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Hakam, Dzikri

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Gas Monetisation Intricacies: Evidence from Indonesia

Dzikri Firmansyah Hakam[1,2]*, Ayodele O. Asekomeh[3]

[1]Centre for Energy, Petroleum and Mineral Law, and Policy. University of Dundee, Scotland, United Kingdom, [2]PT. PLN (Persero), Jakarta, Indonesia, [3]Department of Accounting and Finance, Aberdeen Business School, Robert Gordon University, United Kingdom. *Email: d.f.hakam@dundee.ac.uk

ABSTRACT

Indonesia's geographical spread as an archipelago results in a unique and sophisticated electricity distribution. Consequently, PLN, Indonesia's state-owned electricity company, faces several challenges in implementing a robust gas monetisation scheme given these peculiar features of Indonesia's electricity sector. We identify and evaluate the risks and critical issues regarding Indonesia's gas monetisation policy formulation and implementation, particularly the changing regulation and reforms of the past three decades. We surmise that a sound energy policy of gas investment and utilisation by PLN and other energy stakeholders is fundamental. This will manifest in sound business strategies, especially in addressing contractual difficulties and infrastructural deficiencies in securing long-term gas supplies for gas power plants. Some positive approaches are already being adopted by the Indonesian electricity sector stakeholders to tackle the challenges in gas transportation like small scale liquefied natural gas (LNG), marine LNG and compressed natural gas but these efforts need to be consistently pursued over the planning horizon.

Keywords: Gas Monetisation**,** Long-term Gas Supplies, Gas Transportation
JEL Classifications: L95, N7, Q4

1. INTRODUCTION

Selected studies (Bacon, 1995; Bacon and Besant-Jones, 2001; Fraser, 2003) have identified the principal driving forces behind electricity sector reforms. The first is the poor performance of state-run electricity sectors, including the inability to meet electricity demand. There is also the inability of state-owned electricity utility companies to finance infrastructure projects. Governments often grant energy subsidies, which burden or inhibit fiscal policy. Thus, the removal of such subsidies is widely seen as an essential reform-enabler. Additionally, reforms provide governments with an opportunity to gain immediate revenue from selling electricity assets. However, reforms are unsurprisingly challenging to implement since policies need to be contextualised for an adopting country's peculiar circumstances.

In this study, we examine the risks and challenges for achieving the electrification targets for Indonesia. The country is characterised by a growing demand for electricity across a vast archipelago, which poses severe infrastructural challenges, especially for gas transportation and monetisation. Thus, there is the need to examine the strategy for meeting growing demand for electricity where access to electricity was previously enshrined in the constitution in a manner that prevented the efficient allocation of resources. Reforms are pursued with the strong assumption that resources are usually efficiently allocated by market conditions and forces.

First, we review the changes in Indonesia's electricity regulation and policy that have shaped the sector in the past three decades. Building on this, we examine the current energy mix of Indonesia and the task of the state-owned electricity company, PT PLN (Persero) or PLN, in providing electricity in a manner that seeks to satisfy constitutional requirements on the one hand and contracting obligations that are mostly arbitrated by the forces of supply and demand on the other. Next, given the projected energy mix and the vital role of gas in achieving Indonesia's energy sustainability objectives, we examine the various gas monetisation schemes that PLN can consider and evaluate the issues surrounding securing gas supply contracts to ensure cost-efficient operations of existing and new gas-fueled power plants. Finally, we evaluate policy implications and draw proper conclusions for the Indonesian electricity sector.

2. ELECTRICITY MARKET REFORM AND POLICY

The electricity law of 1985 was a significant development in the electricity industry in Indonesia. The law allowed private parties to participate in Indonesia's electricity supply business in limited capacities. The private participants acted as Independent Power Producers (IPPs) and were restricted to generating electricity supply for PLN under Private Purchase Agreements (PPAs). The goals of the IPP program are to attract international investment, reduce electricity cost through competitiveness and assign project risks in a considered manner. The purposes of IPPs' participation are to meet excess electricity demand and follow international financing trends (Lefevre and Todoc, 2000). However, countries adopting IPP arrangements have difficulty paying their financial obligation to the IPPs (Wamukonya, 2003) since the national utility company buys electricity from IPP in US$ and sells in domestic currency, e.g., the Indonesian Rupiah.

Indonesia's IPP program was hindered by the Asian financial crisis in the late 1990s (PWC, 2011). Due to the financial crisis, the Indonesian government could not meet its financial obligations to IPPs as specified in partnership contracts. Moreover, PLN's inability to pay IPP's caused a delay in the take-off of a majority of the power plant infrastructure projects and resulted in massive debts to the IPPs over unresolved contracts. In 2002, the Indonesian government introduced new electricity reforms through the re-enactment of the electricity law. Under the 2002 electricity law, private parties could participate in both the electricity supply business and the retail market, with electricity tariffs determined by the market under supervision by the electricity market supervisory agency.

