System Dynamics Modelling for a Sustainable Natural Gas Supply and Demand in Indonesia to Meet up the Additional Demand of 52 Converted Power Plants

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Abstract. US Trade Representatives at WTO had recently excluded Indonesia in the list of Least Developed countries. One of the reason behind the decision was that considering the potential economic of Indonesia that has consistently shown positive trend of growth. As the economic and population growth, the energy demand in Indonesia is also increasing over the time. Indonesia has an abundant natural gas reserves and in fact is the largest reserves in Southeast Asia. In line with the increasing of global awareness toward the sustainable development and environmental concerns, choices over an affordable source of energy with a less carbon footprint is inevitably. With the latest LNG technology, has made distribution even possible to reach remote areas of Indonesian archipelago. The Indonesian government had set up a strategy to promote the use of natural gas in power generation. The Ministerial Energy and Mining Resources Decree No. 13 K/13/MEM/2020 (Ministerial Energy and Mining Resources, 2020e) issued, January 2020, has mandated the state owned enterprise PERTAMINA to establish LNG supply within 2 years time frame to support the conversion of 52 power plants from diesel fueled to natural gas. This study, is offering stages of research, first is determining supply and demand of natural gas in Indonesia, and then conducting a market analysis. A market review analysis on gas supply and demand is done upon various sectors, ie power plants (in relation to additional demand for the conversion of 52 power plants), industries, transportation and households. From which, it will be analyzed, whether or not the gas supply meet the demand. The result of the simulation is revealing the fact that there will be deficit of supply starting sometime in 2031 (much earlier than Asia Pacific Energy Research Centre’s prediction by 2040), with short gap of about 55 MTPA by end of simulation time, thus if the Government is deciding to maintain the existing export commitment.

1. Introduction
The recent rapid changes & development of LNG technologies, has so far made the LNG trade possibly reach out areas where pipeline could not reach. The phenomenon of the rapid changes of world LNG trades, considered as a second game changer, after the shale gas invention in 2010–2012 (International Energy Agency, “world Energy Outlook” 2016). Further on in its November 2018 outlook, the LNG was estimated to take of about 60% of the global gas trade in 2040 (International
Energy Agency, 2018). Ever since then Liquid Natural Gas (LNG) trade has triggered of increasing world’s energy need of LNG for power generation mainly due to it’s efficiency and it’s enviro friendly reasons. [1]

Referring to Government Instrument of Law Nos. 79 of 2014, pertaining to the Nation wide Energy Policy, the domestic need of natural gas is aimed to raise from existing 19% projected to 24% in the coming 2050. In contrary, the use of fossil fuel is going to be kept down from the current 42% to 20% in 2050. [2] The total gas reserves of Indonesian is about 142.71 TSCF, in fact is the biggest reserves in Southeast Asia.

Indonesia is also considered as one of Southeast Asia’s biggest gas producer, with export capacity up to 45% out of its existing production level. The biggest undeveloped reserves are located in East Natuna Block, holding estimated about 49.6 TSCF, also several potential areas as West Papua and Maluku. At the prevailing rate of consumption with assumption no new discoveries, the current reserves would probably last for about 50 years [3].

The Indonesian demand for power will also materially increased up to about 4.5 times in the year of 2040 under preserving scenario as it is today [11]. Yet however report said that coal share will remain dominant in the overall energy-mixed configuration for the country. Back in 2015, coal share was about 56%, it was higher than oil share. This share dominance is projected to keep on increasing, reaching up to approximately 70% in the year 2040. Whilst back in 1990, oil had the domination over the energy-mixed configuration for power generation, approximately 47% share. By 2015, portion share of oil is deluted and maintained as low as 8.4% only, in line as coal and natural gas production is increasing. In the preserving scenario as today, the oil share in the year of 2040 is projected less than 3%. The use of diesel fuel in the small-scale off-grid diesel-fired and dual-engine (diesel fire and natural gas) is dominating today. It constitutes majority of the power generation system in eastern Indonesian islands. Report issued by ERIA [4], in anticipating potential deficit capacity of supply, the Indonesia gov’t shall take the priority of meeting up the domestic demand first by not to proceed any new commitment of gas export with any potential importer and not to extend also the current contracts agreement, and shall reallocate such capacity instead for meeting up first the domestic needs.

