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NATIONAL ENERGY COUNCIL

Indonesia Energy OUTLOOK 2017

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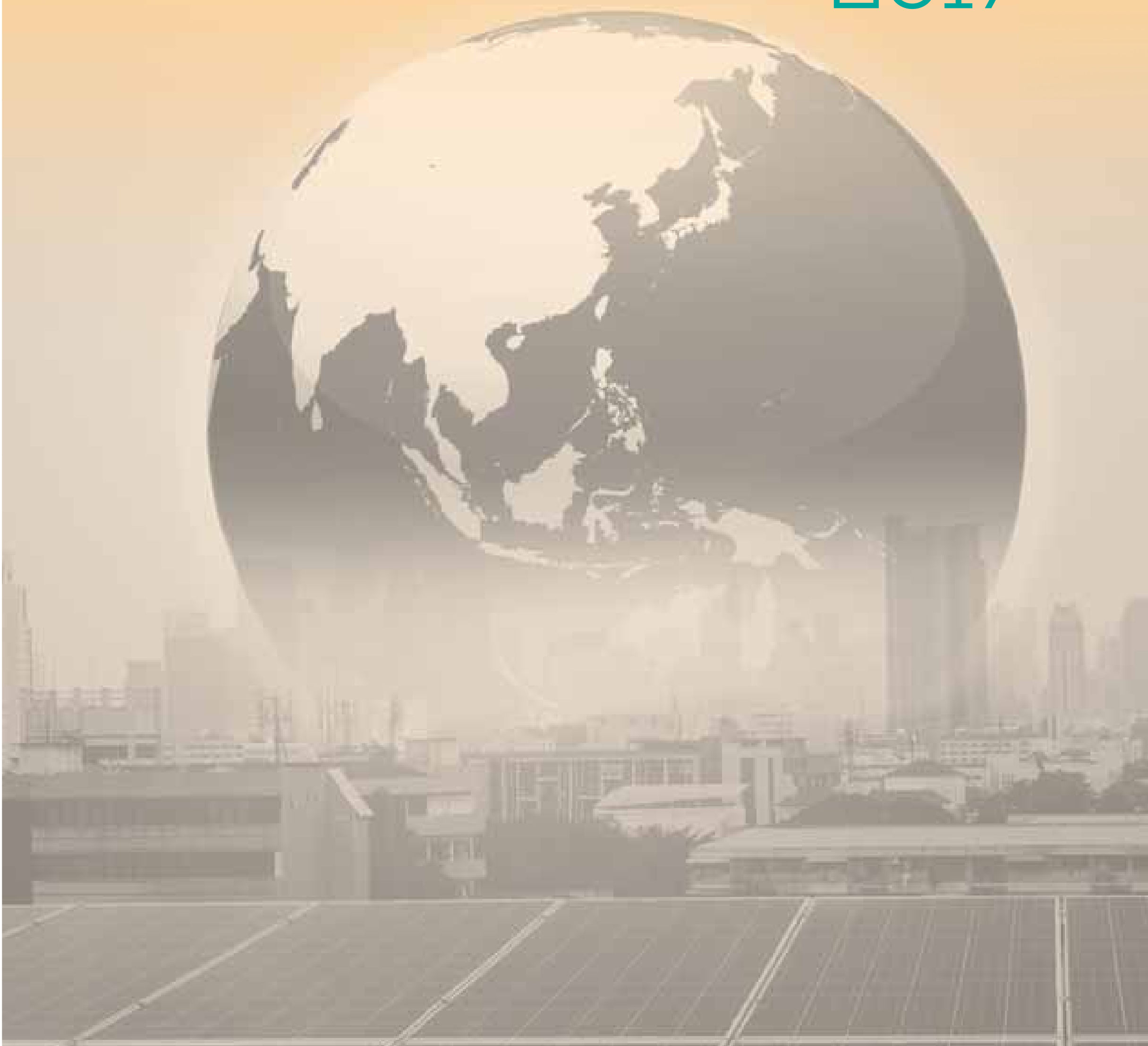

INTRODUCTION

Indonesia Energy Outlook (IEO) 2017 principally presents the energy demand and supply condition and projection in Indonesia in 2017-2050 based on 2016 data.

The focus in Indonesia Energy Outlook 2017 is the optimization of renewable energy potential utilization and the increase of efficiency especially in energy consumption side. The method used in IEO is LEAP (Long-range Energy Alternatives Planning System). Meanwhile, Balmorel model is used in the optimization on power supply side. Photovolatic (PV) penetration in the grid especially in Kupang and Gorontalo becomes the special topic in IEO 2017 and it is expected that it could be the pilot project for other areas.

This book is expected to be one of the references to find out the future energy demand and supply projection in Indonesia. This book also covers renewable energy utilization optimization and energy efficiency scenario to support the policy formulation and implementation as well as energy development in Indonesia.

Last but not least, we would like to convey our gratitude and appreciation to all related parties for the contribution to this book.

Jakarta, December 2017
Secretary General of National Energy Council

Saleh Abdurrahman

EDITORIAL BOARD

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We would like to convey our gratitude to all related parties for the inputs and suggestions in formulating Indonesia Energy Outlook:

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DISCLOSURE

Indonesia Energy Outlook (IEO) 2017 serves as an analysis and projection of the long term national energy demand and supply. The data in this IEO is derived from official publication, temporary data or data being updated continuously by the sources.

The material in this IEO contains energy demand and supply projection with certain assumptions which are developed for future energy scenario formulation. The assumption and projection include energy technology development based on current data and condition. Thus it is possible that there will be a change of dynamics on what being projected in this IEO.

LIST OF ABBREVIATION

BBN : Biofuel
BI : Bank of Indonesia
BOE : Barrel Oil Equivalent
BOPD : Barrel Oil per Day
BP : British Petroleum
bph : Barrel per hari
BPS : Statistic Indonesia Agency
BRT : Buss Rapid Transit
CBM : Coal Bed Methane
CCGT : Combined Cycle Gas Turbine
CdTe : Cadmium Telluride
CF : Capacity Factor
CIGS : Copper Indium Gallium (di) Selenide
CO2 : Carbon Dioxide
COD : Commercial of date
DME : Dimethyl Ether
EBT : New Renewable Energy
ESDM : Energy and Mineral Resources
FSRU : Floating Storage Regasification Unit
GDP : Gross Domestic Product
GHG : Greenhouse Gas
GRR : Grass Root Refinery
GW : Giga Watt
GWh : Giga Watt hour
HEESI : Handbook of Economy and Energy Statistic Indonesia
IEA : International Energy Agency
IMF : International Monetary Fund
IO : Operation Permit
IPCC : Intergovernmental Panel on Climate Change
IPP : Independent Power Producer
JTM : Jaringan Tegangan Menengah (Medium Voltage Network)
KBI : Kawasan Barat Indonesia (Western part of Indonesia)
KEN : National Energy Policy
KP : Kyoto Protocol
KS : Current Policy
kWh : Kilo Watt hour
LEAP : Long-range Energy Alternatives Planning

LED	: Light-Emitting Diode
LNG	: Liquified Natural Gas
LPG	: Liquified Petroleum Gas
LRT	: Light Rail Transit
LTSHE	: Energy Saving Solar Lamp
MMBTU	: Million Metric British Thermal Unit
MMSCF	: Million Standard Cubic Feet
MMSTB	: Million Stock Tank Barel
MPa	: Mega Pascal
MRT	: Mass Rapid Transit
MW	: Mega Watt
NDC	: National Determined Contributions
NEMA	: National Electrical Manufacturers Association
NRE	: New and Renewable Energy
OEE	: NRE Optimization and Energy Efficiency
OEI	: Indonesia Energy Outlook
ONWJ	: Offshore North West Java
Perpres	: Presidential Regulation
PLN	: Electricity State Company
PP	: Power Plant
PMK	: Minister of Finance Regulation
Polytam	: Polypropylene
PPU	: Private Power Utility
PSH	: Pumped-storage hydroelectricity
PTA	: Purified Terephthalic Acid
PV	: Photovoltaic
RDMP	: Refinery Development Master Plan
RE	: Renewable Energy
RIKEN	: National Energy Conservation Master Plan
RIPIN	: National Industry Development Master Plan
ROPP	: RCC Off gas to Propylene Project
RPJMN	: National Medium Term Development Plan
RUEN	: National Energy General Plan
RUPTL	: Electricity Supply Business Plan
SCADA	: Supervisory Control and Data Acquisition
SHS	: Solar Home System
TOE	: Tonnes of Oil Equivalent
TWh	: Tera Watt hour
TSCF	: Trillion Standard Cubic Feet
UC	: Ultra Critical
UNFCCC	: United Nations Framework Convention on Climate Change

USA : United States of America
USC : Ultra Super Critical
USD : United States Dollar

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TABLE OF CONTENTS

LIST OF PICTURES

LIST OF TABLE

EXECUTIVE SUMMARY

Indonesia Energy Outlook 2017 presents national energy supply and demand projection in 2017 to 2050 based on social assumption as well as economy and technology development in the future. IEO 2017 utilizes 2016 data as base year.

The energy demand and supply analysis is conducted based on LEAP (Long-range Energy Alternatives Planning System) and Balmorel calculation model. LEAP is an energy planning modeling application to take an integrated energy demand and supply analysis. Meanwhile, Balmorel is an energy planning modeling application for power especially in supply side with optimization approach.

Population growth, economic growth, energy price and technology development are the basic assumptions of these two scenarios which are developed to obtain an illustration of energy demand up to the year 2050. Besides these four basic assumptions, additional assumptions related to a number of energy policies are also used.

IEO 2017 uses 2 scenarios for the projection period of 2017 to 2050 namely Current Energy Policy (KS) scenario with basic assumption of Gross Domestic Product of 5.6% in average per year, energy mix target as in National Energy Policy (KEN), National Energy General Plan (RUEN), National Industry Development Master Plan (RIPIN), and emission reduction target as in National Determined Contribution (NDC). The second scenario is NRE Optimization and Energy Efficiency scenario (OEE) with basic assumption of Gross Domestic Product of 5.6% in average per year, higher biofuel share than in national biofuel roadmap, higher quantity of electric vehicle in transportation than in RUEN, and higher efficiency in industry than in KS scenario.

Based on analysis, primary energy supply without traditional biomass will reach 283 million TOE for KS scenario and 261 million TOE for OEE scenario in 2025. In 2050, it increases into 708 million TOE for KS and 495 million TOE for OEE. The NRE share in energy mix in 2050 scenario of KS and OEE is 31% and 48%, respectively. Meanwhile, national final energy demand in 2025 based on KS and OEE scenario will reach 184 million TOE and 171 million TOE. Final energy demand in 2050 in the same scenario is 433 million TOE for KS and 280 million TOE.

Power Plant Capacity in 2050 in two scenario which is dominated by coal and gas. In 2050, total capacity of power plant increase into 402 GW (KS) and 285 GW (OEE), where NRE power plant starts dominate the two scenario with share 51% (KS) and 67% (OEE).

Secretariat General

National Energy Council

CHAPTER I
INTRODUCTION

Indonesia Energy OUTLOOK 2017

I INTRODUCTION

The publication of IEO 2017 follows the situation and condition of energy development as well as current regulation and policy especially after the stipulation of Presidential Regulation number 22 of 2017 on National Energy General Plan.

The purpose of IEO 2017 publication is to present national energy condition especially the demand and supply projection in 2017-2050. IEO 2017 can be used as a reference and input for policy makers and stakeholders in future energy planning.

