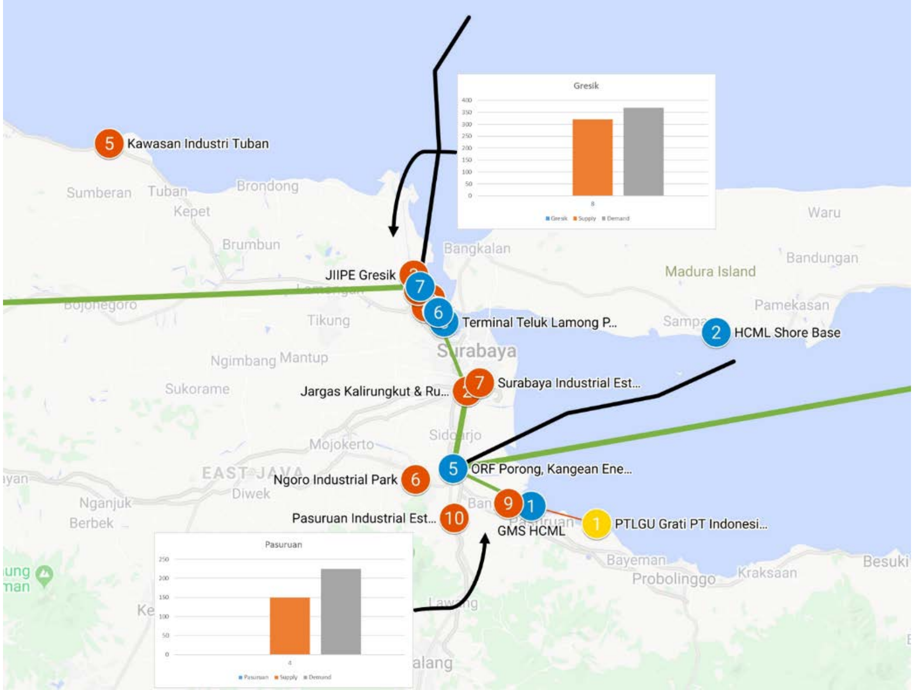

Figure 5.3 Gas Supply and Demand Map of East Java Region in 2032

In year 2032, the supply and the demand geographical location is more or less the same, with the addition of Kawasan Industri Tuban. In Gresik, the supply came from PHE WMO, Pangkah Indonesia Saka Limited, Husky-CNOOC Madura Limited, and LNG Terminal Teluk Lamong with a total of 320.55 MMSCFD The demand came from PT Petrokimia Gresik with the amountof 150 MMSCFD, industrial area with the amount of 120 MMSCFD, and PLTGU Jawa 3, with the amount of 100 MMSCFD. The total of demand in Gresik area is 370 MMSCFD.

In Pasuruan, the supply came from Kangean Energy Indonesia, from four of their operating fields, which are Terang, Sirasaun, and Batur Field and from PHE, in Jambaran Tiung Biru Field. The total supply is 150 MMSCFD. The current demand are from PLTGU Grati, with the amount of 140 MMSCFD and industrial estates with the amount of 85 MMSCFD. The total current demand is calculated at 225 MMSCFD.

5.2. Result Analysis

From the analysis of the supply gas and demand and their geographical distribution in Figure 5.1, 5.2, and 5.3, it can be concluded that additional supply of gas is needed. Two scenario is created to accommodate the growth of demand from 2018 until 2032.

5.2.1. Scenario by using new LNG Receiving Terminal in Pasuruan

The first scenario is to the capacity of LNG Terminal in Teluk Lamong by 150 MMSCFD. The location of LNG Terminal Teluk Lamong is well-connected via distribution pipeline to Gresik. The LNG import is done accommodate the future industrial demand in Gresik Area. Whereas an LNG receiving terminal 100 MMSCFD should be added in Pasuruan Area by 2027, because there will be a big growth of industrial gas demand and electricity demand with the development of Pasuruan Industrial Estate and the operation of PLTGU Jawa 3.

5.2.2. Scenario by using existing Terminal

The second option would be to use the LNG Terminal Teluk Lamong and add its capacity from 180 MMSCFD to 400 MMSCFD because the distribution pipeline of East Java is well developed and connected compared to other areas in Indonesia. The re-gasified gas from LNG Terminal can reach both the Gresik and Pasuruan Area.

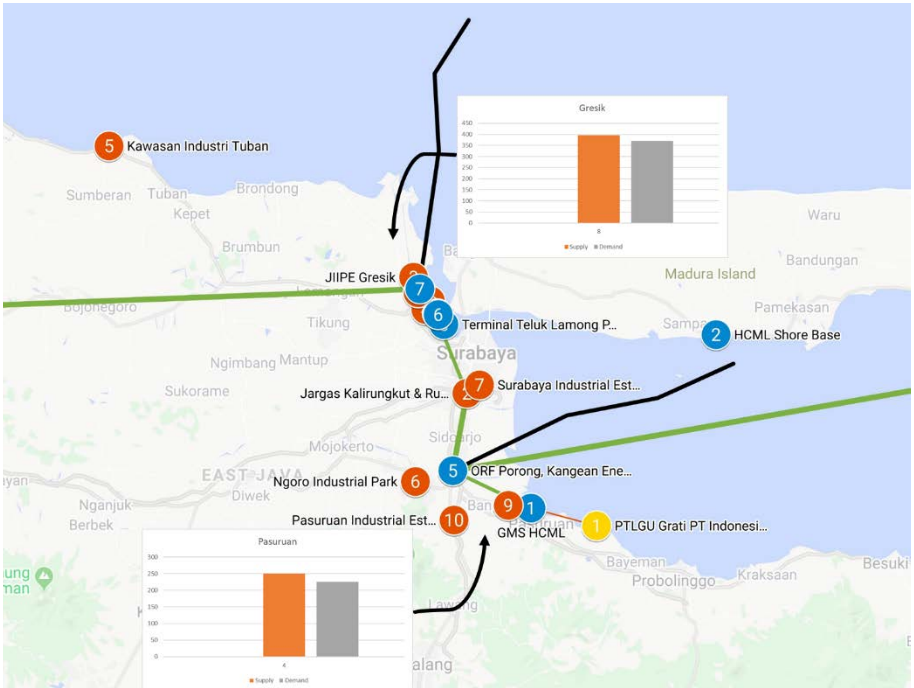

Figure 5.4 Gas Supply and Demand Map of East Java Region in 2032 with Imports Scenarios

Figure 5.4 shows the map of a model for scenarios to improve the natural gas supply in East Java Province by importing gas in the form of LNG from BP Tangguh Train 3. With the import of natural gas, the supply in Pasuran became 250 MMSCFD and the demand is 225 MMSCFD. Whereas in Gresik, the supply became 395 MMSCFD.

5.3. Source of Gas

For the supply, a viable and reasonable supply would come from LNG Tangguh. BP. With the Train 3 in development and projected to operate in year 2021, it would add the capacity of LNG Tangguh Terminal to 3.8 MTPA, or around 545 MMSCFD.

According to the Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas), the production of the Tangguh Train III project will be postponed from the target in the third quarter of 2020. SKK Migas projects that the Tangguh Train III project will start operating in the third quarter of 2021. There were a number of factors that caused the project to start production in the third quarter of 2021. One of the factors was the delay in the delivery of material originating from Sulawesi and Java.

Growth of (domestic) demand is not expected to surge but a steady grow will occure. Meanwhile, production growth is expected to surge with the start of Jambaran Tiung Biru and Tangguh Train 3. The government of Indonesia aims to limit the country's gas exports in an attempt to ensure domestic supplies while encouraging usage of natural gas as a fuel source for industrial and personal consumption.