However, in 2004, the Indonesia constitutional court invalidated the 2002 electricity law as it was deemed unconstitutional, reverting to the 1985 law. The Indonesian constitution considers electricity to be a social necessity that should be exclusively delivered by the state-owned company. In 2009, the Indonesian government passed Electricity Act No. 30, which embodies the main provisions of the 2002 electricity law in regards to the participation of private parties in the electricity supply business. Also, regional governments are now given a more prominent role in building infrastructure and determining electricity tariffs. According to Article No 4, Point 1 of Electricity Act No. 30, central and local governments are responsible for securing the electricity supply through state-owned electricity companies. The Act is also intended to guide the liberalisation of the electricity sector with the participation of private companies in the generation market (Article No 4, Point 2). IPPs and cooperatives play a significant role in Indonesia's electricity sector since some of the power plant investments are financed and constructed by them.

The electricity sector liberalisation in Indonesia is partial since the private enterprise cannot enter the transmission and distribution sectors, which are exclusively operated by PLN. Transmission and distribution are performed by PLN transmission and PLN distribution respectively, both operating a PLN dispatch centre. The current law empowers PLN to play a leading role in the market, although private companies are progressively being given a more significant role in new power plant investments. Thus, of the 35,000 MW power plant investment expected in the next 5 years, PLN will construct 10.681 MW while private companies will account for 25,904 MW installed capacity (PLN, 2015b). However, it is questionable whether a state-owned entity is equipped or able to operate autonomously and contract efficiently with other market participants. Indonesia's National Energy Policy informs PLN's corporate strategy. The strategies are focused on the final objective of delivering energy sustainability as can be seen in Figure 1. Indonesia's energy stakeholders are interested in shifting the paradigm from supply-side policy to demand-side policy, securing energy supply through several strategies (such as new exploration and production and energy conservation), increasing consumer awareness of efficient utilisation of energy (by putting into operation energy conservation and diversification strategies), and increasing energy prices in order to remove energy subsidy and convert the energy subsidy to a direct subsidy for the poor.

Further details of Indonesia's electricity policy can be found in (PLN, 2015b). Electricity policy was established to solve electricity supply deficit and support economic growth. Indonesia's generation expansion planning is designed to provide reliable and sustainable electricity to the customer and focus on local and green energy sources. The general plan of electricity supply (RUPTL) is intended to implement the national mandate in government regulation No. 14 of 2012 that dictates that electricity supply business for public services should be undertaken solely by PLN through specified planning criteria. The plan revised some of the assumptions made in previous years report due to the delay in some power plants' commercial operation dates (COD[1]s).

RUPTL is conducted based on the National Electricity Master Plan (RUKN) from the Ministry of Energy and Mineral, as can be seen in Figure 2. The electricity demand forecast is used as a basis for power generation planning and is supported by transmission and distribution planning. The optimisation principle in power plant development is to achieve the least cost and a reliable electricity supply for the consumer. The "go" versus "no-go" decision-making in power plant projects is influenced by project investment valuation criteria, such as net present value (NPV), internal rate of return and environmental impact study (PLN, 2015b).

3. STATE OF INDUSTRY AND ENERGY MIX

PLN, Indonesia's state-owned electricity company, has a social and political duty or Public Service Obligation (PSO) to support government targets in the country's development by establishing sufficient power plants to meet high growth in electricity demand. Indonesia is one of the world's emerging economies and is a member of the G-20 countries. Indonesia is projected to become the 7th largest economy in the world, overtaking Germany and the United Kingdom by 2030 (Oberman et al., 2012). A prerequisite for Indonesia's high economic growth target is steady and rapid electrification for both domestic and industrial use (Oberman et al., 2012).

1 COD is the date from when a power plant starts delivering electricity energy to the consumer after rigorous technical tests.

Figure 1: National Energy Policy adapted from (Sutijastoto, 2012)