For modelling, IEO 2017 uses 2016 base year. IEO 2017 is developed in two scenarios namely Current Policy scenario (KS) and NRE Optimization and Energy Efficiency scenario (OEE). KS scenario covers the stipulated policies including RUEN, while OEE scenario is KS scenario with optimization on NRE penetration and energy efficiency.

The energy demand and supply projection modelling uses Long-range Energy Alternative Planning System (LEAP) software dan Balmorel System especially for electricity.

The main focus in Indonesia Energy Outlook 2017 is optimization of new and renewable energy with Gross Domestic Product (GDP) realistic growth assumption of 5.6% per year which is the same or close to Bank of Indonesia's projection.

This year's edition will also discuss special topic on solar power plant penetration especially solar PV into regional grid in 5 MW Kupang Solar PV and 2 MW Gorontalo Solar PV case study. The result of this case study is expected to be the reference and example in developing Solar Power Plant in other areas in Indonesia.

The main data source in IEO 2017 is Handbook of Economy and Energy Statistic Indonesia (HEESI) 2016, RUPTL 2017-2026, Statistic Indonesia, as well as data from Kupang and Gorontalo Solar PV. For power plant technology data, it uses data sources from Technology Data for Indonesia Power Sector (Katalog Teknologi Pembangkit Indonesia/ Indonesia Power Plant Technology Katalog) formulated by Secretariat General of National Energy Council in cooperation with the Government of Denmark.

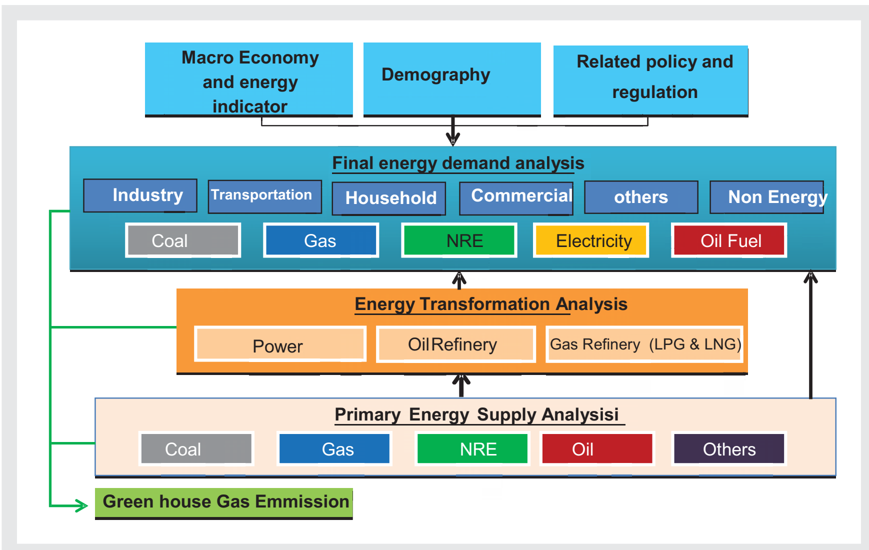
CHAPTER II
METHODOLOGY

Indonesia Energy OUTLOOK 2017

II METHODOLOGY

2.1 Framework Analysis

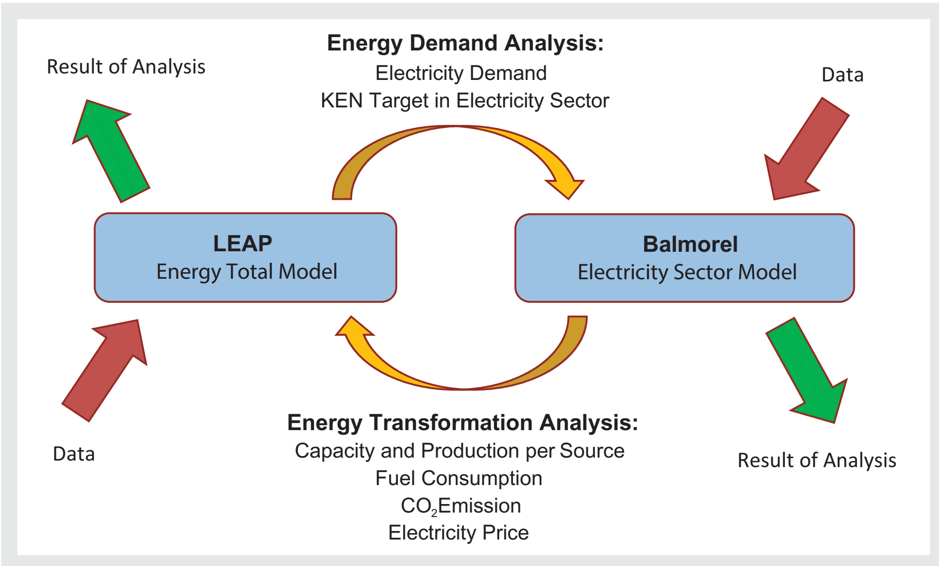
The analysis is divided into three stages namely analysis on energy demand, energy transformation, and energy supply. Besides sectoral condition such as activity, technology and intensity, the energy supply and demand projection requires inputs on roadmap, strategic planning and existing energy regulation. Assumption on macro economy indicator condition such as GDP, demography, energy price and technology penetration is also needed as the main energy demand driver. The framework analysis of Indonesia Energy Outlook 2017 is shown in Picture 2.1.



Picture 2.1 Framework Analysis of Indonesia Energy Outlook 2017

The energy supply and demand analysis is conducted based on calculation of LEAP and Balmorel model. LEAP is a simulation model in energy planning which can conduct an integrated energy supply and demand analysis, while Balmorel is an energy supply planning with partial equilibrium model to analyze electricity sector in international perspective. Balmorel is implemented to count optimum investment to meet electricity demand and targets in policy. In IEO 2017, Indonesia electricity demand is divided into 34 provinces. Each province implements electricity demand growth assumption data per year, load curve characteristic per hour and limitation on implemented technology as well as transmission capacity demand.

The relation between LEAP and Balmorel in counting energy demand is shown in Picture 2.2.



Picture 2.2 LEAP and Balmorel Synergy

2.2 Energy Projection Scenario

Statistics Indonesia shows that Indonesia economy real growth in 2014, 2015, and 2016 is 5.01%, 4.88% and 5.02%. Indonesia economic growth prediction in 2017 is about 5.3% or still below 6% as stipulated in RPJMN (National Medium Term Development Plan) 2015-2019. This has become one of the considerations in formulating long term Indonesia energy demand scenario since statistically every economic growth comes together with energy demand growth.

Indonesia Energy Outlook 2017 developes two scenarios namely Current Policy scenario and NRE Optimization and Energy Efficiency scenario with GDP growth assumption of 5.6% in average.

Current Policy (KS) scenario which uses basic assumption of annual average real GDP growth of 5.6% in 2017-2050. This assumption is based on 2015 IMF and World Bank review which says that Indonesia economic growth until 2020 is around 6% per year. This scenario also uses energy mix target assumption of KEN (National Energy Policy), RUPTL (Electricity Supply Business Plan), RUEN (National Energy General Plan), RIPIN (National Industry Development Master Plan), and target of emission reduction based on National Determined Contribution (NDC).

NRE Optimization and Energy Efficiency (OEE) scenario which uses the same GDP with the first scenario. Besides this basic assumption, the second scenario uses higher share of biofuel than the share in national biofuel roadmap, more quantity of electrical vehicles in transportation sector than in RUEN, higher efficiency in the industry, and the priority to implement new technology in power plant such as super and ultra critical (UC) in Steam Fueled Power Plant, pump storage, battery, and power plant from NRE such as waste to energy processing technologies.

2.3 Modelling Assumption

The main driving factor in energy demand increase to be considered in Indonesia Energy Outlook 2017 includes population growth, economic growth, energy price, and technology development. These four factors become the basic assumptions from the two developed scenarios to obtain an overview on energy demand until the year 2050. Besides these four basic assumptions, there are also additional assumptions as presented in Table 2.1.

2.3.1 Population Growth

Population growth highly influences energy demand volume and composition, both directly and indirectly from its impact to economic growth. In the last two decades, Indonesia population growth rate tends to decline. Based on Indonesia population projection publication year 2010 to 2035 (Statistics Indonesia 2014), Indonesia population growth declined from 1.4% in 2010 to 0.6% in 2030. The growth rate in 2030 to 2050 is assumed to be constant at 0.6% per year. Thus, it is predicted that Indonesia population will be 335 million in 2050.

Due to the difference in energy consumption pattern between urban and rural residents, the urbanization rate indicator has been very important in obtaining a more accurate energy projection. The urbanization rate also follows Statistic Indonesia projection in which urban residents reaches 53% in 2016 and continues to increase up to 70% in 2050.

If it is assumed that the average family member is 3.84 in 2016 and gradually decreases into 3.54 in 2050, then the number of household will grow from 66.5 million households into 94.7 million households in the same period.

2.3.2 Economic Growth

Energy demand is closely related to economic activity. GDP growth assumption will be very sensitive toward energy projection from the two developed scenarios.

Indonesia economic growth in the last five years tends to decline. It is due to the slowing global economic growth, the low commodity price including oil, the slowing global trade, and the reducing capital rate. Besides that, the weakening investment growth and Indonesia's export also contribute to the current economic condition. However, the high resistance domestic expenditure, the government's commitment to conduct economic deregulation and investment licensing simplification are also expected to support future growth. With the previously explained GDP and population growth assumption, Indonesia GDP per capita in 2050 will increase into IDR 183 million.

2.3.3 Technology

The developed and applied energy technology in supply and demand side will influence the investment decision, as well as future energy demand rate and composition. Thus, energy projection in this Energy Outlook is highly influenced by energy technology development. Power plant technology refers to Technology Data for the Indonesian Power Sector: Catalogue for Generation and Storage of Electricity.

A number of technologies have its role in determining future energy demand rate especially environmentally friendly and efficient technology such as ultra and supercritical technology for steam power plant technology. The supercritical power plant technology is the technology with supercritical boiler and 22-24 Mpa pressure, steam temperature of 560^{o}C, and 45% efficiency. Meanwhile, ultra-supercritical boiler is operating at 26 Mpa, steam temperature above 700^{o}C, and efficiency close to 50%.

Pump storage power plant utilizes two reservoirs, namely lower and upper reservoir. Under the condition of low power load, the power excess will be used to pump the water from upper reservoir to lower reservoir. Meanwhile, under the condition of peak power load, the water in the upper reservoir will be flowed to lower reservoir to spin the turbine and produce power.

Considering the trend of sharp declining solar PV price and the development of a more resistance storage or baterry technology, the utilization of solar energy into Solar PV becomes an interesting option. Indonesia is gifted with high exposure of sunlight that can be utilized to supply reliable and cheap energy for remote areas with high dependency on oil fuel. Thus, it is expected that in the future, domestic solar PV industry could take this opportunity to increase the national economy.

Energy efficiency technology is implemented in all economic sectors including industry, households, commercial and transportation. The impact of energy saving technology implementation toward energy demand is quite significant.