Train 3 is part of the Tangguh Project. The oil and gas development area project has six gas fields in the Wiriagar Berau and Muturi Blocks located in Bintuni Bay, West Papua. The Tangguh project already has two Train with a capacity of 3.8 million tons per year (MTPA) each. With the operation of Train 3, the total capacity of this gas processing project will reach 11.4 million MTPA, which makes the natural gas from LNG Tangguh’s Train 3 a viable source.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

6.1. Conclusion

Based on the research and analysis natural gas supply and demand in East Java Province, there are some conclusion that the author would summarize:

1. The current supply and demand condition is inadequate. There will be deficit of supply every year except for 2023. The maximum daily deficit is 230.1 MMSCFCD in the year 2022.
2. Additional supply of 250 MMSCFD is required in year 2022. The viable option would be building a LNG Receiving Terminal with a capacity of 100 MMSCFD in Pasuruan area and to add the capacity of LNG Teluk Lamong. Another one would be to use the LNG Teluk Lamong facility because the distribution pipeline of East Java is well developed and connected. The supply would come from BP Tangguh Train 3 that is currently in development and will operate in 2021.

6.2. Recommendation

Based on the research and analysis natural gas supply and demand in East Java Province, there are some recommendation that the author would suggest:

1. Geographical distribution of industrial demand should be made in detail. Each supply source should be modelled with its closest demand. This the study only use estimation based on the size of the industry in two areas.
2. Scenarios of household demand growth should be made based on the growth of *Sambungan Rumah* (SR) that is connected each year.
3. Scenarios of electricity demand or power generation demand should be made based on economical and population growth.
4. Scenarios for supply should be made, because a project, for example the development of a field or the construction of a power plant can be delayed or finish before the due date.
5. A technical, economical or HSE aspect of building a new natural gas infrastructure can be included in further study.

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ATTACHMENT 1
GOVERNMENT DATA

Attachment 1.1. Neraca Gas Bumi Indonesia

88 // Neraca Gas Indonesia *2018 - 2027*

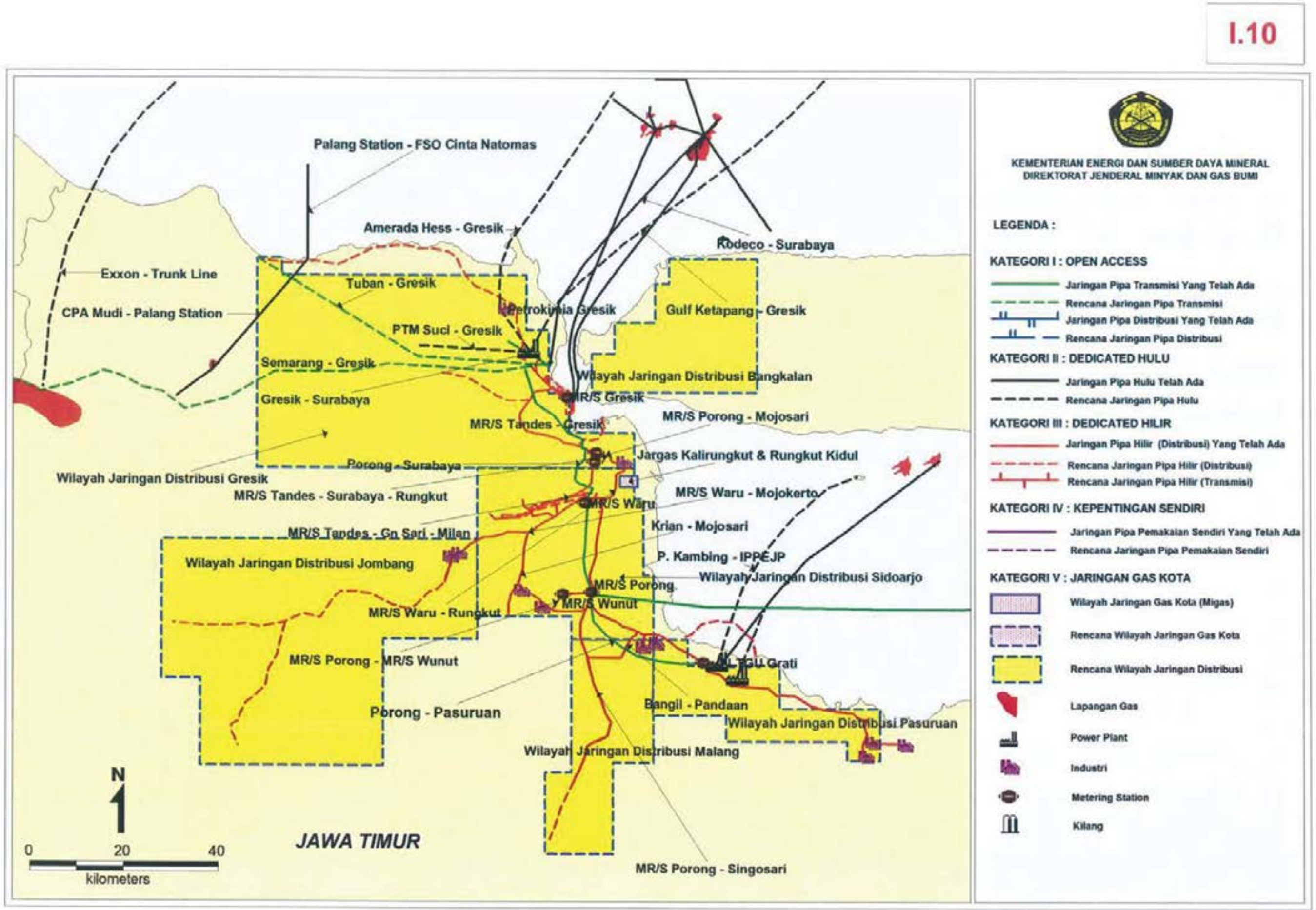
Tabel 4.7.
Perkiraan Pasokan Gas Bumi
Region IV
Januari 2018
@MMSCFD

	Uraian	Tahun 2018	Tahun 2022	Tahun 2027
I.	**Existing**			
IA. Existing Supply				
a	PHE WMO	140.00	80.00	35.00
b	Kangean Energi Indonesia	201.77	99.19	10.31
c	LAPINDO	13.81	-	-
d	SANTOS	66.04	-	-
e	SAKA Pangkah	23.96	11.74	-
f	Pertamina EP - Poleng	14.44	10.26	-
g	JOB P-Ptcna East Java (Sukowati)	1.97	-	-
h	Petronas (Bukit Tua)	35.43	-	-
i	Husky CNOOC Madura Ltd	100.00	100.00	100.00
Total Existing Supply		**597.42**	**301.19**	**145.31**
II. Project Supply				
IIA.	On Going			
a	Husky CNOOC Madura Ltd (MDA & MBH)	-	120.00	75.50
b	Husky CNOOC Madura Ltd (MAC & MDK)	-	72.70	5.15
c	Jambaran Tiung Biru		171.79	171.79
d	PHE WMO	11.42	1.81	-
e	Lapangan Lengo	-	70.00	70.00
IIB.	Confirmed			
a	POD sedang proses	-	-	-
b	POD belum diusulkan	-	-	-
Total Project Supply		**11.42**	**436.30**	**322.44**
III. Potensial Supply				
	PHE WMO	19.82	125.36	40.55
Total Potential Supply		**19.82**	**125.36**	**40.55**
Total Supply Region 4		**628.66**	**862.85**	**508.30**