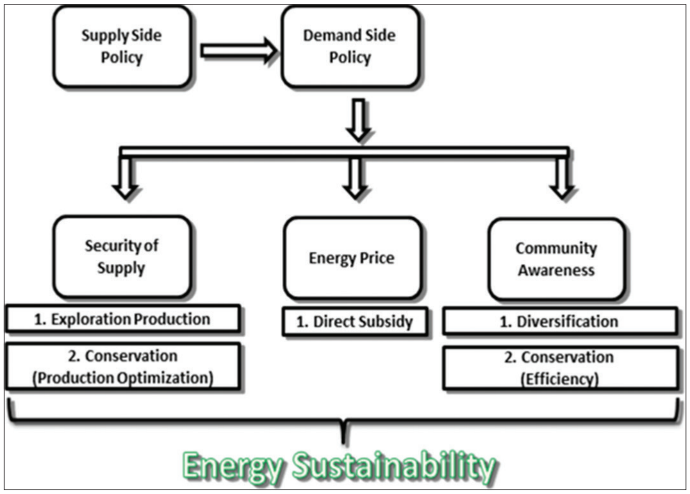


Figure 2: General plan of electricity supply process

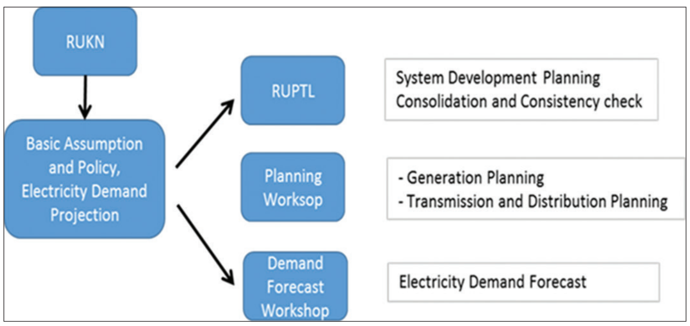


Figure 3 shows a breakdown of PLN's forecasted energy mix from 2015 to 2024. The figure indicates that coal fuel is vital to the energy mix. Coal-fueled power plants have a high capacity factor characteristic (usually close to 100%) due to coal's use as the base load in the power system. Typically, the Indonesia power system, e.g., the Java power system, uses steam coal and geothermal units for the base load, gas combined cycle units for the intermediate load, and oil-fired combustion turbine and peaking hydropower units for the peak load (Rachmatullah et al., 2007). Gas is the second largest fuel in the mix. The importance of gas in Indonesia's energy mix is mainly due to the flexibility of gas-fueled power plants for use in adjusting peak load demand. PLN's gas monetisation consists of natural gas, compressed gas and liquefied gas and is correlated with oil fuel utilisation decline in the future. Electricity production from gas is projected at approximately 95,000 GWH by 2024. Natural gas utilisation is expected to reduce (dropping by 3% during the 2015–2024 period) in the future, to be replaced by the increasing use of compressed natural gas (CNG) and liquefied natural gas (LNG) (e.g., the LNG portion will increase by 75% in the same period).

However, Figure 3 also indicates that renewable energy is not as significant as coal or gas in the mix. Nevertheless, the Indonesian government is committed to developing green energy in the form of hydro, solar, biomass and geothermal energy through energy policies like feed-in tariff (FIT)[2].

PLN is the biggest company in Indonesia with assets value of more than 603 trillion rupiahs (PLN, 2015a), equivalent to US$48.39 billion (2014 average currency; US$1 = 12,461 IDR). PLN has business segments covering electricity generation, transmission and distribution sectors. The main corporate expense is fuel costs. Based on the consolidated financial statements for 2001-2014, fuel expense as a percentage of total annual expenses ranged from 44% to 71%. Figure 4 indicates that PLN's fuel expense is correlated with global oil prices.

Although oil-fueled power plants (MFO) are planned to account for only 1% of the total installed capacity by 2024 (PLN, 2015b), oil fuel expense represents a dominant part of total fuel expense (Figure 5). Also, crude oil price fluctuations affect the cost to the company. Regarding demand, Indonesia's electricity system is currently dominated by residential consumers, but load[3] factors (80% in 2013) and electrification ratios[4] (80.5% in 2013) are still a long way from set targets (Ministry of Energy and Mineral Resources Republic of Indonesia, 2014). PLN utilises existing peaking load power plants, including diesel power plants (HFD), to meet peak demands.

The optimum peaking load power plant with high ramping rate[5] and a short period of project investment that could replace diesel power plants would be gas-fueled power plants. Development of pumped storage power plants takes such a long time to construct that it is not suitable given the high electricity demand in Indonesia. Furthermore, the high capital cost of a hydro project that produces a lower return on investment (ROI) leads investors to prefer gas power plants.

4. GAS MONETISATION CONSIDERATIONS FOR INDONESIA

It is expected that world energy demand will be dominated by three primary sources: Oil, gas and coal fuel (BP, 2015). Of the three, gas is the cleanest fuel and delivers the cheapest process cost in the power generation sector (Fraser, 2003). Natural gas utilisation in the electricity industry is a necessity, and its percentage in the power system energy mix is increasing in many countries (Fernandes et al., 2005; Shukla et al., 2009). However, gas power plant utilisation in Indonesia power system is limited to intermediate and peaking load since it is less competitive for baseload power plants compared to coal, hydro and geothermal power plants. Furthermore, gas monetisation is hampered by the primary challenge of transporting the gas to the scattered load of Indonesia's archipelago. This transportation constraint is shaping