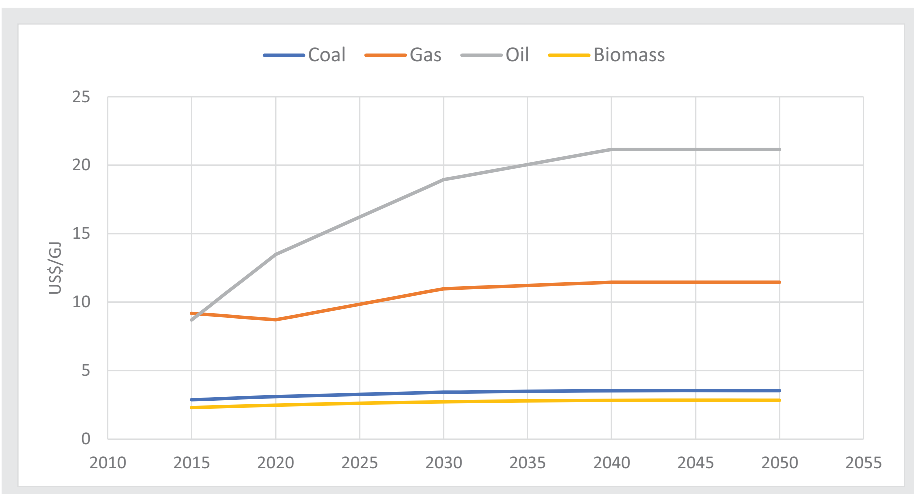
In waste to energy, the considered technologies are landfill gas production, incinerator, thermal gasification, and anaerobic digestion. Landfill gas is the mixture of methane and carbon dioxide with other gas components. This gas is produced naturally from the decomposition of organic substances in landfills into 60% methane. Incinerator is a waste treatment technology that involves combustion in high temperature to produce electricity.

2.3.4 Energy Price

Energy price is a determining factor in energy demand trend. Energy price paid by consumer will influence the choice of technology and devices to meet the energy demand. From supply side, energy price will influence the production and investment decision from the chosen technology.

Since the mid 2014, oil and gas price has been declining sharply of more than 60% due to the increasing production of alternative fuel such as shale oil and shale gas. Meanwhile, Organization of Petroleum Exporting Countries decided not to reduce its production. In Indonesia Energy Outlook 2017, energy price is assumed to be the same for all scenarios. With the consideration that energy is still a strategic commodity, the price for all energy sources in projection period is assumed to increase with variety of growth depending on current energy source price development.

Based on South East Asia Energy Outlook by International Energy Agency (IEA) in 2015, the price is assumed to increase by 0.6% per year for coal and biomass, 0.6% per year for gas, and 2.6% per year for diesel oil and fuel oil for the period of 2015 to 2050 (Picture 2.3).



Source: South East Asia Energy Outlook, IEA 2015

Picture 2.3 Energy Price Assumption

Table 2.1 shows a complete basic and additional assumption used in Indonesia Energy Outlook 2017 for all scenarios.

Table 2.1 Basic Assumption and Additional Assumption

<table>
<tr><th>Num</th><th>Current Policy Scenario</th><th>NRE Optimization and Energy Efficiency Scenario</th></tr>
<tr><td colspan="3">Basic Assumption</td></tr>
<tr><td>1</td><td colspan="2">Annual GDP growth rate of 5.6%</td></tr>
<tr><td>2</td><td colspan="2">Energy Price for each energy source based on World Energy Outlook 2015, IEA</td></tr>
<tr><td>3</td><td colspan="2">Population growth rate based on Indonesia population projection by Statistic Indonesia</td></tr>
<tr><td colspan="3">Additional Assumption</td></tr>
<tr><td>1</td><td colspan="2">Resources or energy reserves assumption based on RUEN:
- Oil and Gas, 100% reserves and 50% resources
- Coal, 80% reserves and 50% resources
- Geothermal, 60% resources, only medium and high temperature (> 150°C)
- Hydro resources assumption and potential (95 GW)
- Biomass waste, 60% resources
- Biofuel, 60% resources
- Development potential of solar power (207 GW), wind (60 GW), and tidal (17 GW)</td></tr>
<tr><td>2</td><td colspan="2">Electrification ratio reaches 100% by 2020</td></tr>
<tr><td>3</td><td colspan="2">The utilization of kerosene in the households is only until 2018. It will be replaced by LPG, gas, electricity, biomass, dymethil ether and biogas.</td></tr>
<tr><td>4</td><td colspan="2">The energy saving which reflects the implementation of policy or regulation on aggresive energy conservation and efficiency.</td></tr>
<tr><td>5</td><td>NRE power plant development by considering all government's policy and program as well targets including Strategic Planning, roadmap, KEN and RUEN</td><td>NRE power plant development by considering emission target referring to decarbonization</td></tr>
<tr><td>6</td><td colspan="2">To meet the target of power plant energy mix, the thermal-based power plant uses technical efficiency depending on type of technology while NRE power plant is based on efficiency assumption in RUEN:
- Geothermal Power Plant of 20%
- Hydro of PLT 33%
- Tidal Power Plant, Solar Power Plant and Wind Power Plant of 25%</td></tr>
<tr><td>7</td><td colspan="2">The utilization of diesel in industry is entirely replaced by biodiesel (B30) after 2025</td></tr>
<tr><td>8</td><td>Biosolar and bioethanol utilization based on biofuel road map</td><td>Biosolar utilization 30% start 2025-2050 and bioethanol increase start 20% in 2025 and 85% in 2050.</td></tr>
<tr><td>9</td><td colspan="2">Gas for transportation increases up to 10% for private vehicles and 20% for public transportation until 2050</td></tr>
<tr><td>10</td><td>The utilization of electric car of 1% from the entire passenger car in 2025 and 10% in 2050, and electric motor cycle of 5% from the entire motor cycle in 2025 and 20% in 2050, to meet the energy mix in RUEN</td><td>The utilization of electric car of 6% from the entire passenger car in 2025 and 25% in 2050, and electric motor cycle of 9% from the entire motor cycle in 2025 and 50% in 2050</td></tr>
</table>

Table 2.1 Basic Assumption and Additional Assumption

Num	Current Policy Scenario	NRE Optimization and Energy Efficiency Scenario
11	There is a shifting in transportation mode up to 15% of total vehicle production until 2050 from passenger car and motor cycle to bus and train and from truck to train	
12	Oil refinery capacity until 2025 is adjusted to RUEN assumption	
13	Gas production is assumed to decline 0.7% per year in average until 2050 from its current production	
14	Oil production is assumed to decrease 3.2% per year until 2050.	
15	Coal production is maintained at constant rate of 400 million ton starting in 2019, but it is assumed to increase when domestic consumption exceeds production	
16	Power plant development in RUPTL 2017-2026 in construction process (construction and feasibility study) is taken into account in power plant supply assumption.	

CHAPTER III
CURRENT CONDITION

Indonesia Energy OUTLOOK 2017

III CURRENT CONDITION

3.1 Energy Balance

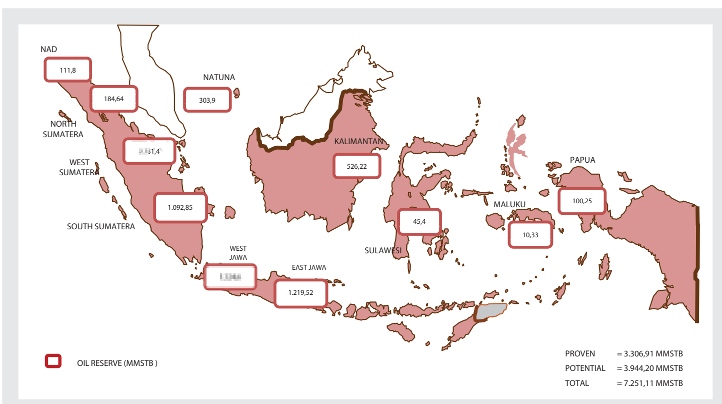
Energy balance is an illustration of sectoral energy supply and demand balance. The energy balance is illustrated in an energy system which includes production and transformation to the end user.

Indonesia total primary energy production (coal, gas, oil and NRE) in 2016 was 445.5 million TOE in which 246.4 million TOE was exported abroad. In the same year, Indonesia imported energy of 47.6 thousand TOE. Coal and LNG were the most exported commodity, while crude oil, fuel and LPG were the highest imported commodities. From this condition, Indonesia primary energy supply in 2016 was 215.8 million SBM including stock change (excluding traditional biomass). Indonesia energy export in 2016 reached 57% from total energy production. Meanwhile, energy import reached 22% from total primary energy supply in the same period.

The total final energy consumption in 2016 was 145.2 million TOE. Transportation was the biggest consumer followed by industry, household, non energy, commercial and other sectors (agriculture, construction, and mining).

3.2 Oil

National oil reserve per 1 January 2016 both proven and potential reserve decreased 0.7% compared to the previous year. Oil potential reserve in 2016 was 3.94 billion barrel, while proven reserve was 3.31 billion barrel.



Source: DG of Oil and Gas, 2016

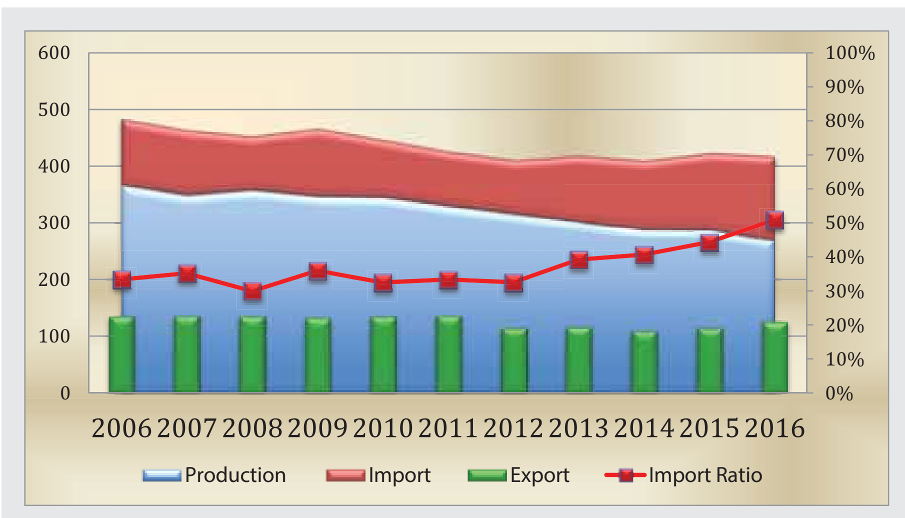
Picture 3.1 Oil Resources 2016

The oil reserve distribution is mostly located in Sumatera reaching 56% from total national oil reserve and the followed by Java reaching 35% and Kalimantan reaching 7%. Meanwhile, the rest of the reserve is found in Papua, Maluku and Sulawesi (Picture 3.1).

According to RUEN there is 5.2 billion barrel of oil and gas reserve potential from the discovery to be considered as additional in oil and gas reserve in 2016 and oil and gas resources potential of 16.6 billion barrel from early exploration. However, it requires further testing.

Meanwhile, Indonesia oil reserve share is only 0.2% from the total world oil reserve. On the other hand, fuel consumption rate as processing product continues to increase. The development of oil production in the last 10 years has shown a decline from 367.05 million barrel or 1 million barrel per day in 2006 into 268.877 million barrel or 737 thousand barrel per day in 2016. The production decline occurred due to the mature oil production wells while new production wells are still relatively limited.

The domestic oil fuel consumption increase and oil production decline have caused the declining oil export. Conversely, crude oil and fuel import keeps increasing. This can be seen in the increase of import dependency ratio with the average ratio of 35% in 2007 into 51% in 2016. It indicates that Indonesia is susceptible to global condition change which can influence the national energy security due to the high dependency on supply from abroad (Picture 3.2)



Source: Ministry of Energy and Mineral Resources processed by Secretariat General of National Energy Council, 2017
Note: Import Dependency Ratio = Import divided by domestic supply (Production+Import-Export)

Picture 3.2 Trend of Oil Import Dependency

The increasing fuel consumption which is not followed by the increasing production due to the stagnant refinery production capacity has caused the increase of crude oil import and the decrease of export. Thus, the development of fuel refinery is unavoidable solution.