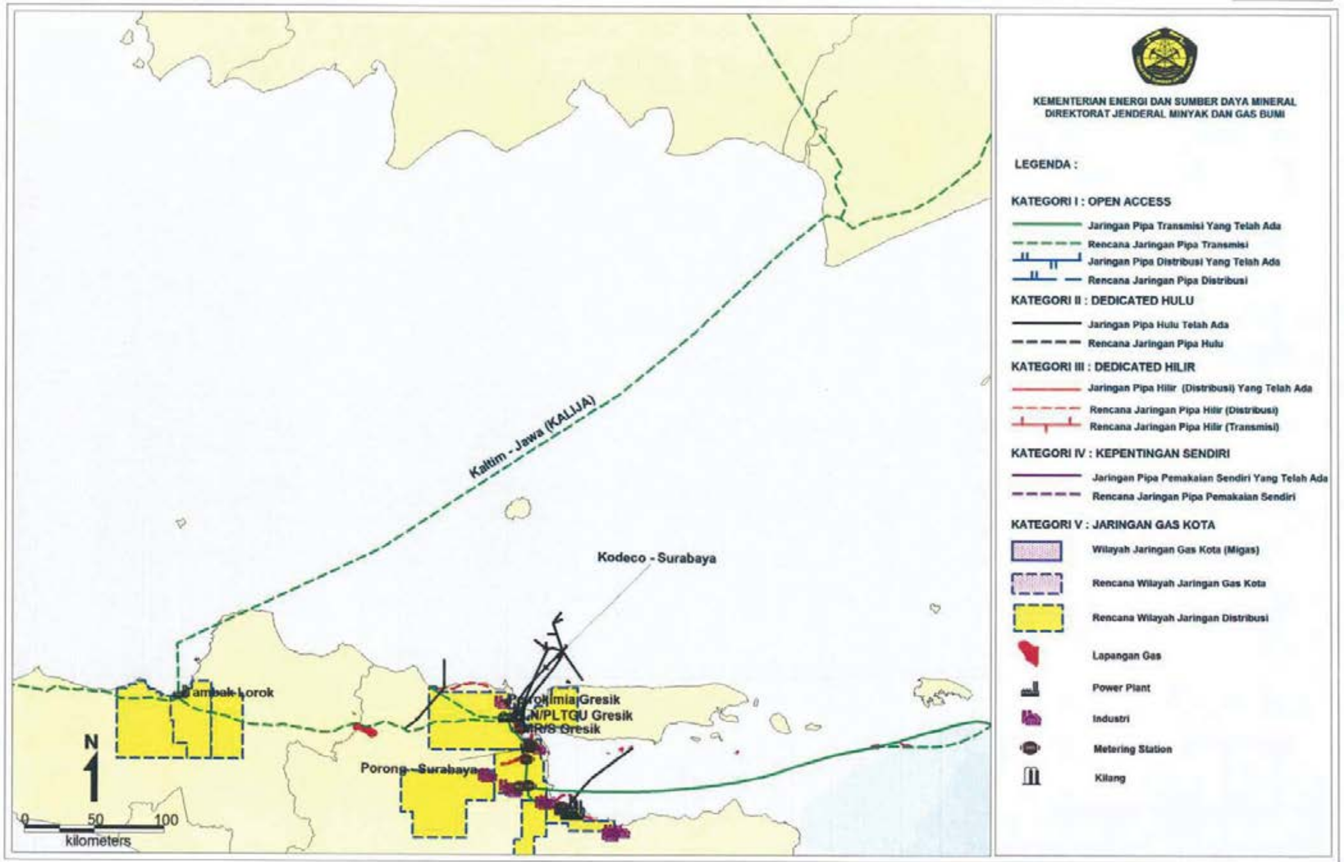
Tabel 4.8
Perkiraan Kebutuhan Gas Bumi
Region IV
1 Januari 2018
@MMSCFD

Uraian	2018			2022			2027		
	Skenario I	Skenario II	Skenario III	Skenario I	Skenario II	Skenario III	Skenario I	Skenario II	Skenario III
Lifting Migas &/Own-Used	-	-	-	-	-	-	-	-	-
Program Pemerintah									
Transportasi	12.20	12.20	12.20	14.83	14.83	14.83	18.93	18.93	18.93
Rumah Tangga	1.10	1.10	1.10	1.34	1.34	1.34	1.71	1.71	1.71
Pupuk dan Petrokimia	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
Kelistrikan	318.21	305.80	305.80	332.45	297.75	297.75	351.14	357.22	357.22
Industri									
Industri Retail	153.62	159.55	283.19	160.50	166.69	344.21	169.52	176.06	439.31
Industri Non Retail	-	-	-	-	-	-	-	-	125.00
Ekspor/Komitmen LNG	-	-	-	-	-	-	-	-	-
Total Demand	**635.14**	**628.65**	**752.29**	**659.11**	**630.60**	**808.13**	**691.29**	**703.91**	**1,092.16**

Attachment 1.2. *Jaringan Pipa Gas Bumi Nasional*



I.11


KEMENTERIAN ENERGI DAN SUMBER DAYA MINERAL
DIREKTORAT JENDERAL MINYAK DAN GAS BUMI
LEGENDA :
KATEGORI I : OPEN ACCESS
Jaringan Pipa Transmisi Yang Telah Ada
Rencana Jaringan Pipa Transmisi
Jaringan Pipa Distribusi Yang Telah Ada
Rencana Jaringan Pipa Distribusi
KATEGORI II : DEDICATED HULU
Jaringan Pipa Hulu Telah Ada
Rencana Jaringan Pipa Hulu
KATEGORI III : DEDICATED HILIR
Jaringan Pipa Hilir (Distribusi) Yang Telah Ada
Rencana Jaringan Pipa Hilir (Distribusi)
Rencana Jaringan Pipa Hilir (Transmisi)
KATEGORI IV : KEPENTINGAN SENDIRI
Jaringan Pipa Pemakaian Sendiri Yang Telah Ada
Rencana Jaringan Pipa Pemakaian Sendiri
KATEGORI V : JARINGAN GAS KOTA
Wilayah Jaringan Gas Kota (Migas)
Rencana Wilayah Jaringan Gas Kota
Rencana Wilayah Jaringan Distribusi
Lapangan Gas
Power Plant
Industri
Metering Station
Kilang
Kaltim - Jawa (KALIJA)
Kodeco - Surabaya
Porong - Surabaya
N
0
50
100
kilometers

Matriks Jaringan Pipa Gas Bumi Nasional Yang Telah Ada
Pulau : Jawa

No	Sumber Gas (Blok)	Kategori	Jenis Pipa	Data Jaringan							Keterangan
				Pemilik-Jaringan	Jalur	Wilayah	Diameter (inchi)	Panjang (km)	Kapasitas (MMSCFD)	Utilisasi (MMSCFD)	
						KATEGORI OPEN ACCESS					
1	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Bitung - Cilegon	Tanggerang, Banten	24	74	270	270	Kepmen ESDM No. 0023 K/10/MEM/2009
2	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Nagrak - Bitung	Tangerang, Bogor	24	51	270	140	Kepmen ESDM No. 0023 K/10/MEM/2009
3	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Tegal Gede - Nagrak	Bekasi, Bogor	24	27	270	140	Kepmen ESDM No. 0023 K/10/MEM/2009
4	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Citarik - Tegalgede	Karawang, Bekasi	24	45	350	150	Kepmen ESDM No. 0023 K/10/MEM/2009
5	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Citarik - Tegal Gede	Bekasi, Karawang, Jawa Barat	32	45	450	200	Kepmen ESDM No. 0023 K/10/MEM/2009
6	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Citarik - Dawuan	Karawang, Jawa Barat	18	7	350	60	Kepmen ESDM No. 0023 K/10/MEM/2009
7	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Cilamaya - Citarik	Karawang, Jawa Barat	24	21	350	120	Kepmen ESDM No. 0023 K/10/MEM/2009
8	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Cilamaya - Citarik	Karawang, Jawa Barat	18	21	250	50	Kepmen ESDM No. 0023 K/10/MEM/2009
9	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Kandang Haur Timur - Cilamaya	Indramayu, Subang, Karawang	14	59	90	30	Kepmen ESDM No. 0023 K/10/MEM/2009
10	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Kandang Haur Timur - Cilamaya	Indramayu, Subang, Karawang	18	59	150	60	Kepmen ESDM No. 0023 K/10/MEM/2009
11	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	Balongan - Kandang Haur Timur	Indramayu, Subang, Karawang	14	34	100	30	Kepmen ESDM No. 0023 K/10/MEM/2009
12	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	SKG Mundu - Balongan	Jawa Barat	12	18	90	25	Kepmen ESDM No. 0023 K/10/MEM/2009
13	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Pertagas	SKG Mundu - PLTG Sunyaragi	Jawa Barat	8	32	30	15	Kepmen ESDM No. 0023 K/10/MEM/2009
15	Kangean (Kangen Energy Indonesia)	Open Acces	Transmisi	PT Pertagas	Pagerungan - ORF Porong	Sumenep-Sidoarjo,Jawa Timur	28	369.7	600	130	Kepmen ESDM No. 0023 K/10/MEM/2009
16	Kangean (Kangen Energy Indonesia)	Open Acces	Transmisi	PT Pertagas	ORF Porong - Gresik	Sidoarjo-Surabaya-Gresik,Jawa Timur	28	52.63	600	130	Kepmen ESDM No. 0023 K/10/MEM/2009
17	Kangean (Kangen Energy Indonesia)	Open Acces	Transmisi	PT Pertagas	Gresik - PLN Gresik	Gresik,Jawa Timur	24	3.42	300	100	Kepmen ESDM No. 0023 K/10/MEM/2009
18	Kangean (Kangen Energy Indonesia)	Open Acces	Transmisi	PT Pertagas	Transmisi Gresik - PKG Gresik	Gresik,Jawa Timur	10	4.65	50	20	Kepmen ESDM No. 0023 K/10/MEM/2009
19	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Acces	Transmisi	PT Majuko Utama Indonesia	MS Pertamina Cilegon - PT Chandra Asri Petrochemical dan PT Dong Jin	Cilegon, Banten	12	12.815	40	18	Izin Usaha Pengangkutan No. 14114.K/10/DJM.O/IU/2011 tanggal 20 Mei 2012 s/d 20 Mei 2016
20	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Rabana Gasindo Usama	SKG Tegal Gede - Stasiun Gas Citeureup	Bekasi, Bogor	8 s/d 10	38.425	20	11	Izin Usaha Pengangkutan Gas Bumi Melalui Pipa No. 7047.K/10.01/DJM.O/2011. Masa Berlaku 17 Maret 2011 s/d 17 Maret 2016