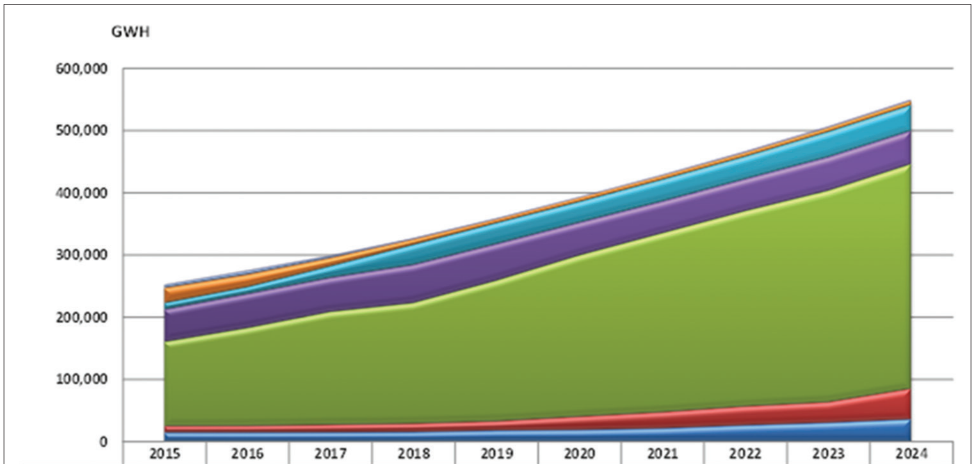
2 Feed-in tariff is a policy mechanism designed to increase investment in renewable energy, e.g., wind and hydro. Tariff applied is a differential rate that allows investors to recover generation cost thereby encouraging investment in renewables. FITs are set to decline over time to monitor and stimulate technological cost reductions. See Couture and Yves (2010) for further explanation.

3 Load factor (LF) is the ratio between average load and peak load. This ratio is important in determining power plant utilisation in each power system, e.g., proportion of base to peak power plants in the energy mix.

4 Electrification ratio is a comparison between households with electricity access and total household number (in percentage).

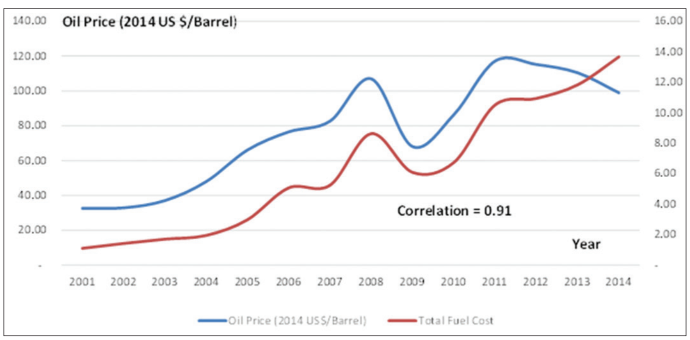
5 Ramping rate is the amount of load the power plant operator could add per unit of time. High ramping power plants respond flexibly to sudden load increase in the power system.

Figure 3: Indonesia power system fuel mix 2015-2024 (PLN, 2015b)



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Import	758	929	1,063	1,582	1,367	1,397	1,172	1,578	1,487	1,503
Biomass	37	50	50	50	50	50	50	50	50	50
Solar	4	4	5	6	6	6	6	7	7	7
MFO	4,834	5,895	3,090	669	644	575	623	690	772	953
HSD	24,004	19,812	12,879	8,250	5,654	5,791	5,882	5,892	6,229	6,568
LNG	10,465	11,094	18,613	32,235	33,640	33,400	34,844	36,388	40,673	41,105
Gas	52,140	54,915	54,833	61,170	58,962	52,525	51,184	51,374	53,747	53,625
Coal	135,264	157,356	181,660	194,003	225,904	259,470	287,629	313,880	340,198	361,131
Geothermal	10,694	11,067	12,550	13,860	15,133	21,391	26,508	30,742	33,395	49,353
Hydro	14,502	14,468	14,749	15,383	17,902	18,916	21,108	26,136	30,200	35,876

Figure 4: Oil price and PLN's total fuel expense. Data source: (BP, 2015; PLN, 2015a)



the development of the market and commodity trading in natural gas (Khalilpour and Karimi, 2012).

Gas monetisation alternatives like CNG, LNG, GTL (gas to liquid) and GTW (gas to wire) are used to address the natural gas transportation challenges. Of these, LNG and CNG use are predominant (Khalilpour and Karimi, 2012). The process of LNG production and delivery consists of several stages including gas exploration, pipeline operation, natural gas liquefaction, gas storage and transportation, terminal storage, and regasification. In the liquefaction stage, the natural gas feed is condensed and stored in atmospheric tanks. The condensed gas, in the form of LNG, is then shipped in specially designed containers. The LNG is then unloaded into storage tanks, re-gasified and supplied to the customer and gas power plant (Khalilpour and Karimi, 2012).

The first world-scale LNG project resulted in LNG sales from Indonesia to Japan in the 1970s. This LNG project was characterised by a high degree of government involvement and a long-term gas take-or-pay (TOP) contract based on sales and specified purchase agreements for selected buyers (Griffin, 2006). On the other hand, the CNG utilisation process consists of three different stages: Compression, transportation and decompression of natural gas. In the compression stage, the natural gas is chilled to a lower temperature, which makes it easier to compress. In the transportation stage, the natural gas is transported using specially designed containers, which are vertically or horizontally stacked. Finally, in the decompression stage, natural gas is heated to the desired temperature and the decompressed gas released into the delivery terminal.