In the end of 2015, the government revised Government Regulation number 79 of 2010 on operation cost as cost recovery and taxation in oil and gas upstream business. The revision is aimed to create a more attractive oil and gas upstream industry in the midst of global competition and the declining crude oil price. The revisions are the tax Incentives in exploration and exploitation period (import VAT, duty free, sales tax, property tax, income tax-free on cost sharing).

In supply side, the national fuel demand is fulfilled from domestic production and import. Fuel production increased from 235.7 million barrel in 2010 to 260.5 million barrel in 2016, while import was fluctuating from 163.8 million barrel in 2010 to 143.1 million barrel in 2016 (Table 3.1).

Table 3.1 Fuel Production and Import 2010-2016

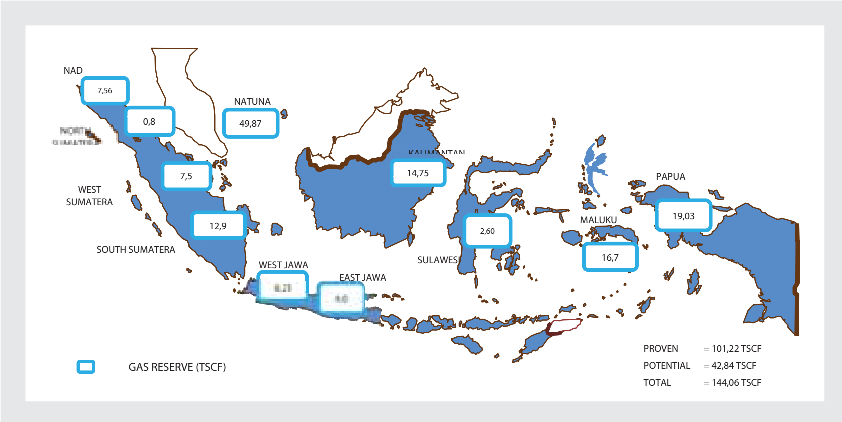
Year	Fuel Production (Million Barrel)		Fuel Import (Million Barrel)
	Fuel	Non Fuel	
2010	235.7	85.8	163.6
2011	237.1	104.2	195.9
2012	240.3	111.9	201.1
2013	237.5	85.2	205.6
2014	245.5	97.1	209.0
2015	248.8	80.68	175.4
2016	260.5	73.5	143.1

Source: Ministry of Energy and Mineral Resources. 2016

In 2016, 67% of domestic consumption of LPG was fulfilled from import. The success of conversion program of kerosene to LPG has resulted in significant increase of domestic consumption of LPG while LPG supply and refinery in the country is still limited. This condition should to be anticipated since 3 kg LPG subsidy is increasing. The current 3 kg LPG selling price is IDR 4,250 per kg and the government has allocated subsidy of IDR 5,750 per kg. Thus, the subsidy of 3 kg LPG in 2016 has reached IDR 25 trillion.

3.3. Gas

The total national gas reserve in 2016 was 144.06 TSCF consisting of 101.22 TSCF of proven reserve and 42.84 TSCF of potential reserve (Picture 3.3).



Source: Directorate General of Oil and Gas. 2015

Picture 3.3 Gas Resources 2016

Compared to the previous year, the national gas reserve decreased 4.8%. Gas production in the last ten years is relatively fluctuating with the production rate around 3 million MMSCF per year. Gas is used to meet the demand of industry, power generation, city gas, gas lift and reinjection. In addition, gas is also used as an export commodity in the form of LNG and piped gas. Gas export through pipeline and LNG reached almost half of total production. However, in the last five years, the export has been declining and reaching 40% in 2016 (Picture 3.4).

Source: Ministry of EMR processed by Secretariat General of National Energy Council, 2016
Note: Export Ratio = Export divided by Production

Picture 3.4 Trend of Gas Production and Export

On the other hand, domestic gas consumption in the last few years has shown an increase from 43% in 2006 to 60% in 2016 along with the increasing gas utilization in industry and power plant.

On 3 May 2016, President Joko Widodo has signed a Presidential Regulation number 40 of 2016 on Gas Price Stipulation which regulates gas price in upstream and certain industry as the effort to drive economic growth and increase national industry competitiveness. Based on this Presidential Regulation, if gas price is higher than USD 6 per MMBTU, Minister of Energy and Mineral Resources may stipulate certain gas price for fertilizer industry, petrochemical industry, oleochemical industry, steel industry, ceramic industry, glass industry and gloves industry.

3.4 Coal

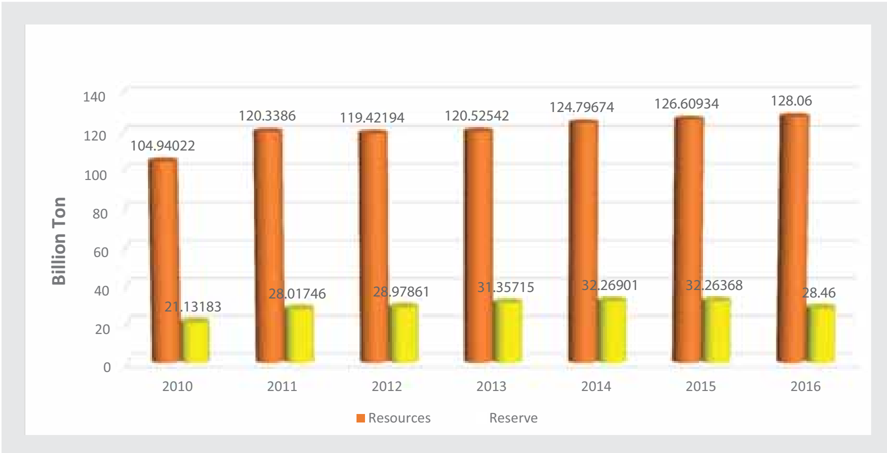
Indonesia coal production is predicted to increase not only to meet domestic demand but also to meet export. Indonesia coal resources until 2016 were 128 billion ton while coal reserves reached 28 billion ton. Coal resources and reserve is dominated by low to medium rank coal (Table 3.2)

Table 3.2 Coal Quality, Resources and Reserve 2016

Quality	Resources (Billion Ton)					Reserve(Billion Ton)		
	Hypothetic	Predicted	Proven	Measured	Total	Predicted	Proven	Total
Low Calorie	0.59	0.11	15.91	16.42	33.03	7.11	7.12	14.23
Middle Calorie	3.3	0.27	19.82	20.36	43.75	3.57	6.84	10.41
High Calorie	0.59	0.39	2.48	2.8	6.26	0.54	2.77	3.31
Very High Calorie	0.002	0.17	0.74	0.6	1.512	0.26	0.24	0.5
Total	4.482	0.94	38.95	40.18	84.552	11.48	16.97	28.45

Source: MEMR, 2016
Note:
Quality based on calories class (Presidential Decree number 13 year 2000 amended by Presidential Regulation number 45 year 2003)
a. Low Calorie < 5100 kal/gr
b. Medium Calorie 5100 – 6100 kal/gr
c. High Calorie > 6100 – 7100 kal/gr
d. Very High Calorie > 7100 kal/gr

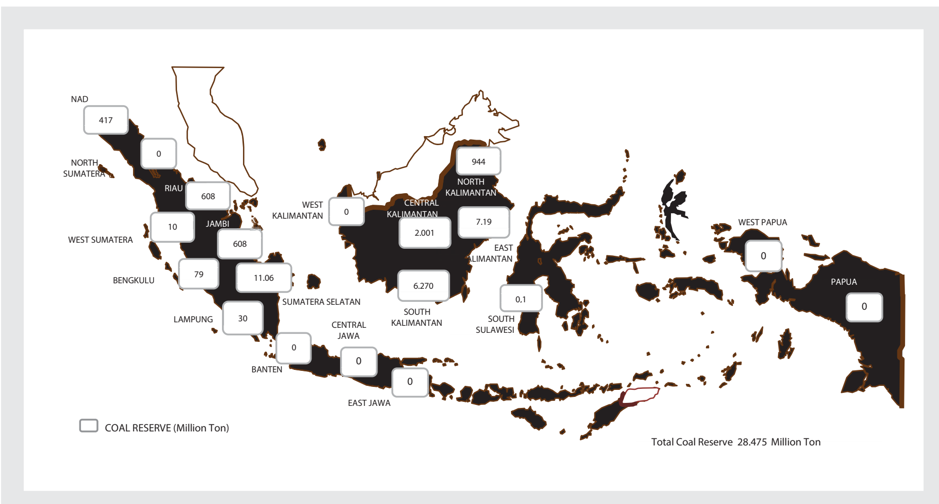
Compared to in 2015, there was a decline of 3.8 billion ton of coal reserve in 2016 as seen in Picture 3.5.



Source: HEESI, 2017

Picture 3.5 Coal Resources and Reserve Year 2010-2016

From the total coal resources and reserve, around 50% is located in Sumatera, 49.5% is located in Kalimantan, and the rest is spread in other islands as shown in Picture 3.6.



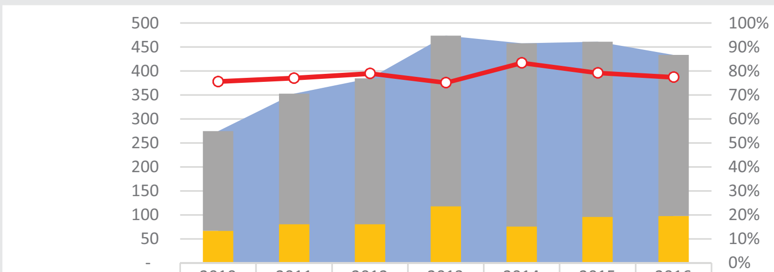
Source: Geological Agency of MEMR, 2017

Picture 3.6 Indonesia Coal Reserve 2016

Coal reserve is mostly located in Kalimantan and Sumatera, while its consumer which uses coal for power plant is mostly in Java. Thus, it needs infrastructure to distribute coal such as port, coal stockpiling, and land transportation especially train and truck.

Coal production development 2010-2016 increases significantly of about 7% per year with production realization in 2016 of about 434 million ton. The increasing coal production is influenced by increasing export and domestic demand. Indonesia coal export is mostly to meet the demand in China and India. Indonesia is the fifth major coal producer in the world after China, USA, Australia, and India based on BP Statistical Review of World Energy 2017.

From the total national coal production, the share of exported coal in 2016 was around 60% and the rest was allocated to meet domestic demand. It shows that coal utilization is still dominated by export since the domestic use is still low compared to its production (Picture 3.7).



	2010	2011	2012	2013	2014	2015	2016
Production	275	353	385	474	458	461	434
Export	208	272	304	356	382	365	336
Domestic	67	81	81	118	76	96	98
Export Ratio	75.6%	77.1%	79.0%	75.1%	83.4%	79.2%	77.4%

Source: MEMR, 2017.

Picture 3.7 Realization of Coal Production and Trend Export 2010-2016

In 2016, domestic coal consumption was 90 million ton in which 77% of it (75.4 million ton) was utilized by Steam Power Plant and the rest was for steel industry, cement industry, pulp and paper industry, and other industries.