Matriks Jaringan Pipa Gas Bumi Nasional Yang Telah Ada
Pulau : Jawa

No	Sumber Gas (Blok)	Kategori	Jenis Pipa	Data Jaringan							Keterangan
				Pemilik-Jaringan	Jalur	Wilayah	Diameter (inchi)	Panjang (km)	Kapasitas (MMSCFD)	Utilisasi (MMSCFD)	
21	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Gasindo Pratama Sejati	Citarik-Tegalgede - Cikarang	Karawang dan Bekasi, jawa Barat	18	48.5	86	-	Ijin Usaha Sementara No. 4087/10/DJM.O/2009 tanggal 27 Februari 2009(perpanjangan ijin sementara) berlaku sampai 27 Februari 2010, saat ini sedang proses melengkapi dokumen untuk Izin Usaha (Tetap) Pengangkutan Gas Bumi Melalui Pipa
22	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Access	Transmisi	PT Rabana Gasindo Utama	Tegalgede - Cikarang	Karawang, Jawa Barat	10	3.6	54.75		Ijin Usaha Sementara No. 4063/10/DJM.O/2009 tanggal 27 Februari 2009 (perpanjangan ijin sementara) berlaku sampai 27 Februari 2010, saat ini sedang dalam proses permohonan Izin Usaha (tetap)
23	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Acces	Transmisi	PT Rabana Wahana Consorindo Utama	Susukan - Palimanan	Cirebon, Jawa Barat	8	30	20		Izin Usaha Sementara Pengangkutan Gas Bumi Melalui Pipa No.32802/10/DJM.O/2010 berlaku 27 Desember 2010 s.d.27 Desember 2012
24	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Acces	Transmisi	PT.Isma Asia Indotama	Gas Tap Out Point Km 73 PT Pertagas - Daeyang		4	1.98	16		Izin Usaha Sementara Pengangkutan No. 2589/10/DJM.O/2011 berlaku 31 Januari 2011 s/d 31 Januari 2013
25	West Madura Offshore (PHE WMO)	Open Acces	Transmisi	PT Surya Cipta Internusa	Kodeco - MS PT Pembangkitan Jawa Bali UP-Gresik	Gresik, Jawa Timur	8 s.d. 16	1.189	20 s.d 90	12	Sedang dalam proses penerbitan Izin Usaha Pengangkutan Gas Bumi Melalui Pipa
KATEGORI DEDICATED HILIR											
26	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Dedicated Hilir	Distribusi	PT Pertagas	Pondok Tengah I - SKG Tegal Gede	Bekasi, Banten	8	35.5	22	9	Izin usaha niaga gas bumi melalui pipa Dedicated Hilir No. 25222.K/10/DJM.O/2010 tanggal 6 Oktober 2010
27	SSWJ Gas (ConocoPhillips,Pertamina EP, Medco E&P)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Tangerang, Serang, Cilegon, Anyer	Tangerang, Serang, Cilegon, Banten	0.79 - 16	282.27	734	631	Izin Usaha Niaga Gas Bumi Melalui Pipa Dedicated Hilir No 1507/DJM.O/2009 tanggal 27 Januari 2009 Hak Khusus 260/KD/BPH-Migas/Kom/IX/2011
28	SSWJ Gas (ConocoPhillips,Pertamina EP, Medco E&P), ONWJ (PHE ONWJ)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Jakarta	Jakarta Pusat, Barat, Timur, Utara, Selatan	0.79 -16	574.24	734	631	Izin Usaha Niaga Gas Bumi Melalui Pipa Dedicated Hilir No 1507/DJM.O/2009 tanggal 27 Januari 2009 Hak Khusus 260/KD/BPH-Migas/Kom/IX/2011
29	SSWJ Gas (ConocoPhillips,Pertamina EP, Medco E&P)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Bogor,Depok, Sukabumi	Bogor, Depok, Sukabumi	0.79 -16	537.77	734	631	Izin Usaha Niaga Gas Bumi Melalui Pipa Dedicated Hilir No 1507/DJM.O/2009 tanggal 27 Januari 2009 Hak Khusus 260/KD/BPH-Migas/Kom/IX/2011
30	SSWJ Gas (ConocoPhillips,Pertamina EP, Medco E&P)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Bekasi	Bekasi	0.79-32	309.5 Data yg tercantum di Izin Usaha: 253.65	734	631	Izin Usaha Niaga Gas Bumi Melalui Pipa Dedicated Hilir No 1507/DJM.O/2009 tanggal 27 Januari 2009 Hak Khusus 260/KD/BPH-Migas/Kom/IX/2011

Matriks Jaringan Pipa Gas Bumi Nasional Yang Telah Ada
Pulau : Jawa

No	Sumber Gas (Blok)	Kategori	Jenis Pipa	Data Jaringan							Keterangan
				Pemilik-Jaringan	Jalur	Wilayah	Diameter (inchi)	Panjang (km)	Kapasitas (MMSCFD)	Utilisasi (MMSCFD)	
31	SSWJ Gas (ConocoPhillips,Pertamina EP, Medco E&P)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Karawang - Purwakarta - Subang	Karawang,Purwakarta, Subang	1-16	122.8 Data yg tercantum di Izin Usaha: 122.8	734	631	Izin Usaha Niaga Gas Bumi Melalui Pipa Dedicated Hilir No 1507/DJM.O/2009 tanggal 27 Januari 2009 Hak Khusus 260/KD/BPH-Migas/Kom/IX/2011
32	SSWJ Gas (ConocoPhillips,Pertamina EP, Medco E&P)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Cirebon	Jawa Barat	0.79 -12	389.9 Data yg tercantum di Izin Usaha: 383.21	8	4.44	Izin Usaha Niaga Gas Bumi Melalui Pipa Dedicated Hilir No 1507/DJM.O/2009 tanggal 27 Januari 2009 Hak Khusus 260/KD/BPH-Migas/Kom/IX/2011
33	Brantas (Lapindo Brantas), West Madura Offshore (PHE WMO) , Madura Offshore (Santos)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Surabaya - Gresik	Surabaya, Gresik (Jatim)	0.79 -12	376.9	230		Ijin Usaha Niaga No 1507.K/10.01/DJM.O/2009, Hak Khusus No. 026/KD/BPH Migas/Kom/IX/2005
34	Brantas (Lapindo Brantas), West Madura Offshore (PHE WMO) , Madura Offshore (Santos)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Sidoarjo - Mojokerto	Sidoarjo, Mojokerto (Jatim)	0.79 -16	185.62			Ijin Usaha Niaga No 1507.K/10.01/DJM.O/2009, Hak Khusus No. 027/KD/BPH Migas/Kom/IX/2005
35	Brantas (Lapindo Brantas), West Madura Offshore (PHE WMO) , Madura Offshore (Santos)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Pasuruan - Probolinggo	Pasuruan, Probolinggo (Jatim)	2 - 16	134.96			Ijin Usaha Niaga No 1507.K/10.01/DJM.O/2009, Hak Khusus No. 028/KD/BPH Migas/Kom/IX/2005
36	PT PGN [Corridor (ConocoPhillips), Lematang dan South&Central Sumatera (Medco E&P), Pertamian EP Reg Sumatera	Dedicated Hilir	Distribusi	PT Krakatau Daya Listrik	Stasiun Bojonegara-AMS (KP11 PT KDL)	Cilegon, Banten	20	16.0	150	30 - 45	SK Izin usaha No. 13392.K/10/DJM.O/2009
37	PT PGN [Corridor (ConocoPhillips), Lematang dan South&Central Sumatera (Medco E&P), Pertamian EP Reg Sumatera	Dedicated Hilir	Distribusi	PT Krakatau Daya Listrik	Valve Box Area Travo AM 04 - MRS. PT Krakatu Steel Cilegon	Cilegon, Banten	20	0.7	150	30 - 45	
38	PT PGN [Corridor (ConocoPhillips), Lematang dan South&Central Sumatera (Medco E&P), Pertamian EP Reg Sumatera	Dedicated Hilir	Distribusi	PT Krakatau Wajatama Cilegon	Valve Box Area Travo AM 08 - MRS. PT Krakatau Wajatama	Cilegon, Banten	6	1.9	150	30 - 45	