Gas Sales and Purchase Agreement (GSPA) is a long-term sales commitment or contract between the gas seller and a buyer. The essential stipulation of the GSPA is the take-or-pay (TOP) clause (Masten and Crocker, 1985). Gas investments are very sensitive to gas prices and require a substantial initial capital outlay. Hence, the TOP clause reduces the investment risk for the gas investor since buyers have to pay for a contractually determined minimum volume, even if gas delivery is not taken. Since the buyer could suffer losses if they cannot use all of the gas, it is vital to calculate gas consumption accurately. The most significant gas purchasers are gas power plants. Thus plant operators should carefully examine gas requirements (Dong et al., 2012).

Where a gas power plant is utilised as a baseload power plant, the TOP clause will not be a problem for the operator. However, where the gas power plant is used for managing load variability in the power system, such as in Indonesia, the rigidity of TOP will reduce the operational flexibility of gas power units. Masten and Crocker (1985) and Dong et al. (2012) suggest flexibility in long-term gas contracts to reduce the investment risk for the buyer. However, this will lead to an increased risk for the natural gas supplier. Moreover, an accurate system dispatching for gas power plant will reduce the losses incurred as a result of the TOP clause.

A gas-fueled power plant is flexible for use in high ramping type power plants that can adjust electricity production according to demand in the short-run. This characteristic is important, especially in countries with liberalised electricity sectors (Fraser, 2003). Fraser (2003) reports that gas monetisation in the world's power generation has been around 65% since 1991. In addition to load flexibility, gas-fueled power plants offer the investor the ability to hedge financial risk and have the advantage of lower CO_2 emissions (EIA, 2010).

The preceding create some special corporate considerations for Indonesia's power system. Firstly, Indonesia's geographical spread as the world's biggest archipelago naturally creates a scattered load, with many isolated islands. The power system consists of several individual power systems dominated by residential consumers with different load factors. The lower the load ratio, the larger the difference between base and peak loads, which then increases the need for gas-fueled power plants. The different power systems in Indonesia's electricity sector and their average load factor projections for 2015 and 2024 are given in Table 1. It is essential to provide sufficient must-run peaking power plants, such as gas-fueled power plants, to respond to the sudden shifting from base load to peak load, especially in power system interconnections with low load factors.

The national electrification ratio for Indonesia has increased significantly, rising from 60.8% in 2007 to 80.5% in the year 2013 (Ministry of Energy and Mineral Resources Republic of Indonesia, 2014). The Indonesian government is committed to further developing the electricity infrastructure to increase electricity access to the consumer. New generation infrastructure needs to be combined with the utilisation of all existing power plant capacity, including plants using high-cost fuel types such as diesel.

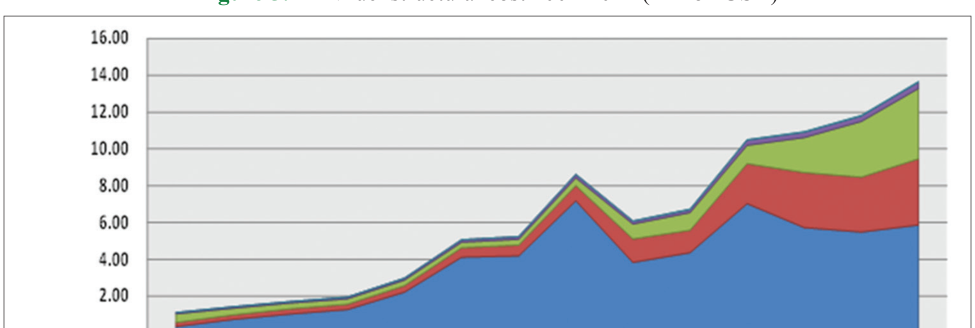
Indonesia currently has proven gas reserves of approximately 103 Tcf (trillion standard cubic feet) or about 3 million cubic meters, which represents 1.4% of total world gas reserves BP (2015). Indonesia exports natural gas to countries like the United Kingdom, Japan and China, thus reemphasising Indonesia's role in the world gas market. Based on Ministry of Energy and Mineral Resources Republic of Indonesia (2014), the total amount of Indonesia's gas reserves is 152.9 Tcf, which comprises of proven reserves of 104.7 Tcf and potential reserves of 48.2 Tcf. The gas reserves are scattered across the Indonesian archipelago, with the main contributions being from Natuna Island (51 Tcf), South Sumatra (16 Tcf), and East Kalimantan (19 Tcf).

Figure 6 shows Indonesia's historical natural gas reserves for 2000–2013 in Tcf. Energy resource adequacy is essential to minimise market risk in securing electricity supply. Indonesia's gas reserves experienced a degradation in 2000–2013 due to a lack of investment in gas exploration. Although the proven reserves increased from 95 to 101 Tcf, the total gas reserves declined from 170 to 150 Tcf. Corresponding to the decrease in the total national gas reserve, the gas supply for PLN's use will decline in the future, resulting in potential shortages for power plants.

To reduce the cost burden of diesel power plant utilisation, PLN implemented a number of policies, including gas monetisation to replace diesel power plants as peaking plants. Gas-fueled power plants utilise piped gas, LNG, CNG, marine CNG, marine LNG, mini scale LNG fuel, which are all considered to deliver a higher return on investment, NPV and shorter payback period compared to diesel-fueled and pumped storage power plants. Reduction of dependence on diesel has been made in phases, according to the CODs of ongoing new plant constructions. Similarly, to reduce oil utilisation in power generation, PLN has pursued a diversification away from oil.