3.5 New and Renewable Energy

a. New and Renewable Energy Potential

The declining fossil energy potential especially oil and gas as well as the international commitment in reducing emission have encouraged the government to put RE particularly renewable energy as the main priority to maintain energy security and independence. Indonesia has huge potential of NRE to be the source in national energy supply in the future. In Government Regulation number 79 of 2014 on National Energy Policy, the target of renewable energy mix is 23% by 2025 and 31% by 2050. The renewable energy potential is shown in Table 3.3.

Table 3.3 Renewable Energy Potential

Energy Source	Resources	Installed Capacity	Utilization (%)
Hydro	94.3 GW	5.1 GW	5.4%
Geothermal	29.5 GW	1.6 GMW1	5.4%
Bioenergy	32.6 GW and 0.2 million bph BBN	1.7 GW	5.2%
Solar energy	207.8 GWp	0.085 GWp	0.04%
Wind	60.6 GW	1.1 MW	0.002%
Ocean energy	17.9 GW		

Beside the energy in the above table, Indonesia also has new energy potential such as 574 TSCF of shale gas and 456.7 TSCF of CBM which currently are not yet developed. The NRE potential spread per Province refers to RUEN document.

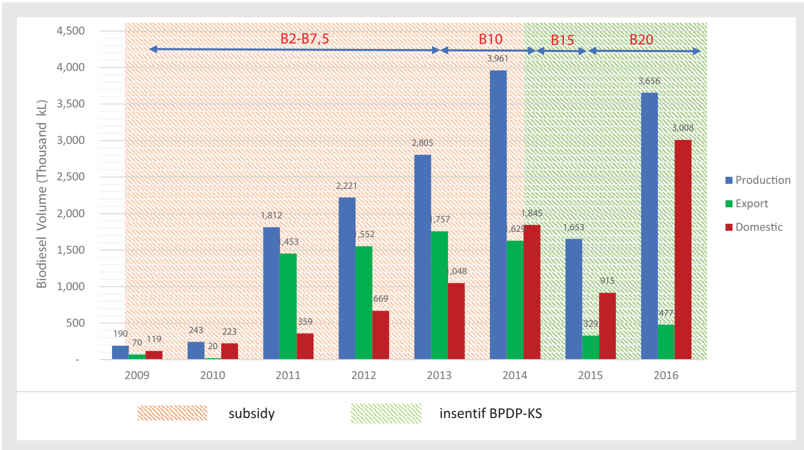
b. New and Renewable Energy Utilization

In total, RE potential in Indonesia is around 441.7 GW, but only 2% or 8.8 GW is utilized. Meanwhile, the total capacity of power plant both fossil and non fossil in 2016 was 59.7 GW. Thus, NRE power plant capacity contributes only 15% of the current power plant capacity. NRE is mostly utilized for power plant, while other NRE resources such as biofuel and biogass are used as fuel in transportation, household, commercial and industry.

Until 2016, the biggest installed capacity from renewable energy power plant was derived from hydro power including hydro power plant, mini hydro power plant, and micro hydro power plant of around 5.1 GW. Geothermal development is now reaching 1.65 GW or around 5.4% from the total resources, while wind power plant is reaching 1.1 MW. Biomass power plant is now producing 1.7 GW (excluding traditional biomass), but its development is mostly off grid. Another NRE potential utilization is solar power which is still relatively low and spread in all areas in Indonesia.

The low utilization of NRE-based power generation is due to the high RE power plant production cost. Thus, it is difficult to compete with fossil fuel power plant especially coal which does not count externality cost. Besides that, issues on electricity price negotiation, far located-demand, and lack of support to domestic industry concerning renewable energy power plant and power plant components have contributed to the slow development of RE.

NRE, especially biodiesel, is also utilized in transportation. Biofuel mandatory policy says that the mix of biofuel in fuel in transportation sector should reach 20% (B20) by 2016. Biodiesel production, export and utilization are seen in Picture 3.8.



Source: DG of NREEC

Picture 3.8 Biodiesel Utilization

c. NRE Supporting Policy

To accelerate the development of NRE, the Government has enacted several key policies including:

1. Presidential Regulation number 4/2016 on Electricity Infrastructure Acceleration;

   Article 14 states that the acceleration in power infrastructure should prioritize the utilization of new and renewable energy. The Central Government and/or Regional Government may give support in the form of fiscal incentive, simplification in permits or non permits, power purchasing price stipulation from each new and renewable source, the establishment of business entity to supply power to PT PLN (Persero), and/or subsidy.

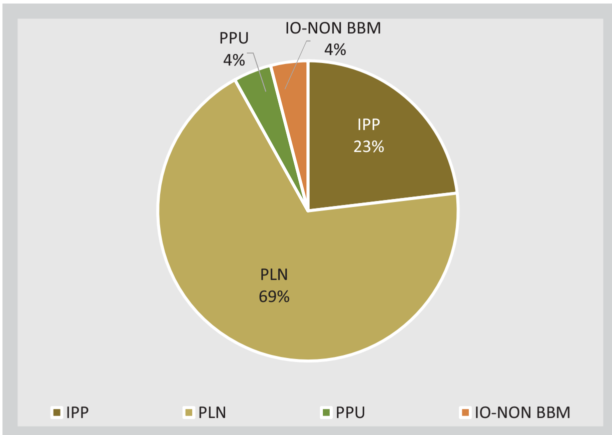
2. Minister of Finance Regulation on fiscal and non fiscal incentive on NRE development. One of them is Minister of Finance Regulation number 177/PMK.011/2007 on Duty Free for Imported Goods in Oil and Gas Upstream Business and Geothermal.

3. Minister of Energy and Mineral Resources Regulation number 49 of 2017 as the refinement of Minister of Energy and Mineral Resources Regulation number 10 of 2017 on Principles in Power Sales and Purchase Agreement.

4. Minister of Energy and Mineral Resources Regulation number 50 of 2017 as the revision of Minister of Energy and Mineral Resources Regulation number 12 of 2017 on Renewable Energy Utilization for Power Supply. This regulation is issued to create a better investment climate by promoting efficiency and affordable electricity price.

3.6 Electricity

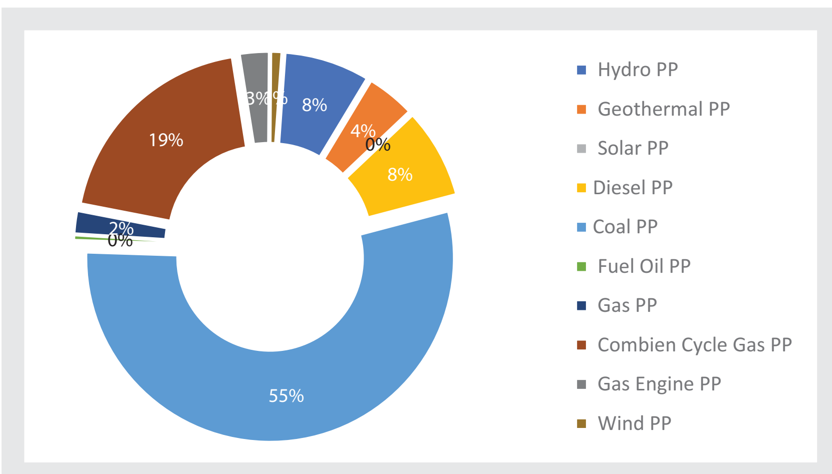
Installed power generation capacity in Indonesia reached 59.7 GW in 2016 which was dominated by fossil energy (85%) especially coal. Most power plants are operated by PLN reaching 41 GW, while the rest 13.7 GW is operated by IPP. Meanwhile, Private Production Utility (PPU) produces 0.24 GW and non-fuel Operation Permit (IO) produces 0.24 GW and 0.23 GW (Picture 3.9).



Source : HEESI,2017

Picture 3.9 Power Plant Capacity 2016

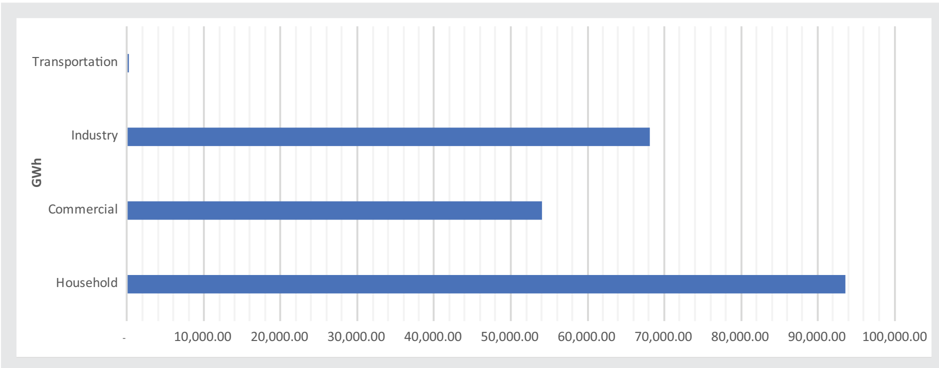
In 2016, power plant production reached 247.918 GWh derived 55% from coal, 26% from gas, 7% from fuel and 19% from NRE. The detail is shown in Picture 3.10.



Source : HEESI,2017

Picture 3.10 Electricity Production by Energy 2016

Electricity from PLN and non PLN which is already connected to PLN network (on grid) is distributed to consumer. The biggest consumer is household, followed by industry, commercial and transportation as seen in Picture 3.11.



Source : HEESI,2017

Picture 3.11 Electricity Sale 2016

CHAPTER IV
CURRENT POLICY SCENARIO

Indonesia Energy OUTLOOK 2017

IV CURRENT POLICY SCENARIO

4.1 Final Energy Demand and Primary Energy Supply

As explained earlier, current policy (KS) scenario is a scenario which uses several government's energy policies including electricity, economy, industry, transportation, household, commercial and environment.

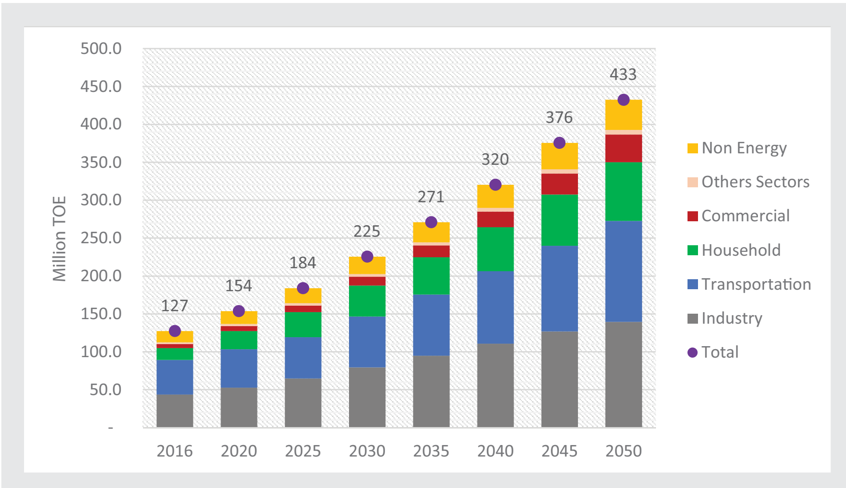
KEN and RUEN mandate a more aggressive utilization of NRE to reduce high dependency on fossil energy. NRE power plant development is prioritized to utilize local energy resources. Policy in industry includes green industry development which implements energy saving and environmentally friendly technology as stipulated in RIPIN. Policy in transportation includes development of public transportation such as mass rapid transit (MRT), light rapid transit (LRT), and bus rapid transit (BRT). Besides that, biofuel utilization as well as electric and gas fueled car development are also parts of energy policy in transportation. Household in rural areas is directed to use biogas from cattle dung for cooking. City gas has been developed in several cities in Indonesia with major gas potential. Energy conservation and efficiency programs in commercial sector especially in building and green building certification are promoted as stipulated in National Energy Conservation Master Plan (RIKEN). In environmental sector, Indonesia has agreed to ratify COP21 Paris Agreement. Indonesia through Nationally Determined Contributions (NDC) has the obligation to reduce GHG of 29% without international help or 41% with international aid from GHG emission rate in basic scenario in 2030.