The case in Indonesia, in the attempts to increase and promoting more use of natural gas in power generation sector, Government with its regulatory instrument of the Ministry of Energy and Mineral Resources (MEMR) Decree No.13 K/13/MEM/2020 (Ministerial Energy and Mining Resources, 2020e) issued in late January 2020 has assigned the state owned oil and gas enterprise PERTAMINA to set up all the required infrastructures for liquefied natural gas (LNG) supply. That must be started at the latest within 2 years after its first issuance. It was meant to support and facilitate the implementation of the conversion program towards 52 power plants scattered located all over Indonesian islands, migrate from diesel fueled to natural gas. The conversion constitutes of total capacity about 1,697 MW and to feed up of about 169 billion BTU (British thermal unit) of natural gas per day. With this growing rate of the demanded energy, there has been lack of of information on the integrity of the supply and demand situation over a given time. In order to always maintain the fulfilment rate over the needs of gas in Indonesia at a certain sustainable level. This research is aimed to assess the chances to fulfill the additional demand of natural gas due to the conversion of 52 power plants on top of the current existing demand and their growth, to be met up with the existing available supply and its growth in the future. This research is also meant to offer recommendations over the alternative solution, for any indications that lead in to the deficit situation in the future. The method and tools that would be used to serve this purposes is system dynamic modeling simulation.

2. Methodology

2.1. Conceptual Modelling.

This study offers 2 Stages of research, i.e. first is conducting a demand and supply review study, get modelling the existing system in real-life situation. Then after model is generated, the current situation is then assessed, SD simulation would help for it. The simulation is aimed to analyze the conditions of
existing and future fulfilment rate and get it optimized. Then, at later stage several scenarios to fulfil the demand are thereafter defined and tested. The second stage is suggesting a recommendation over an efficient and reliable supply chains system to reach out the locations where all that 52 power plants are located, off which this will become the frame work of the next consecutive research.

Several researchers [5] have done a similar research works in the topics of natural gas supply and demand study in china and the result had revealed to the fact of an increasing demand thus has led to a recommendation to raise the gas supply capacity in China. Another more recent work done by J. Kusuma to asses the some for the context of East Java, Indonesia [3] he foresaw East Java will have to face a deficit in the upcoming year despite of few attempts to enhance the infrastructure capacity such as Teluk Lamong new LNG terminal. Similar to that of J.Kusuma, the most recent study was also conducted by Haekal [6] with conclusion of suggesting an additional gas infrastructure at certain area as alternative to solve the future gas deficit problem in east Java. Those all the afore-mentioned earlier works were also using System Dynamic modelling simulation for their analysis tool with various objects of observation, this research would like to offer a different scopes and observation objects as the potential research gap to fill in with.

2.2. System Dynamic
System Dynamic is one method believed to be the most fits to determine feedback behavior over a complex model that represent a state of situation in a real-life real-world system, off which each element is influenced by one and another. This system characteristic has the capability to fill up the gap left by the previous tools such as mathematical based linear model as well as regression with some circular structures. Thus the approach is found out to be most appropriate for modelling a complex systems, such as ecosystems and human socio-structures, on a complex multi-dimensional with some time-dependent variables. SD simulation will help to demonstrate the interactions of the environment and socio-economic variables clearly, and also helps in identifying the key variables that potentially alter the whole dynamic of the system materially.

This section elaborate first how the natural gas environment is getting modelled structurally, what is the main variables and how will the causal loops looks like. Then based on the generated model assumptions, then the structural stock and flow diagram and model are formulated.

Within this research work the System Dynamics model simulation is helping to give a clear picture of the supply & demand situation throughout the period of simulated time and it would be able to give also description over the supply and demand gap of each sectors & regions so that the effective and efficient supply chain system could be further designed & developed on the basis of a future-accurate information at later stages.