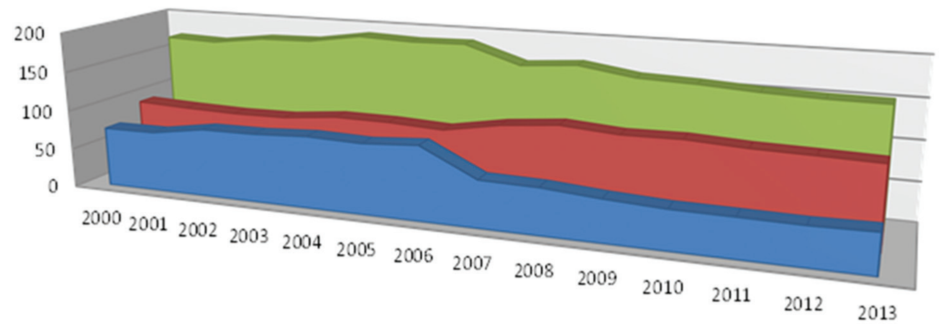
Gas project development involves several risks and challenges. Based on the EIA report (EIA, 2014), there are several significant risks in power plant investment. Power plant risks include changes in construction costs, lead time, operational costs, and availability/performance. Market risk relates to the variability of fuel cost, demand, competition, and electricity prices. Regulatory risks

Figure 5: PLN fuel structural cost 2001-2014 (Billion USD)



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Water	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.02
Geothermal	0.07	0.08	0.08	0.09	0.10	0.13	0.14	0.18	0.16	0.16	0.28	0.29	0.30	0.35
Natural Gas	0.47	0.36	0.32	0.30	0.30	0.31	0.32	0.42	0.81	0.96	1.00	1.91	3.03	3.83
Coal Expense	0.22	0.25	0.28	0.29	0.35	0.51	0.58	0.82	1.27	1.22	2.17	2.99	2.98	3.60
Oil fuel	0.35	0.74	1.03	1.27	2.22	4.12	4.19	7.19	3.84	4.36	7.03	5.73	5.49	5.87

Figure 6: Indonesia natural gas reserve 2000-2013 (Ministry of Energy and Mineral Resources Republic of Indonesia, 2014)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Potential	75.56	76.05	86.29	86.96	90.53	88.54	93.1	59	57.6	52.29	48.74	48.18	47.35	48.85
Proven	94.75	92.1	90.3	91.17	97.81	97.26	94	106	112.5	107.34	108.4	104.71	103.35	101.54
Total	170.31	168.15	176.59	178.13	188.34	185.8	187.1	165	170.1	159.63	157.14	152.89	150.7	150.39

Table 1: Load Factor in Indonesia power system adapted from (PLN, 2015b)

No.	Power system interconnection	LF 2015 (%)	LF 2024 (%)
1	Java-Bali	79	80
2	Sumatra	69	77
3	Kalbar	66	66
4	Kalseltengtimra	67	68
5	South Sulawesi	68	69
6	North Sulawesi	68	73

manifest as issues with market design, regulation of competition, and regulation of transmission. Policy risks relate to compliance with environmental standards, CO2 constraints, support for specific technologies, and energy efficiency. In addition to the power plant investment risks mentioned above, Bhattacharyya (2012) points out that several additional investment risks are peculiar to developing countries. Firstly, governments in developing countries have difficulty in attracting international investors, primarily due to poor pricing policies which lead to poor benefit investment. Secondly, the lack of transparency and weak governance in such countries increase the risk premium and cause international investors to be more reluctant to invest their money.

Regarding generation technology options, gas power plant technology is considered to deliver lower risk in the investment process compared to other generation technology types (EIA, 2010). The risk factor that should be carefully assessed in gas power plant investment is a market risk, where resource inadequacy and fuel costs become significant issues. However, investment preference in Indonesia is from coal rather than gas power plants. This is because of the absence of carbon pricing arrangements and environmental costs. Thus, coal is cheaper and relatively easier to acquire than gas.

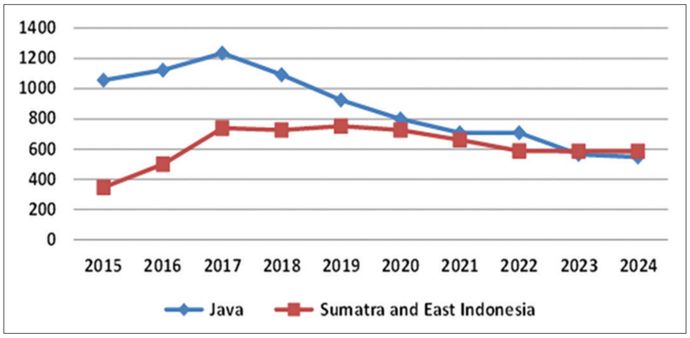
The main problem in gas utilisation in Indonesia power system is the insufficiency of natural gas sources for gas-fueled power plants. Oil is often used as a substitute for gas, but this leads to higher fuel costs. Also, the challenges in establishing gas supply in the future are due to the difficulties in setting up long-term gas contracts and the depletion of existing gas wells. Thus, there is a contradiction between the decline in future gas supplies for the PLN and the expectation that the future energy mix will have an increased role for gas power plants. Figure 7 shows the projected pattern of gas supply for Java and Sumatra and East Indonesia.