Matriks Jaringan Pipa Gas Bumi Nasional Yang Telah Ada
Pulau : Jawa

No	Sumber Gas (Blok)	Kategori	Jenis Pipa	Data Jaringan							Keterangan
				Pemilik-Jaringan	Jalur	Wilayah	Diameter (inchi)	Panjang (km)	Kapasitas (MMSCFD)	Utilisasi (MMSCFD)	
52	West Madura Offshore (PHE WMO), Poleng (TAC Kodeco Poleng)	Dedicated Hilir	Distribusi	PT Media Karya Sentosa	LPG Plant PT Media Karya Sentos - PLN PJB Plant	Gresik, Jawa Timur	8	1.1			Izin Usaha Pengolahan Gas Bumi Nomor 11048K/14/DJM.O/2009 tanggal 10 Juni 2009
53	West Madura Offshore (PHE WMO)	Dedicated Hilir	Distribusi	PT Gresik Migas	Connecting point pipa Kodeco Co Ltd ke Metering Station PT Gresik Migas di Jl. Amak Asim, Sidorukun, Gresik	Gresik, Jawa Timur	8	0.12			Izin Usaha Niaga Gas Bumi melalui Pipa Dedicated Hilir No. 79.K/10/DJM.O/2012 tanggal 10 Pebruari 2012
54	Gas suar bakar Lap Sukamandi, Jawa Bagian Barat (PT Pertamina EP Reg Jawa)	Dedicated Hilir	Distribusi	PT Energi Kompresindo Utama	Lapangan Sukamandi ke Hot-tap pipa 18" PT Pertamina di Desa Ciasem Baru	Subang, Jawa Barat	3	10.24			Izin Usaha Sementara Niaga Gas Bumi Melalui Pipa Dedicated Hilir No : 18584/10/DJM.O/2008 tanggal 23 Oktober 2008
KATEGORI DEDICATED HULU											
55	South East Sumatera (CNOOC SES)	Dedicated Hulu	Transmisi	CNOOC	Banowati - Cilegon	Jawa Barat	20	65			
56	Offshore North West Java (PHE ONWJ)	Dedicated Hulu	Transmisi	PHE ONWJ	APN -MM Compressor PLTGU Muara Krg	Jawa Barat	24	50			
57	Offshore North West Java (PHE ONWJ)	Dedicated Hulu	Transmisi	PHE ONWJ	Ardjuna NGL Plant - Cilamaya	Jawa Barat	32	41			
58	Offshore North West Java (PHE ONWJ)	Dedicated Hulu	Transmisi	PHE ONWJ	MM Comp-PCP	Jawa Barat	26	32			
59	Offshore North West Java (PHE ONWJ)	Dedicated Hulu	Transmisi	PHE ONWJ	PCP-Muara Karang	Jawa Barat	26	40			
60	Offshore North West Java (PHE ONWJ)	Dedicated Hulu	Transmisi	PHE ONWJ	LL Comp-Ardjuna NGL Plant	Jawa Barat	12	27.2			
61	Sampang (Santos Sampang)	Dedicated Hulu	Transmisi	Santos (Sampang)	Oyong-PLN Grati	Jawa Timur	14	40			
62	Madura Offshore (Santos Madura Offshore)	Dedicated Hulu	Transmisi	Santos (Madura Offshore)	Maleo-EJGP	Jawa Timur	14	7			
63	West Madura Offshore (PHE WMO)	Dedicated Hulu	Transmisi	PHE WMO	Poleng - Porong ORF	Jawa Timur	14	65			
64	Ujung Pangkah (HESS)	Dedicated Hulu	Transmisi	HESS	Pangkah - Gresik	Jawa Timur	18	39			
KATEGORI KEPENTINGAN SENDIRI											
65	Corridor (ConocoPhillips Indonesia)	Kepentingan Sendiri	Transmisi	PT PLN Pembangkit Muara Tawar	Muara Bekasi - Muara Tawar	Jawa Barat	26	7,2	400	300	Surat Persetujuan pengoperasian pipa gas bumi untuk kepentingan sendiri berdasarkan KepMen ESDM No. 14677.K/10/DJM.O/2010 berlaku 16 Juni 2010 s/d 16 Juni 2015
66	Brantas (Lapindo Brantas)	Kepentingan Sendiri	Transmisi	Petrokimia Gresik	Pipa PGN 12" - Pipa Pertamina 28" Wunut	Sidoarjo, Jawa Timur	12	0.105	40		Sudah tidak dioperasikan lagi