3. Data Acquisition and Processing
Natural gas plays is one of the important source of energy in Indonesian energy-mixed for the power generation. With The Presidential Decree No. 22/2017 pertaining to the National Energy General Plan and road-map [14], energy supply will be served by various energy-mixed under following shares composition:

1) Group sources of low-carbon energy and renewables – targeted at least 23% by 2025 and 31% by 2050
2) Oil – targeted less than 25% by 2025 and maintained as low as 20% by 2050
3) Coal – was targeted at least 30% by 2025 and 25% by 2050
4) Natural Gas – targeted at least 22% by 2025 and 24% by 2050

Report of the Asia Pacific Energy Research Centre (APERC) on “APEC Energy Supply–Demand Outlook 2019” [7] projected the growth of Indonesia’s gas need to meet up it’s domestic and export commitment from 58.8 Mtoe in 2020 to 60.9 Mtoe by 2040 (Table 1). Gas need in power generation sector will continue dominating, took in to account 30% in 2020 and keep growing up to 40%. Industry sector scores the second-largest gas consumer. Yet Indonesia will remain maintaining export
commitment. Nonetheless, the volume will keep on decreasing materially up to only 4.4 Mtoe by 2035. And in 2040, Indonesia is projected to be one ofnett importer country for natural gas.

The implementation policy crafted by Ministerial Energy and Mining Resources Decree No. 13 K/13/MEM/2020 (Ministerial Energy and Mining Resources, 2020c) pertaining to the assignment of procuring infrastructures and facilitating the gas supply to support the conversion of fuel oil into natural gas for power generation sector mostly power plants located in the eastern part of Indonesia. The government has assigned PERTAMINA (State Owned Oil Enterprise) to build up logistics infrastructures (i.e transport, storage and regassification plant) to support the conversion of 52 power plants in Eastern Indonesia. It constitutes of total LNG need of about 170 billion BTU per day.

| Year | 2020 | 2025 | 2030 | 2035 | 2040 |
|------|------|------|------|------|------|
| Total Gas Demand | 58,8 | 54,3 | 55,8 | 59,7 | 60,9 |
| Electricity | 18 | 17,1 | 19,1 | 24,8 | 33,1 |
| Energy Industry (Owned Used) | 3,4 | 3,8 | 4,2 | 4,6 | 4,9 |
| Transport | 0,1 | 0,3 | 0,7 | 1,1 | 1,6 |
| Building | 1,2 | 1,6 | 2,1 | 2,8 | 3,4 |
| Non energy use | 3,4 | 3,8 | 4,2 | 4,6 | 4,9 |
| Industry | 11,8 | 13,8 | 15,8 | 17,5 | 19 |
| Exports | 20,9 | 13,7 | 9,6 | 4,4 | -6 |

Source: Asia Pacific Energy Research Centre, Indonesia Energy outlook (2019), Mtoe: Million Ton of Oil equivalent

3.1. Demand Condition of Natural Gas

Government Regulation No. 79/2014 on the National Energy Policy directed the role of natural gas in Indonesia's energy supply [8] Domestic demand of natural gas until 2050, per the National Energy Policy, will grow from 1.84 TCF (trillion cubic feet) in 2015 to 3.29 TCF in 2025 and to 9.21 TCF in 2050 (Table 2). The average growth of natural gas demand from 2015 to 2020 is 6% per year; 2020–2025, 7% per year; 2025–2030, 5% per year; 2030–2040, 5% per year; and 2040–2050, 3% per year. The demand for natural gas will increase significantly from 2015 to 2025 (6%–7% per year). During that period, the government will optimize the use of gas for domestic use both as fuel and industrial raw material to create higher added value and as a transition to the use of cleaner technologies, such as new energy and renewables.

| Year | 2015 | 2020 | 2025 | 2030 | 2040 | 2050 |
|------|------|------|------|------|------|------|
| Gas Demand | | | | | | |
| Share (%) | 22 | 22 | 22 | 23 | 24 | 24 |
| Volume (Mtoe) | 47 | 64 | 84 | 110 | 178 | 235 |
| Volume (TCF) | 1,84 | 2,51 | 3,29 | 4,31 | 6,98 | 9,21 |
| AAGR (%) | 6 | 7 | 5 | 5 | 3 |

Source: Government of Indonesia, DEN (2014), TCF: Trillion Cubic Feet

Indonesia’s demand for electricity was about 234.6 gigawatt-hour (GWh) in 2018, in accordance to the information served by DG of Electricity (2019). Most of this demand was set out by residential consumption (42%) and industrial need (33%). Regional of Java constitutes of about 71% of the total consumption in Indonesia, and Eastern Indonesia shares were only 9%. Those representing the
consumption of Sulawesi, Maluku, North Maluku, Papua, West Papua, Bali, West and East Nusa Tenggara (NTB and NTT).