Another primary challenge in gas utilisation in Indonesia's electricity sector is the lack of pipeline infrastructure to transport natural gas from gas wells to power plants. Investment in gas infrastructure has been meagre, with the bulk of the network concentrated around Java and Sumatra Islands while gas resources are spread over the archipelago. The lack of gas pipeline and supporting infrastructure lead investors to sell gas to foreign countries usually at a higher margin than can be obtained by delivering to the Indonesian market. To tackle these challenges regarding servicing scattered load demands, PLN is pioneering the implementation of Marine CNG/LNG in the region to deliver gas supply to scattered gas-fired power plants.

Investment in LNG and CNG power plants aims to avoid the risk of failing to secure electricity supply by solely relying on pipeline gas source. There is a need for targeted efforts from the electricity regulators to overcome the problem of gas supply decline and lack of gas infrastructure. Although PLN has already established construction planning of the Trans-Java gas pipeline on Java Island, the plan does not accommodate gas transportation from gas well sources since the dominant gas resource is located not on Java Island. However, there is a commitment from Indonesian stakeholders to build floating storage and regasification unit (FSRU) LNG facilities in Sumatra and Java Islands to support the diversification policy. The facilities are Lampung FSRU in Sumatra Island to supply gas power plants in the Sumatra power system; West Java FSRU in Java Island to supply plants in the Java power system, and Arun Re-gas facility in Aceh Province to secure electricity supply especially in North Sumatra. However, it is likely that these arrangements will result in higher prices compared to pipeline gas.

PLN gives priority to peak load non-oil fuel to answer the high electricity demand, especially at night. However, due to

Figure 7: Total Gas Supply for PLN, 2015–2024 (PLN, 2015b)



the generation deficiency in the system, PLN is constrained to firing the diesel plant in peak load. The merit order[6] of peak load power plants in Indonesia's electricity system is based on price and operational flexibilities and is configured as follows. First, hydropower plants comprised of pumped storage and runoff river[7] power plant. Next, LNG and CNG gas-fueled power plants are considered and followed lastly by diesel power plants. The significance and benefits of CNG and LNG gas-fueled power plants accrue in conditions where there is uncertainty in field and pipe gas supply for combined cycle gas turbine (CCGT) power plants that lead to a decreasing role in filling the intermediate load. Subsequently, coal power plants switch roles from base load to intermediate load to substitute the CCGT role in the system. However, coal power plants are not flexible in adjusting the ramping rate to follow the load profile in the system and can cause severe power system problems.

Other approaches to gas monetisation by PLN are as follows. First, to meet electricity demand, especially in electricity deficit regions, PLN will continue to purchase gas supply from various sources, including buying natural gas in the form of marginal gas[8] and flare gas[9]. Next, PLN seeks to convert any surplus gas into CNG to add value by deriving a fuel source that offers flexibility in controlling gas utilisation according to the merit order. For power plants located near to gas sources, some marine CNG projects are now operating, and some are under development. For much longer distances with a higher volume of potential supply, marine LNG projects are high on PLN's priority. Thirdly, PLN is increasing mini LNG technology utilisation, mainly in eastern Indonesia where there is no pipeline infrastructure in the system. Lastly, to meet the target of additional 2000 MW gas-fired power plants per year to be assigned as peaking units, PLN is undertaking feasibility studies for a temporary solution for a midstream facility, i.e. LNG shuttle and LNG floating storage. Many logistics options are being explored for additional gas power plants at distributed locations. In this regards, some commercial schemes need to be assessed to comply with the cabotage law for offshore vessels enacted since December 2013 in Indonesia.

The investment decisions of PLN and the IPPs with which it contracts highly depend on the long-term gas contracts, fuel price and the capacity factor of the power plants. Capacity factor influences the rate of revenue from investment since increasing the load factor offers an opportunity to recover the capital cost of power plants more quickly. However, increasing capacity factor also increases fuel, operating and maintenance costs. It is important to note that the primary consideration of private companies in power plant investment is profit, which heavily depends on the long-term contract in fuel price and the economic life of power plant operation. On the other hand, PLN's consideration transcends profitability and focuses on securing the electrical energy needs of Indonesian consumers regardless of energy price.