4.1.1 Final Energy Demand

National final energy demand by KS scenario will reach 184 MTOE in 2025. It increases with the average annual growth rate of 4.2% compared to final energy consumption in 2016. Final energy demand will reach 433 MTOE in 2050 or increases with average annual growth rate of 3.7%.

Based on energy consumer, national final energy demand until 2050 is still dominated by transportation and industry. The increase of industrial activity and vehicle activity give a significant contribution in the increase of energy demand in both sectors despite of the implementation of energy saving technology. The share from industry and transportation in national energy demand is 35% and 29% in 2025. The share becomes 31% and 30% in

2050. The rest of the share is consumption from household, commercial and other sector including the utilization as raw material and other non-energy utilization. In KS scenario, energy demand share in household is around 18% in 2025 and 17% in 2050, while the share in commercial sector is around 5% and 8% in the same period. Other sectors and non energy decreases into 1% and 9% in 2050 (Picture 4.1).

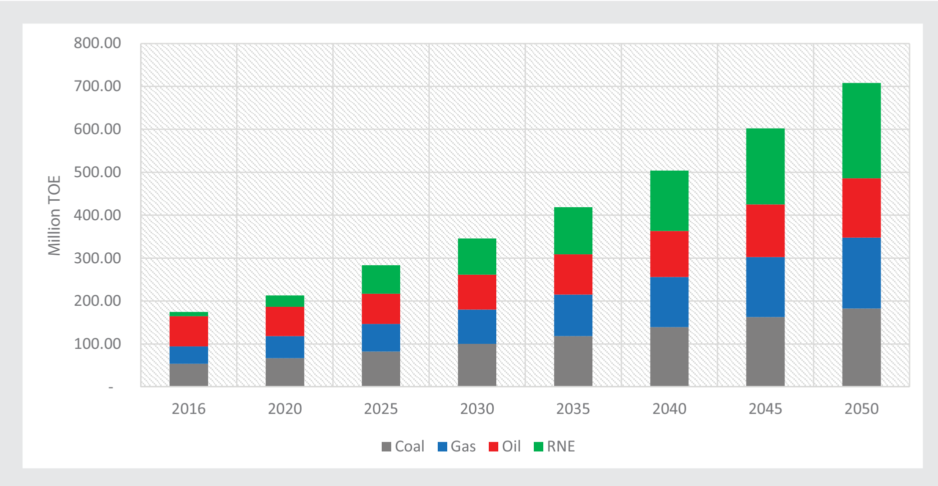


Picture 4.1 Final Energy Demand by Sector

4.1.2 Primary Energy Supply

Primary energy supply in KS scenario in 2025 is projected of around 283 million TOE and increases to 708 million TOE in 2050 or it grows 4.2% per year. A number of policies on energy diversification, conservation and efficiency as well as environment give an impact on a more rational primary energy supply growth. The implementation of these policies has retained the growth rate of primary energy supply.

In the last few years, the government has cut energy subsidies such as gasoline RON 88, diesel, and electricity for middle and upper class households. The increase of economic activity is predicted not to be influenced by fuel and electricity price increase. Thus, energy demand will keep increasing especially fossil energy demand such as coal, gas, and oil. These three fossil energy sources are still the main options in meeting the national energy demand until 2050. The projection of primary energy supply development per energy source by KS scenario and energy mix is shown in Picture 4.2.



Picture 4.2 Primary Energy Supply by Energy

During the period of 2016-2050, coal demand including briquettes increases 3.7% per year into 183 million TOE with the share of 25% in 2050. The government's policy to optimize domestic coal utilization will increase coal demand for industry and power plant. Gas demand including gas, LPG and LNG grows 4% per year into 64 million TOE in 2025 and 163 million TOE in 2050. It is due to the government's policy in prioritizing domestic demand than gas and LNG export by developing national gas infrastructure in which gas share reaches 23% in 2050.

Oil share decrease reaches 24.8% in 2025 and 19.5% in 2050. However, in terms of quantity, oil demand grows 2.3% per year reaching 81 million TOE in 2025 and 138 million TOE in 2050. The increase of demand occurs since the utilization of oil is not entirely replaced by other energy especially NRE.

NRE share (hydro, geothermal, biofuel, wind, solar, biogas) also increases into 23% in 2025 and 31% in 2050 with demand growth of 9.5% per year. This condition is influenced by a more aggressive government's policy to increase the utilization of NRE for power plant and the utilization of biofuel in industry, commercial and household. NRE which is projected to develop significantly is liquid fuel such as biofuel and NRE power plant source such as geothermal, hydro and biomass (including waste).

The detail explanation on demand and supply per energy source will be explained in the following sub chapter.

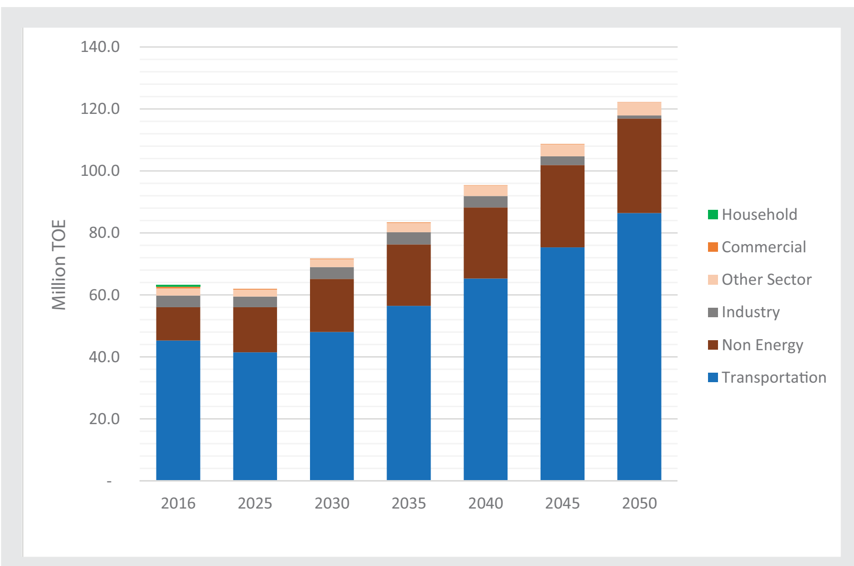
4.2 Oil

Indonesia dependency on oil is still very high despite of the fact that the government has conducted energy diversification and conservation in all consumer sector. It is shown by the dominant oil share in national energy mix (39% in 2016).

4.2.1 Oil Demand

The biggest oil demand in 2025 comes from transportation (67%) followed by non energy (raw material) (23.5%) and the rest is from other sectors. The high oil demand in transportation in 2050 (70.7%) is due to the low substitution of oil with other fuels such as biofuel, gas, and electricity. Besides gas, other refinery products are also the main raw materials for petrochemicals industry such as Methanol Refinery in Bunyu Island, East Kalimantan; Purified Terephthalic Acid (PTA) and Polypropylene (Polytam) Refinery in Plaju, South Sumatera; and Paraxylene and Benzene Refinery in Cilacap, Central Java.

Oil demand in transportation will keep growing at 1.9 per year reaching 86,4 million TOE in 2050. While, oil demand in other sector and non energy will increase 4,3 million TOE and 30.5 million TOE in same year. Then oil demand in industry sector will decrease 3.8 % per year to 1 million TOE in 2050. Oil demand in commercial sector decrease 5.7 % per year to 0.1 million TOE in 2050. Oil consumption such as kerosene in household will end in 2020 and to be replaced by LPG, gas and electricity (Picture 4.3).



Picture 4.3 Oil Demand by Sector

4.2.2 Oil Refinery

In the current government era, refinery development is one of the national strategic projects as stated in Presidential Regulation number 146 of 2015 as the legal framework of refinery development acceleration. The refineries to be revitalized are Cilacap refinery, Balikpapan refinery, Balongan refinery, and Dumai refinery through PT Pertamina's Refining Development Master Plan (RDMP) project. Meanwhile, the new refinery development will be conducted in Tuban and Bontang through Grass Root Refinery (GRR) project. One of the completed projects is RCC Off Gas to Propylene Project (ROPP) in Refinery Unit VI Balongan in which one of the products is propylene.

Based on RDMP and GRR project plan, the addition of oil refinery capacity is projected to increase from 1 million barrel per day in 2016 to 1.8 million barrel per day in 2025 and is projected to increase in double in 2050. This condition is assumed to be the same for all scenarios. The development of new refinery is prioritized in high fuel demand area. New oil refinery will be built with environmentally friendly concept as part of Blue Sky Project and has higher performance than the existing refinery (Table 4.1).

Table 4.1 Comparison of Oil Refinery Performance

	Current Oil Refinery (2015)	New Oil Refinery
Capacity Utilization (oil, gas/condensate and other refinery products)	88% (from refinery input capacity)	95% (from refinery input capacity)
Oil processing capacity	72% (from refinery input capacity)	80% (from refinery input capacity)
Yield	92%	100%

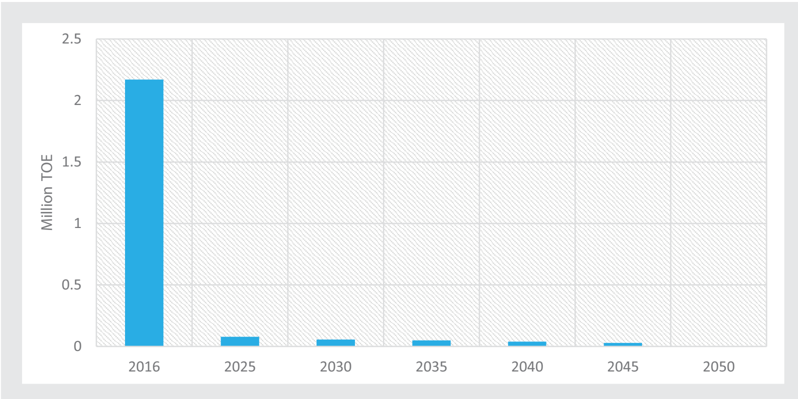
Source: PT Pertamina

The oil refinery performance in table 4.1 is an assumption from RUEN formulation related to oil supply program.

With the operation of private refinery and Balikpapan refinery stage 1, refinery capacity will reach 49.6 million TOE in 2020. In 2025, refinery production is projected to increase to 88 million TOE along with the increasing capacity in Cilacap refinery (2022), Dumai refinery (2023) and Balongan refinery (2023).