Matriks Jaringan Pipa Gas Bumi Nasional Yang Telah Ada
Pulau : Jawa

No	Sumber Gas (Blok)	Kategori	Jenis Pipa	Data Jaringan							Keterangan
				Pemilik-Jaringan	Jalur	Wilayah	Diameter (inchi)	Panjang (km)	Kapasitas (MMSCFD)	Utilisasi (MMSCFD)	
67	West Madura Offshore (PHE WMO)	Kepentingan Sendiri	Transmisi	Petrokimia Gresik	ORF Kodeco Gresik - Tie in Pipa Pertamina P2B Gresik	Gresik, Jawa Timur	12	0.35	40	24	Izin pengoperasian pipa gas bumi untuk kepentingan sendiri berdasarkan Kepmen ESDM No. 7405.K/10/DJM.O/2010 berlaku 22 Maret 2011 s/d 22 Maret 2016
68	Tuban (Petrochina Tuban)	Kepentingan Sendiri	Transmisi	Petrokimia Gresik	ORF Kodeco Gresik - Gas Metering PKG	Gresik, Jawa Timur	8	3.45	40	24	
69	West Madura Offshore (PHE)	Kepentingan Sendiri	Transmisi	Petrokimia Gresik	CPP Sumur Lengowangi I JOB-PPEJ s/d Gas Metering PKG	Gresik, Jawa Timur	8	4.50	30	3.7	
70	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Kepentingan Sendiri	Transmisi	PT Super Silicaindo Semesta	Mainline 24" PT Pertamina - Gas Metering PT SSS	Ciruas, Serang	8	0.015	6	0.4	BU belum mengajukan persetujuan pembangunan dan pengoperasian Pipa Gas Bumi untuk Kepentingan Sendiri Belum ada permohonan baru dari BU (idle)
							2	0.2	1.5	0.4	
71	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Pipa Kepentingan Sendiri	Distribusi	PT Fajar Surya Wisesa	SKG Tegalgede - PT SF Cibitung	Jawa Barat	12.75	5.2	30	25	
KATEGORI JARINGAN GAS KOTA											
73	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Gas Kota	Distribusi	Ditjen Migas	Wilayah Jaringan Distribusi Kelurahan Beji dan Kelurahan Beji Timur	Kota Depok, Jawa Barat	180 mm	5.465			Pembangunan Tahun 2010
							125 mm	0.894			
							90 mm	19.06			
							63 mm	41.522			
74	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Gas Kota	Distribusi	Ditjen Migas	Tapping out 04 Kec. Setu - Kec. Rawa Lumbu, Bekasi	Kota Bekasi	4	2.88			Pembangunan Tahun 2010
							6	10.00			
75	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Gas Kota	Distribusi	Ditjen Migas	Wilayah Jaringan Distribusi Kelurahan Bojong Rawa Lumbu	Kota Bekasi	180 mm	3.712			Pembangunan Tahun 2010
							90 mm	7.858			
							63 mm	20.827			
76	PT PGN (Persero) Tbk	Gas Kota	Distribusi	Ditjen Migas	Wilayah Jaringan Distribusi Jakarta, Bogor, Bekasi	Jakarta, Bogor, Tangerang	25 mm	12.815			Pembangunan Tahun 2011
							63 mm	11.999			
77	Brantas (Lapindo Brantas)	Gas Kota	Distribusi	Ditjen Migas	Wilayah Jaringan Distribusi Medaeng, Tambak Sawah, Kalidawir	Siduarjo, Jawa Timur	20 mm - 180 mm	72.263			Pembangunan Tahun 2011
							4	0.3			
78	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Gas Kota	Distribusi	Ditjen Migas	Wilayah Jaringan Distribusi Kelurahan Rawa Lumbu	Kota Bekasi	20 mm - 180 mm	58.666			Pembangunan Tahun 2011
79	Brantas (Lapindo Brantas)	Gas Kota	Distribusi	Ditjen Migas	Wilayah Jaringan Distribusi Kalirungkut	Surabaya, Jawa Timur			2		Pembangunan Tahun 2009
80	Brantas (Lapindo Brantas)	Gas Kota	Distribusi	Ditjen Migas	Wilayah Jaringan Distribusi Rungkut Kidul	Surabaya, Jawa Timur			2		Pembangunan Tahun 2009
81	Brantas (Lapindo Brantas)	Gas Kota	Distribusi	Ditjen Migas	MR/S Waru - Rungkut		4	10.687			Pembangunan Tahun 2010
82							2	8			
83	Brantas (Lapindo Brantas)	Gas Kota	Distribusi	Ditjen Migas	Desa Kalidawir, Tanggulangin - Tie in Pipa PT Pertamina Gas di Desa Kalisampurno, Tanggulangin		4	5.775			Pembangunan Tahun 2010
84	Brantas (Lapindo Brantas)	Gas Kota	Distribusi	Ditjen Migas	Wilayah Jaringan Distribusi Kelurahan Wedodo, Ngingas	Sidoarjo, Jawa Timur	180 mm	4.69			Pembangunan Tahun 2010
							125 mm	3.13			
							90 mm	20.543			
							63 mm	29.734			

Matriks Rencana Jaringan Pipa Gas Bumi Nasional
Pulau : Jawa

No	Sumber Gas (Blok)	Kategori	Jenis Pipa	Data Jaringan							Keterangan
				Pemilik-Jaringan	Jalur	Wilayah	Diameter (inchi)	Panjang (km)	Kapasitas (MMSCFD)	Utilisasi (MMSCFD)	
						KATEGORI OPEN ACCESS					
1	Cepu (Exxon Mobil Oil Indonesia), FSRU Jawa Tengah	Open Acces	Transmisi	PT Pertamina EP	Gresik-Semarang	Gresik, Semarang, Jawa Timur, Jawa Tengah	28	260	500		Izin usaha sementara No. 9124/24/DJM.O/2005, Penetapan Pemenang lelang dengan SK Kepala BPH No 034/Kpts/PL/BPHMigas/Kom/III/2006 Moratorium Izin Usaha Sementara Pengangkutan Gas Bumi Melalui Pipa No. 4277/10/DJM.O/2011 Berlaku 27 Februari 2011 s/d tersedianya pasokan gas
2	FSRU Jawa Tengah	Open Acces	Transmisi	PT Rekayasa Industri	Cirebon-Semarang	Cirebon, Semarang, Jawa Barat, Jawa Tengah	28	230	500		Izin usaha sementara No. 2947/10/DJM.O/2009 tanggal 16 Februari 2009 berlaku sampai dengan 16 Februari 2011 Moratorium Izin Usaha Sementara Pengangkutan Gas Bumi Melalui Pipa No. 4277/10/DJM.O/2011 Berlaku 27 Februaru 2011 s/d tersedianyu pasokan gas
3	Kangean (Kangean Energy Indonesia)	Open Acces	Transmisi	PT Pertagas	Tie In East Java Gas Pipeline (EJGP) KP 319 - PLTG Grati	Jawa Timur	20	20	200		Tidak dilakukan lelang, karena dianggap sebangan pengembangan dari ruas pipa yang telah ada yaitu ruas pipa open access Pagerungan - ORF Porong
4	Cepu (Exxon Mobil Oil Indonesia)	Open Acces	Transmisi	PT Pertagas	Tegalgede - Pembangkit Muara Tawar	Jawa Barat	20	50	200		Tidak dilakukan lelang, karena dianggap sebangan pengembangan dari ruas pipa yang telah ada yaitu ruas pipa open access Citarik - Tegal Gede - Nagrak
5	Pertamina EP Reg Sumatera	Open Acces	Transmisi		Muara Bekasi - Cirebon	Cirebon, Jawa Barat		220	500 - 700		Jalur pipa belum di lelang, PGN bukan pemilik jaringan
6	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Acces	Transmisi	PT Isma Asia Indotama	SKG Tegal Gede - MM2100	Bekasi, Jawa Barat	4 - 6	4.8	16		Ijin Usaha Sementara No 14119/24/DJM.O/2005 tgl 25 November 2005 berlaku sampai dengan 24 November 2008 untuk dapat dioperasikan (mengalirkan gas bumi) wajib mendapatkan ijin usaha tetap
7	Kangean (Kangean Energy Indonesia)	Open Acces	Transmisi		Terang - Sirasun - Pagerungan	Pagerungan, Jawa Timur		20	300		
8	Jawa Bagian Barat (Pertamina EP Reg Jawa)	Open Acces	Transmisi		Bojonegara, Merak, Anyer	Cilegon, Banten		25	30		

Matriks Rencana Jaringan Pipa Gas Bumi Nasional
Pulau : Jawa

No	Sumber Gas (Blok)	Kategori	Jenis Pipa	Data Jaringan							Keterangan
				Pemilik-Jaringan	Jalur	Wilayah	Diameter (inchi)	Panjang (km)	Kapasitas (MMSCFD)	Utilisasi (MMSCFD)	
28	Jawa Bagian Timur (Pertamina EP Reg Jawa), Cepu (Exxon Mobil Oil Indonesia)	Open Acces	Distribusi		Wilayah Jaringan Distribusi Kendal	Kendal, Jawa Tengah		2076			
29	Jawa Bagian Timur (Pertamina EP Reg Jawa), Cepu (Exxon Mobil Oil Indonesia)	Open Acces	Distribusi		Wilayah Jaringan Distribusi Semarang	Semarang, Jawa Tengah		1317			
30	Jawa Bagian Timur (Pertamina EP Reg Jawa), Cepu (Exxon Mobil Oil Indonesia)	Open Acces	Distribusi		Wilayah Jaringan Distribusi Ponorogo	Ponorogo, Jawa Tengah		1035			
31	Jawa Bagian Timur (Pertamina EP Reg Jawa)	Open Acces	Distribusi		Wilayah Jaringan Distribusi Gresik	Gresik, Jawa Timur		2661			
32	Jawa Bagian Timur (Pertamina EP Reg Jawa), Tuban (Pertamina Hulu Energi Tuban)	Open Acces	Distribusi		Wilayah Jaringan Distribusi Sidoarjo	Sidoarjo, Jawa Timur		1194			
33	Jawa Bagian Timur (Pertamina EP Reg Jawa)	Open Acces	Distribusi		Wilayah Jaringan Distribusi Jombang	Jawa Timur		2505			
34	Jawa Bagian Timur (Pertamina EP Reg Jawa)	Open Acces	Distribusi		Wilayah Jaringan Distribusi Malang	Malang, Jawa Timur		717			
35	Jawa Bagian Timur (Pertamina EP Reg Jawa)	Open Acces	Distribusi		Wilayah Jaringan Distribusi Pasuruan	Pasuruan, Jawa Timur		557			
36	Jawa Bagian Timur (Pertamina EP Reg Jawa)	Open Acces	Distribusi		Wilayah Jaringan Distribusi Bangkalan	Madura, Jawa Timur		760.7			
					KATEGORI DEDICATED HILIR						
37	Sampang (Santos Sampang)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Grati - Pasuruan - Probolinggo	Grati, Pasuruan, Probolinggo (Jatim)	16	9			Proses perizinan
38	Madura Strait (Husky Oil (Madura) Ltd)	Dedicated Hilir	Distribusi	PT PGN	Distribusi Surabaya - Gresik	Surabaya, Gresik (Jatim)	0,79-1,5	1			
39	Madura Strait (Husky Oil (Madura) Ltd)	Dedicated Hilir	Distribusi	PT Inti Alasindo Energi	ORF Semare - Porong	Pasuruan & Sidoarjo, Jatim	16	25	80		Ijin Usaha No. 26310/10/DJM.O/2009 tanggal 29 Desember 2009 (Status sedang dalam proses permohonan perpanjangan Izin Usaha Sementara Niaga Gas Bumi melalui Pipa Dedicated Hilir)
40	Madura Strait (Husky Oil (Madura) Ltd)	Dedicated Hilir	Distribusi	PT Inti Alasindo Energi	ORF Semare - PLTGU Grati	Pasuruan, Jatim	16	22	80		