The Ministerial Energy and Mining Resources issued Decree No. 13 K/13/MEM/2020, and assigned PT PLN, the State Electricity Company, to convert the 52 of their diesel power plants to burn gas. The reason is quite clear, to reduce the trade deficit and to support the energy diversification program. The impact of such conversion would expected to reduce PT PLN’s diesel consumption from 2.6 million kiloliters (kL) per year to only 1.6 million kL per year, the potential savings amounted worth of about Rp4 trillion (US$286 million). The ministry also assigned PERTAMINA, the state owned oil&gas enterprise to supply the gas. This would include the development and procuremet of the LNG infrastructur es to receive, store, and regasify LNG. PERTAMINA is then oughted to set the price of the gas at 'plant gate’.

Table 3 showing The Plant Capacity of each of 52 Power Plants mentioned in the Ministerial Energy and Mining Resources Decree No. 13 K/13/MEM/2020 with each indicative volume of gas feed required (in BBTUD). It’s obvious that the calculation of the required volume of feed gas was made not all on the basis of base load condition, yet some were made on the basis of Peaker load condition instead. Thus some minor adjustment is required to revise some of the calculated figures and get it back as close as to the basis of installed capacity of the plant itself.

The additional demand volume to feed up the 52 converted Power Plants (Table 3) as of the exercising of Ministerial Energy and Mining Resources Decree No. 13 K/13/MEM/2020 (Ministerial Energy and Mining Resources, 2020e), would be used to add on the basis of current existing demand and it’s growth rate, and The System Dynamics Model will simulate this against the current existing supply base with its growth rate, throughout pre-defined simulation time, in this case its defined for as long as 30 years length of simulation time.

3.2. Supply Condition of Natural Gas
Indonesia had been producing LNG ever since 1977, setting out with Badak LNG plant and followed after by the Arun LNG facility back in 1978. During its peak operation, LNG Arun performed with it’s six trains with through put capacity of 12.85 MTPA. Whereelse Bontang facility with it’s eight trains able to produce through put capacity up to 22.5 MTPA.

Table 3. Plant Capacity & Indicative required feed gas volume (BBTUD) for the 52 Power Plants

| NO | Power Plant | Capacity (MW) | Gas Volume (BBTUD) |
|----|-------------|--------------|--------------------|
| 1  | Krueng Raya | 165          | 19.64              |
| 2  | Nias        | 25           | 5.17               |
| 3  | MPP Jeranjang | 50   | 3.6                |
| 4  | PLTMG Sumbawa | 50  | 6.13               |
| 5  | PLTMG Bima | 50          | 6.13               |
| 6  | PLTMG Maumere | 40   | 2.9                |
| 7  | PLTMG Alor | 10          | 1.3                |
| 8  | PLTMG Kupang | 40   | 2.9                |
| 9  | PLTMG Waingapu | 10  | 1.3                |
| 10 | MPP Kalbar Jungkat | 50  | 6                     |
| 11 | Pontianak Peaker | 100 | 13.44              |
| 12 | PLTMG Siantan | 30   | 1                   |
| 13 | Tanjung Selor | 15   | 0.66               |
| 14 | MPP Ternate | 30          | 2.75               |
| 27 | MPP Fak-Fak | 10          | 0.62               |
| 28 | PLTMG Bula | 10          | 0.42               |
| 29 | PLTMG Bacan | 10          | 0.96               |
| 30 | PLTMG Morotai | 10  | 0.65               |
| 31 | PLTMG Kaimana | 10   | 0.62               |
| 32 | PLTMG Tobelo | 10   | 0.47               |
| 33 | PLTMG Sofifi | 10   | 0.47               |
| 34 | PLTMG Termate 2 | 30   | 1.71               |
| 35 | PLTMG Maleo | 100         | 17.52              |
| 36 | PLTMG Nii Tanasa | 59  | 7.48               |
| 37 | PLTMG Bau Bau | 39   | 2.67               |
| 38 | PLTMG Rangko (Flores) | 23  | 1.65               |
| 39 | PLTMG Gilimanuk | 134 | 13.9               |
| 40 | PLTMG Sorong 1 | 50   | 8.45               |
Another two more facilities were put on stream afterwards. LNG Tangguh facility, with through put of 7.6 MTPA were on stream back in 2009, and another one is LNG facility Donggi Senoro, with a through put capacity of 2 MTPA, were on stream in last 2014. However, due to declining reserves, the LNG Arun were ceased up operation back in 2014. The existing total capacity of all LNG facilities in Indonesia is 31.4 MTPA. The declining gas reserves in East Kalimantan had led them ran out of option but to close down four of their trains. In 2019, the Indonesian total LNG production was remain only 16.4 MTPA: with detailed break down of 6.4 MT from the Badak facility, 7.8 MT from the Tangguh facility, and the rest of 2.2 MT from the Donggi Senoro facility.