4.2.3 Oil Input to Power Plant

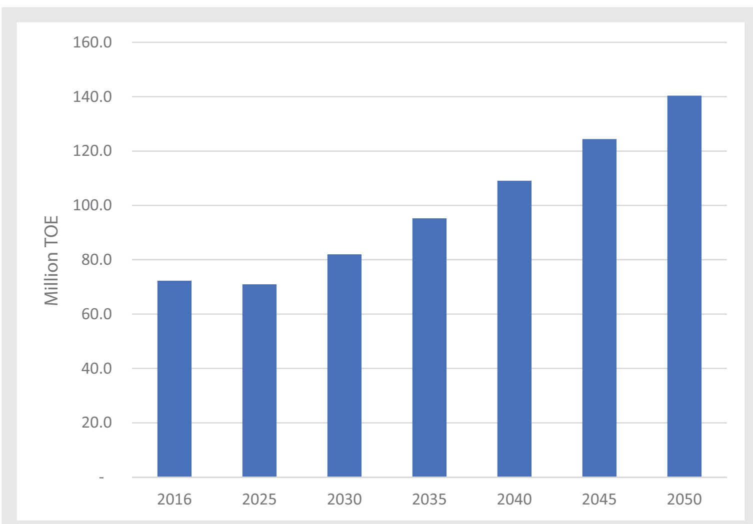
Oil input to power plant is 0.08 million TOE in 2025 and in 2050 it decreases significant or decline around 57%. Based on the government's policy, oil utilization in power plant will be substituted by other energy sources. Oil is only used in remote areas (picture 4.4)



Picture 4.4 Oil Input to Power Plant

4.2.4 Oil Primary Energy Supply

Oil primary energy supply development which covers crude oil production, crude oil export-import, and refinery product would reach 71 Million TOE in 2025 and 140 Million TOE in 2050 (Picture 4.5).

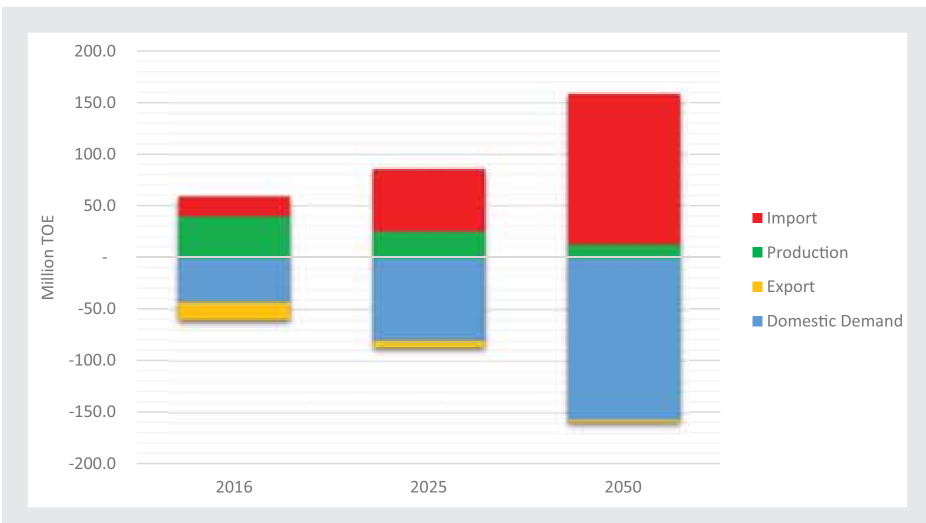


Picture 4.5 Oil Supply

Oil production in 2016 was 788 thousand barrel per day (bph) or only 50% from production in 1995. It happened since oil wells in Indonesia are mature and the exploration activity to discover new oil resources has been decreasing.

Despite of that, there is a new hope to maintain oil production from new oil fields such as Banyu Urip, Bukit Tua and Matindok field. Peak production potential from Banyu Urip is around 201,000 bph. Bukit Tua produces 20,000 bph and Matindok produces 500 bph. Oil production from three fields is expected to meet decline rate from existing fields which reaches 20% to 30% in average. Around 60% of Indonesia new oil field potential is located in deep water which requires advanced technology and substantial capital investment.

Oil production is projected to decline at the rate of 3% per year into 13 million TOE in 2050. Oil production is not sufficient to meet refinery demand of 157 million TOE in 2050. Thus, it requires crude oil import of 146 million TOE in 2050. Crude oil export will continue during projection period as part of foreign oil contract despite that it is declining to 1.9 million TOE in 2050 along with the declining oil production. Picture 4.6 shows oil balance between supply and demand in which to meet oil demand and export in 2025, it needs 60.7 million TOE from import and 25.3 million TOE from oil production.



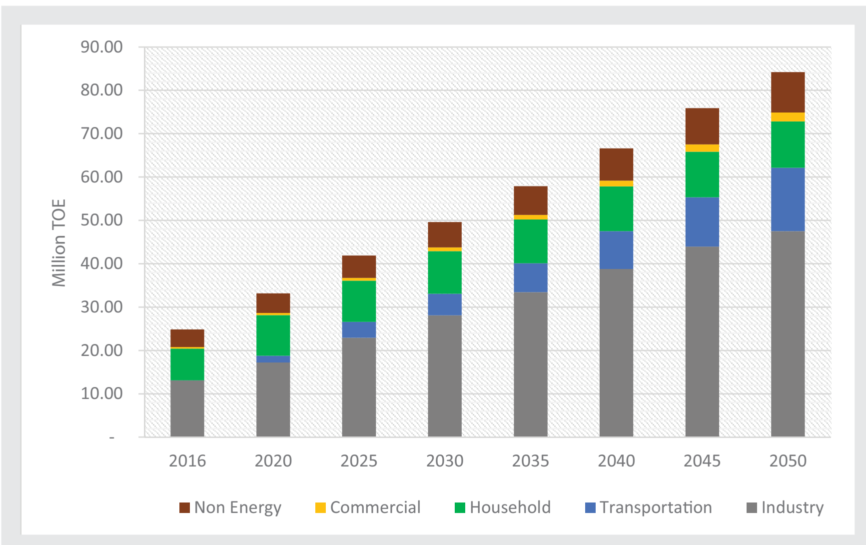
Picture 4.6 Oil Balance

4.3 Gas

Indonesia gas reserve is quite significant of about 101.22 TSCF (HEESI, 2017). Major gas production contributes a competitiveness of gas among other energy sources. Thus, gas is still an important fuel for industry and electricity. In electricity, gas is an interesting option since it produces lower local emission rate than oil and coal, power plant on-off flexibility, and high power plant efficiency especially in Combined Cycle Power Plant. Gas final energy demand for KS scenario is ~~42~~ million TOE in 2025 and 84 million TOE in 2050 with the average growth of ~~3.7~~% per year.

4.3.1 Demand per Sector

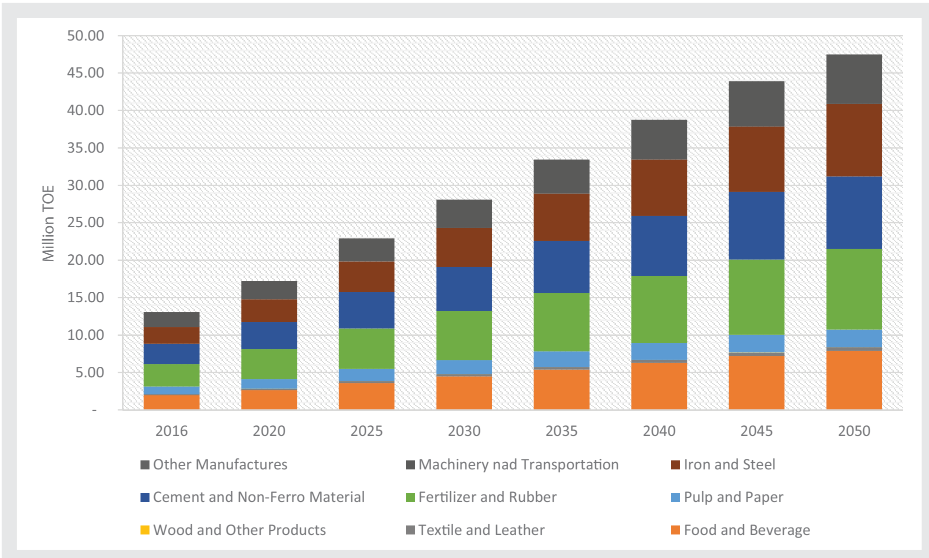
In KS scenario, total gas demand in 2025 (including LNG and LPG) is 41.9 million TOE in which gas consumer is about 54.7% in industry, 22.7% in household, 12.3% in non energy, 9% in transportation, and 2% in commercial sector. In 2050, total gas demand is 84 million TOE consisting 57% in industry, 17% in transportation, 13% in household, 11% in non energy, and 2% in commercial sector (Picture 4.7).



Picture 4.7 Gas Demand by Sector

National gas supply is allocated to meet gas demand in industry (as boiler fuel, furnace, captive power/cogeneration) and as a feedstock. Fertilizer, petrochemical and rubber industry as well as cement and non metal industry are still the biggest gas consumer in industry with the share of 24% and 21% in 2025 and become 23% and 20% in 2050.

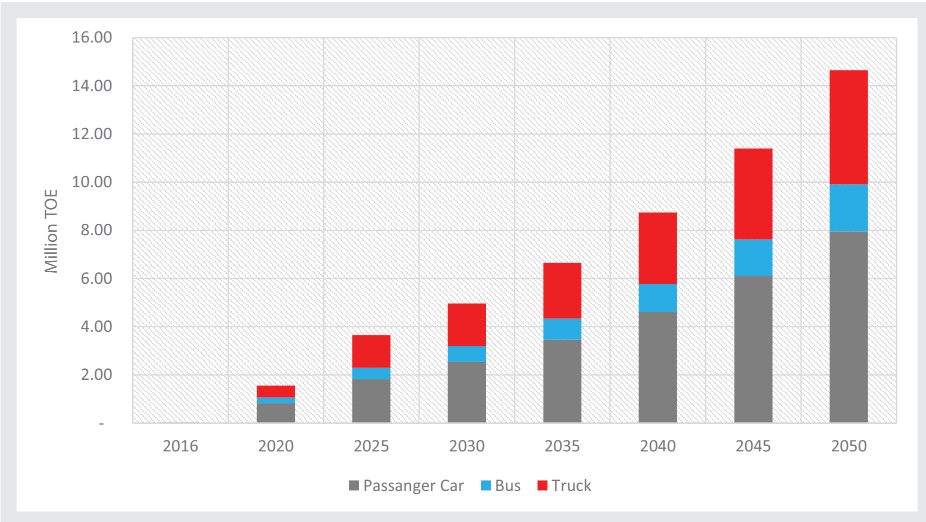
Besides that, sector with high gas share is base metals and steel industry as well as food and beverage industry with the share of 18% and 16% in 2025 and increases into 20% and 17% in 2050. High gas demand in industry in the future is expected to be fulfilled with gas supply from coal gasification process (Picture 4.8).



Picture 4.8 Gas Demand in Industry

Based on Presidential Regulation number 40 of 2016 on Gas Price Stipulation, gas price for certain sector can be decreased with two conditions; if not meeting the economic of gas consuming industry and if the gas price is higher than USD 6 per MMBTU. Presidential Regulation number 40 of 2016 states that gas price is determined by considering field economic, price in international and domestic market, domestic purchasing power, and gas utilization added value. Inexpensive gas is at first allocated for seven sectors. Then, it is suggested to be ten sectors. The ten industries are industries of fertilizer, petrochemical, oleochemical, steel or other metals, ceramics, glass, tire and rubber gloves, pulp and paper, food and beverages, as well as textile and footwear.

Despite that gas utilization share in transportation is relatively small compared to in industry and electricity, but the policy to develop gas as transportation fuel increases gas demand for transportation. Gas demand for transportation allocation is projected to increase to meet energy demand in road transportation consisted of passenger cars, truck and bus (Picture 4.9).