Matriks Rencana Jaringan Pipa Gas Bumi Nasional
Pulau : Jawa

No	Sumber Gas (Blok)	Kategori	Jenis Pipa	Data Jaringan							Keterangan
				Pemilik-Jaringan	Jalur	Wilayah	Diameter (inchi)	Panjang (km)	Kapasitas (MMSCFD)	Utilisasi (MMSCFD)	
				KATEGORI JARINGAN GAS KOTA							
50	Brantas (Lapindo Brantas)	Gas Kota	Distribusi	Ditjen Migas	Wilayah Jaringan Distribusi Sidoarjo	Sidoarjo, Jawa Timur			2		Pembangunan Tahun 2012
51	PT PGN (Persero) Tbk	Gas Kota	Distribusi	Ditjen Migas	Cirebon	Cirebon, Jawa Barat	32 mm - 180 mm 4"	47.4 0.625			Pembangunan Tahun 2012
52	PT PGN (Persero) Tbk	Gas Kota	Distribusi	Ditjen Migas	Cibinong, Bogor	Bogor, Jawa Barat	32 mm - 180 mm 4"	60.1 0.8			Pembangunan Tahun 2012
53	Pertamina EP	Gas Kota	Distribusi	Ditjen Migas	Subang	Subang, Jawa Barat					Rencana Pembangunan Tahun 2013
54		Gas Kota	Distribusi	Ditjen Migas	Semarang	Semarang, Jawa Tengah					Rencana Pembangunan Tahun 2015

ATTACHMENT 2
FORMULATION AND UNIT OF VARIABLES

Fulfillment_Ratio(t) = Fulfillment_Ratio(t - dt) + (Supply - Demand) * dt
INIT Fulfillment_Ratio = 0

INFLOWS:

Supply = Production_Rate+Developed_Reserves

OUTFLOWS:

Demand = Electricity_Demand+Household_Demand+Industry_Demand

Stock_Demand(t) = Stock_Demand(t - dt) + (Growth_of_Electricity_Demand - Previous_Demand) * dt
INIT Stock_Demand = 305.8

INFLOWS:

Growth_of_Electricity_Demand = IF (TIME<365) THEN (Stock_Demand)
ELSE (Delay_Growth_1)

OUTFLOWS:

Previous_Demand = Stock_Demand

Stock_Demand_2(t) = Stock_Demand_2(t - dt) + (Growth_of_Household_Demand - Previous_Demand_2) * dt
INIT Stock_Demand_2 = 1.1

INFLOWS:

Growth_of_Household_Demand = IF (TIME<365) THEN (Stock_Demand_2)
ELSE (Delay_Growth_2)

OUTFLOWS:

Previous_Demand_2 = Stock_Demand_2

Stock_Demand_3(t) = Stock_Demand_3(t - dt) + (Growth_of_Industrial_Demand - Previous_Demand_3) * dt
INIT Stock_Demand_3 = 153.62

INFLOWS:

Growth_of_Industrial_Demand = IF (TIME<365) THEN (Stock_Demand_3)
ELSE (Delay_Growth_3)

OUTFLOWS:

Previous_Demand_3 = Stock_Demand_3

Supply_of_Field_1(t) = Supply_of_Field_1(t - dt) + (Field_1 - Production_1) * dt
INIT Supply_of_Field_1 = 201.77

INFLOWS:

Field_1 = IF (TIME<365) THEN (Supply_of_Field_1)
ELSE (Delay_Field_1)

OUTFLOWS:

Production_1 = Supply_of_Field_1

Supply_of_Field_11(t) = Supply_of_Field_11(t - dt) + (Field_11 - Production_11) * dt
INIT Supply_of_Field_11 = 19.82

INFLOWS:

Field_11 = IF (TIME<365) THEN (Supply_of_Field_11)
ELSE (Delay_Field_11)

OUTFLOWS:

Production_11 = Supply_of_Field_11

Supply_of_Field_2(t) = Supply_of_Field_2(t - dt) + (Field_2 - Production__2) * dt
INIT Supply_of_Field_2 = 140

INFLOWS:

```
    Field_2 = IF (TIME<365) THEN (Supply_of_Field_2)
        ELSE (Delay_Field_2)
  OUTFLOWS:
    Production__2 = Supply_of_Field_2
Supply_of_Field_3(t) = Supply_of_Field_3(t - dt) + (Field_3 - Production_3) * dt
INIT Supply_of_Field_3 = 100
  INFLOWS:
    Field_3 = DELAY(Supply_of_Field_3*Depletion_Rate_3,365)
  OUTFLOWS:
    Production_3 = Supply_of_Field_3
Supply_of_Field_4(t) = Supply_of_Field_4(t - dt) + (Field_4 - Production_4) * dt
INIT Supply_of_Field_4 = 33
  INFLOWS:
    Field_4 = IF (TIME<365) THEN (Supply_of_Field_4)
        ELSE (Delay_Field_4)
  OUTFLOWS:
    Production_4 = Supply_of_Field_4
Supply_of_Field_5(t) = Supply_of_Field_5(t - dt) + (Field_5 - Production_5) * dt
INIT Supply_of_Field_5 = 47
  INFLOWS:
    Field_5 = IF (TIME<365) THEN (Supply_of_Field_5)
        ELSE (Delay_Field_5)
  OUTFLOWS:
    Production_5 = Supply_of_Field_5
Supply_of_Field_6(t) = Supply_of_Field_6(t - dt) + (Field_6 - Production_6) * dt
INIT Supply_of_Field_6 = 23.96
  INFLOWS:
    Field_6 = IF (TIME<365) THEN (Supply_of_Field_6)
        ELSE (Delay_Field_6)
  OUTFLOWS:
    Production_6 = Supply_of_Field_6
Supply_of_Field_7(t) = Supply_of_Field_7(t - dt) + (Field_7 - Production_7) * dt
INIT Supply_of_Field_7 = 14.44
  INFLOWS:
    Field_7 = IF (TIME<365) THEN (Supply_of_Field_7)
        ELSE (Delay_Field_7)
  OUTFLOWS:
    Production_7 = Supply_of_Field_7
Supply_of_Field_8(t) = Supply_of_Field_8(t - dt) + (Field_8 - Production_8) * dt
INIT Supply_of_Field_8 = 120
  INFLOWS:
    Field_8 = IF (TIME<1825) THEN (0)
        ELSE (Delay_Field_8)
  OUTFLOWS:
```