Even though LNG production had far declined from 19.1 MT back in 2015 up to remain only 16.4 MT in 2019, yet however its projected that Indonesian LNG production will rebound after the train 3 of LNG Tangguh is expected on stream by 2022. This will boost up the production capacity by 3.8 MTPA, totaling of 11.4 MTPA. The projected Masela facility will add on about 9 MTPA in capacity by 2028. As earlier mentioned, The Indonesian LNG is mainly produced by its 2 main (large-scale) LNG Liquefaction Plants i.e. Bontang LNG Plant & Tangguh LNG Plant , another large-scale facility is coming up ie Masela facility, the production is targeted to come on stream by 2027. The Figure 1 & 2 below are showing The Production Outlook of the Bontang LNG Plant and its allocation purposes as well as Tangguh LNG Plant.
The calculated volume of Supply within this study is made upon the basis of the production rate of all Large scale LNG plants in Indonesia, and also few of small scale LNG facilities that are expected coming on stream in the near future (only those who has secured to get the Government Licenses & Permit), yet however still deducted further by their total committed volume for export, thus only net off figure are taken in to account, plus the production rate of all gas reserves at Jawa and Sumatera region representing the number of volume of gas that so far been distributed through gas pipe.
4. Stage of Modelling

4.1. The Causal Loop Diagram

It represents a concept model in the context of the SD model going to be built up. Over such diagram the model then further examined by tracking all of the causal relations amongst variables and elements earlier inputed in the system model. With the visualization of big picture explaining of each relationship amongst all variables and elements of the system, it simply help us to show the hypothetical prediction of a modelled system. In this research, the causal loop diagram was crafted with the help of software VENSIM as a tool.

The Figure 3 showing four main groups of consumers in part of demand, which are Transport, Electricity Generation, Industrial need and domestic consumption for household. One of them i.e. Power Generation will be directly impacted by the Government conversion program toward 52 power plants. The blue color mark in the Figure 3 is showing on how the additional demand due to the 52 converted power plants is differed from the Existing demand for power generation. Each of the group has few contract relation with variables. For example in Transport group the consumption will relate to the raised rate (in percentage) of the numbers of vehicles and or ship that has consumed gas as fuel per-an-num. In this case we employ an assumption of 5% for the percentage of car gas based upon KESDM [2] and some other converted data sourced up from PGN (state owned gas enterprise).

In the group of Electricity the consumption rate is much related to the growth rate of the consumption annually. In this case we will straight forward employing annual consumption data from PT PLN Persero [9] without having to do any form of conversion priorly. Meanwhile for the Industrial group, the consumption rate is much related to each industries.

We employ an assumption of 1.1% growth annually as per- Neraca Gas Bumi [2] and BPH Migas statistics. Whilst for the last group, i.e. household, the raise of consumption is in line with to the growth rate of the population, the consumption rate it self, and it’s annual growth rate.
Certain conversion interface need to be done towards the data available and used within the previous research works and what was PGN developed [10]. The consumption growth rate is much relied upon the population growth of which data is obtained with computed mathematical method. Meanwhile for the percentage data of the household that has utilized gas, the data available from PGN is employed.