The advantage to PLN of the availability of gas supply for gas-fueled power plants does not always extend beyond the peak load time. The power system operator faces difficulty in operating power plants due to the take-or-pay (TOP) clauses with contractors. Thus, to abide by these clauses, the power system dispatcher would sometimes have to fire up gas power plants in the morning and afternoon for filling intermediate and base loads instead of firing up it's cheaper coal power plants. TOP clauses require purchasers to pay for a contractually specified minimum quantity of gas, even if the purchasers do not utilise the gas or the delivery is not taken (Masten and Crocker, 1985). Thus, TOP clauses force PLN to incur additional costs by using more expensive gas instead of coal. If it chooses to run the coal power plants, it would still have to pay for unused gas, which leads to inefficiencies. The TOP contract delivers advantages for the company's suppliers regarding risk hedging on gas delivery and an incentive to prevent competitors supplying gas to PLN. Regarding long-term gas contracts design, a study by Masten and Crocker (1985) suggests an incentive to provide flexibility is an important consideration. It is crucial for PLN negotiators to critically set long-term gas contracts that are suitable for Indonesia's power system characteristics.

5. IMPLICATIONS AND CONCLUSIONS

Indonesia will experience high electricity demand growth in the future at a rate of approximately 8.5% per annum. Securing the electricity supply is essential to meeting this high growth in energy demand to support Indonesia's economic growth sustainably. Moreover, it is essential to building power plant infrastructure according to the schedule in the National Master Plan. Based on the future energy mix and the characteristics of gas power plants, gas monetisation plays a vital role in Indonesia's electricity system.

The importance of gas utilisation in Indonesia's power system is likely to increase in the future. PLN will be optimising CNG, LNG and mini LNG power plants to replace diesel power plants to meet load peaking power plant requirements. Modern gas generation

6 Merit order is the way an electricity utility company ranks the available sources of energy according to their marginal cost. Power plants with the lowest marginal cost are the first to come online in order to produce and deliver electricity.

7 Run off river power plant is a type of hydro power plant whereby no water storage is provided. The generation technology only relies on the water flow from the river in order to produce electricity.

8 This is gas from marginal fields i.e., oil or gas field that is not economically viable to produce oil or gas. However, such field could become commercially viable if technological and economic conditions change favourably. In the case of Indonesia, access and remoteness are usually the main issues for marginal field developments.

9 This is raw natural gas produced as associated gas when oil is produced from the well site. Where a country lacks or has inadequate gas infrastructure, such gas is usually flared thus resulting in waste and environmental pollution.

technologies such as CNG, LNG and mini LNG power plants are beneficial to electricity operators for adopting a merit order system (in which fuel sources are selected according to the least cost principle) for managing variability in load. Also, gas power plant projects deliver a quick return on investment with higher profitability compared to any other generation technologies.

The gas utilisation and power plant infrastructure need substantial investment by the Indonesian government and international investors. However, several main challenges could hold back investment in gas power plants. Firstly PLN experiences difficulties in securing gas supplies from various sources because the gas supply for gas power plants is insufficient and will likely continue to decline in the future. Also, the company has difficulty in purchasing long-term gas contracts since the gas suppliers are often already tied to long-term contracts with other parties. The situation is also exacerbated by depletion of existing gas sources. Although there are abundant gas sources scattered in the Indonesian archipelago, PLN may not be able to secure required gas supply due to the lack of gas infrastructure, i.e., pipelines for natural gas, FSRUs and other gas supporting facilities. Furthermore, gas contractors and investors would arguably prefer to export/sell natural gas to foreign countries because of low domestic gas prices and infrastructure problems.

From the preliminary review, it is apparent that PLN is increasingly and will need to continue applying energy and gas policies to resolve the above challenges. One of the critical policies is the development of LNG and CNG technology to replace diesel power plants and absorb surplus gas. Supported by the Indonesian, government, IPPs and subsidiary companies, PLN is developing gas infrastructure in the form of gas pipelines, FSRU, CNG and LNG power plants and marines. The COD of power plants construction are usually delayed, which affects the return of investment in the project. Furthermore, there is uncertainty in the long-term gas supply contract to PLN, which creates a long-term planning risk. A review of PLN's electricity generation plan and gas contract needs to be regularly carried out to minimise risk for international investors and to maintain consistency and continuity of plans. A sound and strict company policy regarding infrastructure construction and gas supply commitments are essential and fundamental.

Acknowledging that CNG and LNG power plant investment is mostly influenced by fuel cost and capacity factors, PLN should design suitable long-term gas contracts in the future. The capacity factor is subjective to power plant operation hours and is related to TOP contracts with the gas supplier. If the gas delivered through the TOP contract is higher than the gas amount needed by PLN's gas power plants, then PLN will incur massive losses. Hence, the long-term gas contract should be congruent with the fuel input demands of the power system and energy mix planning scenarios. In contrast, a TOP contract for a lower amount of gas than needed in the power system will force PLN into utilising more oil fuel to avoid load curtailment and load shedding, thus increasing fuel cost. Furthermore, gas monetisation projects are sensitive to fuel cost, which is mostly affected by fuel heat rate, fuel price (i.e., gas and oil price), and power plant efficiency. For this reason, the technical purchasing ability of PLN to procure gas supply at a low price and high heat rate to achieve high-efficiency gas power plants is essential.

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