Production_8 = IF (TIME<1825) THEN 0 ELSE Supply_of_Field_8

Supply_of_Field_9(t) = Supply_of_Field_9(t - dt) + (Field_9 - Production_9) * dt
INIT Supply_of_Field_9 = 72.7

INFLOWS:

Field_9 = IF (TIME<1825) THEN (0)
ELSE (Delay_Field_9)

OUTFLOWS:

Production_9 = IF (TIME<1825) THEN 0 ELSE Supply_of_Field_9

Deficit = Demand-Supply

Delay_1 = DELAY(Supply_of_Field_8*Depletion_Rate_8, 365)

Delay_2 = DELAY(Supply_of_Field_9*Depletion_Rate_9, 365)

Delay_Field_1 = DELAY(Supply_of_Field_1*Depletion_Rate,365)

Delay_Field_11 = DELAY(Supply_of_Field_11*Depletion_Rate_11,365)

Delay_Field_2 = DELAY(Supply_of_Field_2*Depletion_Rate_2,365)

Delay_Field_4 = DELAY(Supply_of_Field_4*Depletion_Rate_4,365)

Delay_Field_5 = DELAY(Supply_of_Field_5*Depletion_Rate_5,365)

Delay_Field_6 = DELAY(Supply_of_Field_6*Depletion_Rate_6,365)

Delay_Field_7 = DELAY(Supply_of_Field_7*Depletion_Rate_7,365)

Delay_Field_8 = if (time<2190) then (Supply_of_Field_8) else (Delay_1)

Delay_Field_9 = IF (time<2190) then (Supply_of_Field_9) else (Delay_2)

Delay_Growth_1 = DELAY(Stock_Demand+Stock_Demand*Growth_Percentage,365)

Delay_Growth_2 = DELAY(Stock_Demand_2+Stock_Demand_2*Growth_Percentage_2,365)

Delay_Growth_3 = DELAY(Stock_Demand_3+Stock_Demand_3*Growth_Percentage_3,365)

Depletion_Rate = 0.83742

Depletion_Rate_11 = 0.266516492

Depletion_Rate_2 = 0.869442

Depletion_Rate_3 = 1

Depletion_Rate_4 = 0.8

Depletion_Rate_5 = 0.8

Depletion_Rate_6 = 0.839027

Depletion_Rate_7 = 0.9181111

Depletion_Rate_8 = 0.911493

Depletion_Rate_9 = 0.588918

Developed_Reserves = Discovery_Rate

Discovery_Rate = 0

Electricity_Demand = Growth_of_Electricity_Demand

Field__10 = IF (TIME<1825) THEN (0) ELSE (171.79)

Field__12 = IF (TIME<3650) THEN (0)
ELSE (40.55)

Fulfilment_Ratio = supply/demand

Growth_Percentage = 0.020387

Growth_Percentage_2 = 0.05

Growth_Percentage_3 = 0.016017

Household_Demand = Growth_of_Household_Demand

- Industry_Demand = Growth_of_Industrial_Demand+PT_Petrokimia_Gresik
- LNG_Terminal = IF (TIME<365) THEN (0)
  ELSE (Phase_3)
- Phase_3 = IF (TIME<1825) THEN (30)
  ELSE (180)
- Production_Rate =
  Field_1+Field_2+Field_3+Field_4+Field_5+Field_6+Field_7+Field_8+Field_9+Field_11+Field__10+Field__12+LNG
  _Terminal
- PT_Petrokimia_Gresik = 150

ATTACHMENT 3
MAJOR INDUSTIRAL ESTATE

INDONESIA INDUSTRIAL ESTATES IN EAST JAVA PROVINCE

No.	Abbre-viation	Industrial Estate Name Company Name/PT	Location	Size Ha	Tenants	Price Land/SFB	Rental Land/SFB
1.	**JIIPE**	**Java Integrated Industrial & Port Estate** PT Berkah Kawasan Manyar Sejahtera **Marketing Contacts:** Koko Matthew P: +62 31 504 4587 E: marketing.bkms@akr.co.id W: www.jiipe.com	Gresik	3,000	n.a	**Land**: US$ 200/m²	n.a
2.	**KIG**	**Kawasan Industri Gresik** PT Kawasan Industri Gresik **Marketing Contacts:** P: +62 31 398 4472 E: marketing@kig.co.id W: http://www.kig.co.id	Gresik	140	>110	Sold Out	**SFB**: Rp 30,000/m²/month **Warehouse**: Rp 22,000/m²/month
3.	**KIT**	**Kawasan Industri Tuban** PT Kawasan Industri Gresik **Marketing Contacts:** P: +62 31 398 4472 E: marketing@kig.co.id W: http://www.kig.co.id	Tuban	227	3	**Land**: Rp 750,000/m²	**Land**: Rp 50,000/m²/month **SFB**: Rp 30,000/m²/month **Warehouse**: Rp 22,000/m²/month
4.	**NIP**	**Ngoro Industrial Park** PT Dharmala RSEA Industrial Estate/ PT Intiland Sejahtera **Marketing Contacts:** Wihardi Hosen/Mita P: +62 321 681 9432 E: info@ngoroindustrialpark.com W: http://www.ngoroindustrialpark.com	Ngoro, Mojokerto	550	85	**Land**: Negotiable	**SFB**: Negotiable

5.	**SIER**	**Surabaya Industrial Estate Rungkut** PT Surabaya Industrial Estate Rungkut **Marketing Contacts:** M. Kunto Abirowo & Krisnawati P: +62 31 843 9581 +62 31 843 9981 E: customerservice@sier-pier.com W: http://www.sier-pier.com	Pasuruan & Surabaya	895	441	**Land** (**PIER**): Rp 1,500,000/m² + PPN 10%	**SFB** (**SIER**): Rp 30,000 – 35,000/m²/month **Warehouse Conventional**: Rp 30,000 – 35,000/m²/month **Logistic Warehouse**: Rp 40,000/m²/month
6.	**KIM**	**Kawasan Industri Maspion** PT Maspion Industrial Estate **Marketing Contacts:** Welly Muliawan P: +62 31 395 1628 E: general@maspionindustrialestate.com mie@maspion.co.id W: www.maspionindustrialestate.com	Gresik	1,000	34	**Land**: ±2,000,000/m²	n.a
7.	**PISL**	**Pergudangan dan Industri Safe N Lock** PT Makmur Berkah Amanda **Marketing Contacts:** Adi Saputra & Dewi Sartika P: +62 31 896 3355 E: aditedjasurya@gmail.com secretarysafenlock@yahoo.com W: safenlock.com	Sidoarjo	197	n.a	**Land**: Rp 5,500,000/m²	**SFB**: Rp 25,000 – 27,000/m²/month

Note:
SFB = Standard Factory Building
n.a = no information available

AUTHOR’S BIOGRAPHY

Johanna Kusuma was born in Jakarta, 16 July 1998, the firstborn of four siblings. She grew up in Tangerang Selatan, Banten, studying at SMA Santa Ursula BSD (2013-2016), majoring in Science study. Author then continue her education in Marine Engineering Department, Faculty of Marine Technology, *Institut Teknologi Sepuluh Nopember*, joining the Joint Degree Program with *Hochschule Wismar*, Germany. During her study, author had been actively involved in some organization, competition, and activities. She was the Sponsorship Officer of *ITS Solar Boat Team*, and also one of the delegates for *Solar Sport One Competition* in Netherlands, 2018, in which the team earned third place. She was also active in *Society of Petroleum Engineers* (SPE) ITS Student Chapter as the Head of Soft Skills Division (2017-2018), Coordinator of Gala Dinner, Petrolida 2018, and the Treasurer for Petrolida 2019. Author also involved in competition such as ITB’s Petrofest 2019 Oil Rig Design Competition and UI’s PetroGas Days 2018 Smart Competition. Author has done her internship three times; 1) *PT Daya Radar Utama* Shipyard in Lampung, 2) *PT Nusantara Regas*, and 3) *PT CBC Indonesia*. Author is very passionate about Sustainable Development Goals (SDGs) and energy, especially renewable energy. During the research for the bachelor thesis, author was a member of Marine Reliability, Availability, Management, and Safety (RAMS) Laboratory.