Whilst on the other hand, there are 3 primary factors that are directly affecting supply section. Those are Domestic Production, Export and import. The Domestic Production is directly correlated to the production rate of all gas reservoirs in Indonesia both existing and new developed reserves plus in addition to it is, the volume of gas that’s connected to the production rate of LNG from the Liquefaction plants both existing as well as those expected new plants (those who has secured the Government’s principal approval and License is granted). We employ Neraca Gas Bumi [2] as primary data references. Concerning to the data of import, for the purpose of this study we assume that there is no import made yet until when it come it’s really deem required to do so, in accordance to the recommendation at later stage of this study. Whilst for International Export, it assume there is no new export commitment is made as the Indonesia government has decided to focus on more allocating all gas production to serve domestic need only, thus in this study as aforementioned all the figure numbers of gas production volume as well as LNG production volume were made in such away its net off numbers after deducted off the export volume, from the current and existing contract commitment until its contract expiration. Yet however for the sake of further discussion, we deliberately maintain the option of revisit back the policy in regard to the deliverance of the export gas commitment as one of the alternative gas fulfillment scenario, offered by this study.

Table 4 is showing the basis scenario of demand growth of each groups of consumers that is applied in the simulation within this study, as seen all groups are going to be simulated growing in line with it’s each pre-determined constraint, parameters and inputted inter-correlations variables. Particularly for the demand growth of the Electrical Generation, the additional demand due for the conversion of 52 power plants, has already been taken in to account, and the calculation was made on the basis of an assumption cut of date starting effectively in the early 2022 or it took 2 years after the first day issuance of the Ministerial Energy and Mining Resources Decree No. 13 K/13/MEM/2020 (January 2020).

4.2. The Stock Flow Diagram

Upon completion of the causal loop diagram and revealing all the connections amongst the variables and elements, the next following step is crafting the stock and flow diagram. It is a conceptual framework in the system dynamics model, representing the stock and flow of the system being modelled. Having had this stock flow diagram, we will come to aware of the prevailing condition of the supply and demand, here in Indonesia today. In this study we employ the help of POWERSIM software as an effective tool to build up the model we’re up to.

Figure 4, shows that the transformation and the interpretation process set out from the causal loop diagram into the stock flow diagram has been all completed. Thus we have set of 4 major demand groups, of which each group has their own unique characteristics and constraint as well as certain
correlation to other variables and elements. We would be able to see also that there is no of such
errors occurs throughout the simulation, of which it also indicated that each relation amongst variables
are already in the stage acceptable by the given formula. Hence the simulation can be successfully
done completely.

As we seen in the Figure 4, amongst all the demand groups, demand numbers were broke down
into several sub-demand models. Objective out of which is to find out exactly which group is owning
the biggest number of demand so that in the next following study, few fulfillment scenarios could be
applied, tested and analyzed though roughly accurate. Please note that the sub-model “Balance” is
basically a sub-model that is provided to simulate over alternatives of fulfillment scenarios in this
study.
Again Figure 4, has shown us in particular the supply sector, list of all the Liquefaction plants in Indonesia that is producing LNG, whether those already been producing so far or still expected to be producing in the coming years as the basis of supply plus in addition is gas production from the gas reserves in Jawa & Sumatera regions.

We will then set up the time and measure the flow capacity in accordingly, and defining the clear time frame, the exact cut of date it for starting the observation, and again monitor it along the way of its fluctuation and define also when such supply would start to deplete and come in to an end eventually. We also prepare scenarios and balancing such scenarios in order to get the idea on how the system will behave when it encounter with such various scenarios.

This study has prepared & set up 2 main scenarios for the demand fulfillment condition, such as;
1. Condition whereby the existing export commitment is maintained up to its contract expiry
2. Condition whereby Government has to re-visit and re-negotiate the existing contract and export commitment for possibly an early termination and getting focus more on domestic self-fulfillment instead

5. Result & Discussion
Throughout a 30 years length of simulation, we found out the profile of the gas consumption growth out of 4 main group of consumers. As it’s seen in Figure 5a, we came to know that out of 4 main groups of gas consumers, 2 has dominating the demand, with the Power Generation group is in fact contributing the greatest demand amongst all, where else the remaining 2 groups of consumers i.e. Household and transportation in fact contributing not that significant compared to the other 2 groups i.e. Power Generation and Industries group of demand. That are increasing year on year, whilst in contrary the production rate is keep on depleting, in the meantime the Power Generation demand had been seen kept on extremely growing exponentially throughout the simulation time frame.
Figure.5b showing the demand profile for the additional demand of 52 power plants and its growth rate, as it obviously seen that the volume does not quite significant compared to the basis volume of the existing demand for the group of power generation consumers; 169 MMSCFD vs 1265.5 MMSCFD of the existing demand for the power generation in the early 2022.

Figure.5c showing the Supply condition over the choice of having Scenario 1 and Scenario 2 as an alternative. It's obvious that the scenario 2 will give more flexibility of supply compare to Scenario 1. In accordance to the Figure.6, it is obvious that we will have to face deficit in gas supply someday in future, yet however unlike the prediction and gas demand outlook issued by Asia Pacific Energy Research Centre back in 2019, saying that Indonesia would only start to have deficit in the year 2040 to come, in fact based upon the 30 years length simulation done toward alternative scenario of maintaining the export commitment, of which the result as stated in Figure.6, eventually we came to realize that the deficit would probably come in a much earlier time.
As earlier mentioned this scenario was made upon basic assumption that Indonesian Government would maintain the existing export commitment in accordance to the contract up to its expiry. Having this assumption, as well as having additional demand due to the implementation of the Ministerial Energy and Mining Resources Decree No. 13 K/13/MEM/2020 (January 2020) even though the additional impacted volume known to be not so significant compared to its basis volume of existing demand, as it can be seen in the charts as of Figure 6b & Figure 7b below, it seems that the deficit condition would start sometime earlier in 2031, and the short gap is kept on growing up to the volume of 8000 MMSCFD or about 55 MTPA at the end of simulation time. In this chart of Figure 6 the volume required for fulfillment scenario is as much as the deficit (short) itself.

![Figure 5c. Alternative Supply Scenarios](image)

![Figure 6a. Supply & Demand Condition of Alt Scenario 1, of maintaining the export commitment](image)
Meanwhile in the Figure 7, the result of 30 years simulation toward alternative scenario of terminating all the existing export contract and reallocate all the supply from domestic production merely for domestic need fulfillment instead, we found out that the deficit is narrowing, with short gap of only 7000 MMSCFD or about 48 MTPA by end of the simulation time. And it starts lately in the beginning of 2035 only.

It’s obvious that by re-allocating all the domestic gas production merely for meeting the Domestic market need, would delay the commencement of the deficit condition few years later, and narrowing the sort gap by 1000 MMSCFD at the end of the simulation time.

6. Conclusions & Recommendations
Without having new gas field exploration and discovery of the new gas reserves in the future, and only relying upon to the resources what Indonesia has to day, the deficit of gas supply is an evitable and it would happen in much earlier time than what was predicted before. The alternative scenario provided within this study is only able to give slightly delay in the deficit commencement time, and slightly narrowing the short gap. As a conclusion here is the summary result of the simulated scenarios;
1. Alternative 1 – If Indonesian Government decided to maintain the existing export commitment at whatever cost then Indonesia will have gas deficit by early 2031, thus will make Indonesia as one of net importer country by then.

2. Alternative 2 – If Indonesian Government decided to re-visit all the current export contract and find a way to re-allocate the resources to meet domestic self-fulfillment then, Indonesia will only start to have deficit by early 2035, and thus make Indonesia as a Net Importer country by then.

The short gap volume is considerably huge i.e. about 48 – 55 MTPA by 2050, and this study has not taken the growth usage of Alternative New & Renewable source of Energy in to account yet. There is no other way to fill up the short gap of supply but to get it through import from other country’s sources, thus its recommended to do the followings as an anticipation;

1. Start finding alternative potential sources for import Natural Gas from other countries.
2. Preparing all the required infrastructures to enable the import of which will become a set out framework for the next future research.
3. Last but not least is to boost up the exploration activities in the attempt to find and discover new gas reserves, and keep on promoting the use of New and Renewable sources of energy as alternatives.

7. Further Study Recommendations
The next step of further study might require is to give an answer on how is the possible efficient and reliable gas supply chain to reach out most of those locations where all the 52 power plants are located. There are some possible points of views that the future direction of this research might be heading in to;

1. Developing Infrastructure capacity planning on each regions based upon the basis information provided by the supply & demand situation in the future
2. Design & developing the efficient and reliable gas supply chain to reach out most of those locations where all the 52 power plants are located.
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