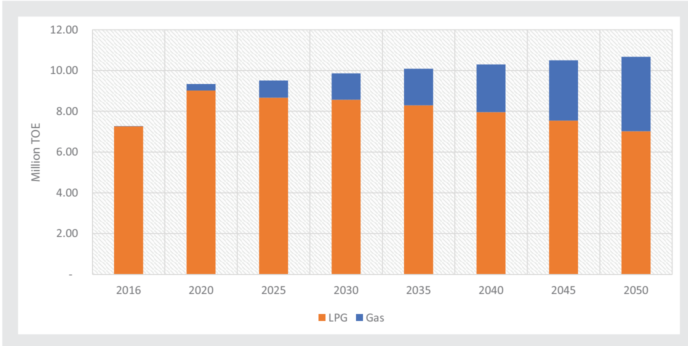


Picture 4.9 Gas Demand in Transportation

Transportation becomes the biggest gas consumer with the average growth of 19% per year, increasingfrom 0.04 in 2016 to 14.6 million TOE in 2050.

The development of Gas Filling Station, the availability of converter kit spare parts, and the gas supply security are also the important things in supporting gas for transportation. There has not been any new policy on gas for transportation.

Gas demand (including LPG and city gas) for household is predicted to increase from 7.28 million TOE in 2016 to 10.7 million TOE in 2050 or it grows at the average of 1.1% per year. The high gas demand is a challenge for the government since most LPG is imported. To reduce LPG import, city gas program needs to be enhanced so that most LPG consumer in the city will switch to use gas. Based on KS scenario, direct gas utilization through city gas is projected to grow at the average of 17.3% per year until 3.7 million TOE in 2050. Meanwhile, LPG utilization will be gradually replaced by piped gas with the average decline of 0.1% per year in 2050 into only 7.2 million TOE. The detail is shown on Picture 4.10.



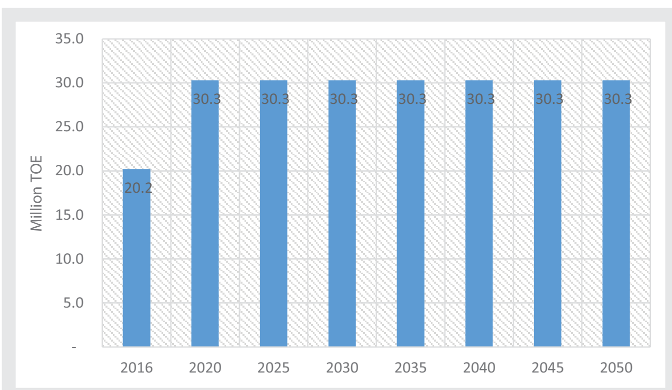
Picture 4.10 Gas Demand in Household

4.3.2 Refinery

Gas is utilized as input in oil refinery, LPG refinery and LNG refinery which produce LPG and LNG. Currently, most LNG is exported and only small portion of it is allocated for domestic consumer. The national gas utilization in the form of LNG is not optimal due to the lack of infrastructure and the existing facility utilization. To promote LNG in Indonesia, we need more Floating Storage Regasification Unit (FSRU) in industrial or power plant location which utilizes LNG as energy or raw material.

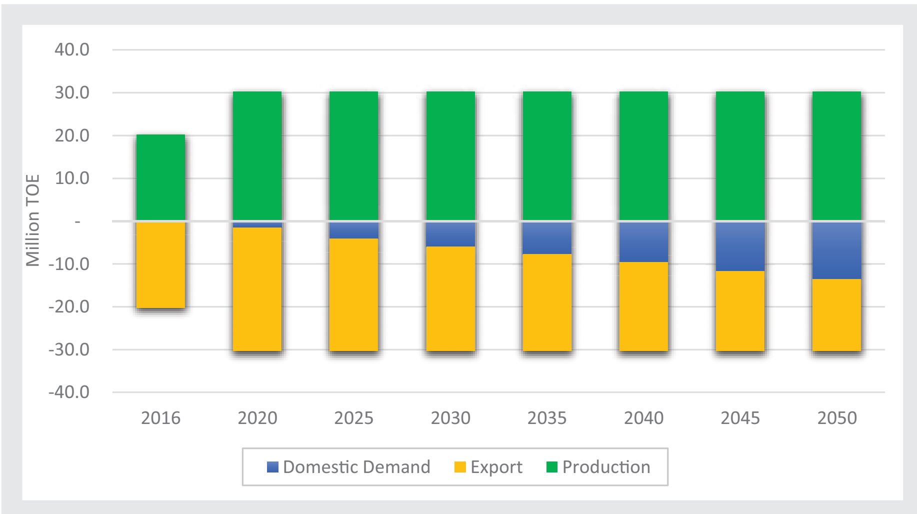
4.3.2.1 LNG Refinery

The current installed capacity of LNG refinery is 44.2 million ton per year from Bontang, Arun, Tangguh and Donggi Senoro LNG refinery. However, since 2014, Arun refinery is no longer in operation. LNG production in 2016 was 20.2 million TOE in which 86% of it was exported. To meet LNG demand, LNG refinery capacity in this Outlook is projected to increase to 30.3 million TOE during the periode 2020 -2050 including the development of Masela and Tangguh Train 3 refinery (Picture 4.11).



Picture 4.11 LNG Refinery Processing Capacity Assumption

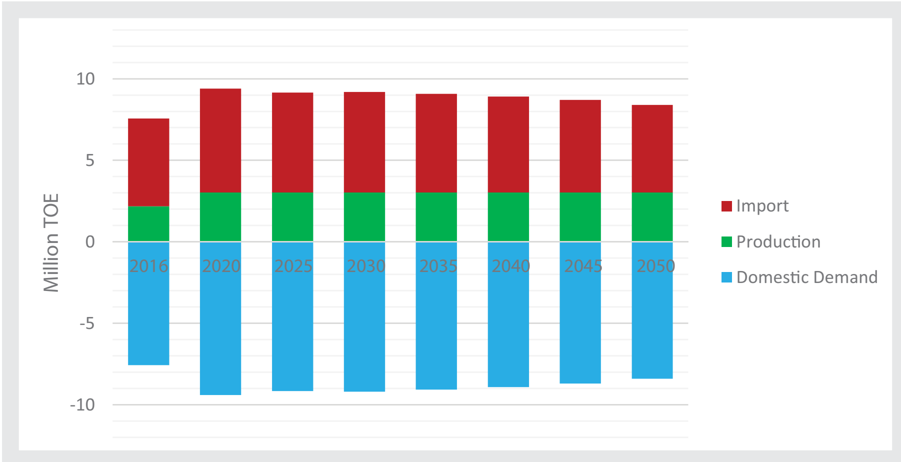
In KS scenario, LNG production is allocated to meet domestic gas demand for industry and power generation. Thus, LNG export is declining significantly. Domestic LNG demand is predicted to reach 13.5 million TOE in 2050 which most of it is allocated for power plant. This requires more FSRU especially in Java. Supplying gas demand with LNG should be supported by a competitive LNG price policy since LNG price will be higher than gas through pipeline (Picture 4.12.)



Picture 4.12 LNG Refinery Balance

4.3.2.2 LPG Refinery

LPG utilization acceleration program in household has increased LPG utilization. The increasing LPG demand has increased LPG import since the LPG refinery has limited capability to meet increasing LPG demand. LPG production increases up to 3 million TOE in 2050 or it grows 1% per year with 49% production from oil refinery and the rest production from gas refinery. LPG demand is predicted to increase until 2020, but it will be gradually decreasing after 2050 with the declining rate of 0.3% per year up to 8.4 million TOE in 2050. LPG import increases until 2030 and then decrease become 5.4 million TOE in 2050 due to the LPG to gas substitution. In this Outlook, LPG refinery production capacity is assumed to be constant (Picture 4.13).

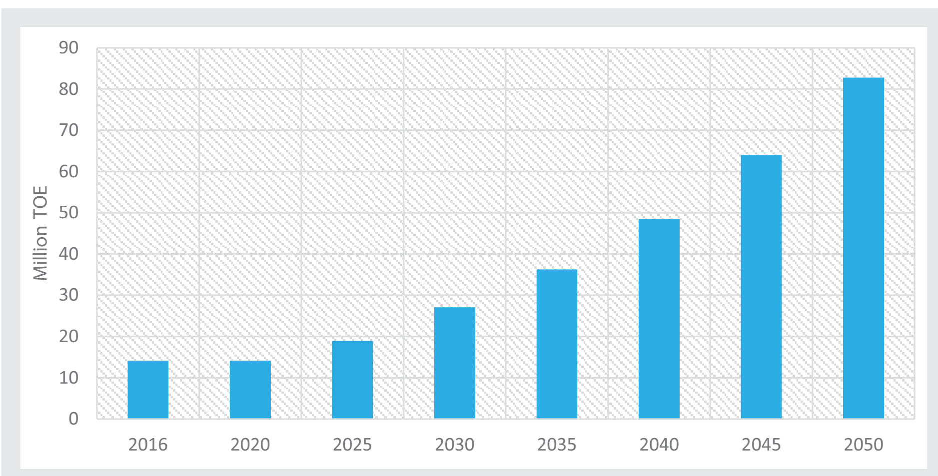


Picture 4.13 LPG Balance

4.3.3 Gas Input to Power Plant

Gas for power will be continued during the projection period by considering the flexible gas-based power plant characteristic in meeting the network load since it does not require longer time for the on-off of the power plant. There is a significant demand to meet Gas Power Plant demand when the peak load and Combined Cycle Power Plant in the medium or basic load.

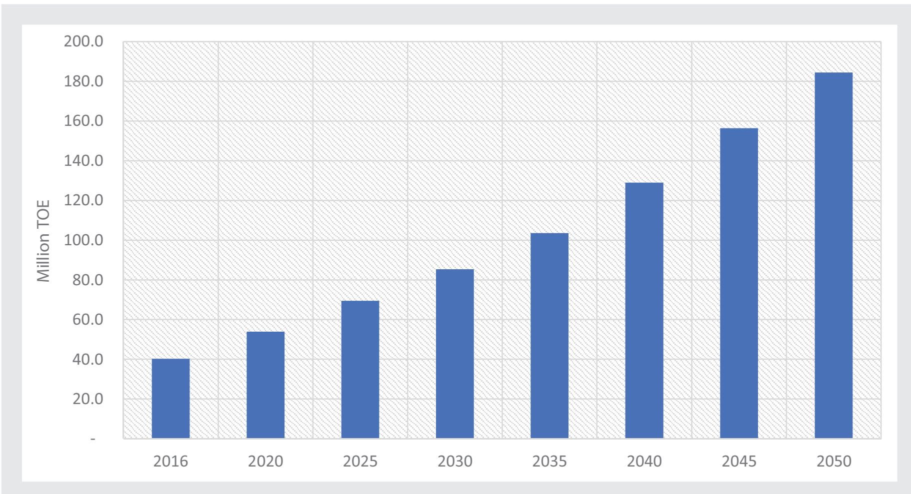
Gas for power will increase to 82.8 million TOE in 2050 at an annual average rate of 5.3%. This number is the same with 21% of the total primary energy in power plant (Picture 4.14).



Picture 4.14 Gas Input to Power Plant

4.3.4 Gas Supply

Today, gas is the third primary energy source in Indonesia after oil and coal. Gas supply is derived from domestic oil and gas field and from import. In the last several years, half of gas production is exported in the form of LNG and through pipeline. However, with the increasing gas utilization in industry, household, commercial sector, transportation and electricity, domestic gas demand is predicted to increase. To secure domestic energy supply in the future, gas will be prioritized to supply domestic demand rather than to be exported. Thus, LNG and gas export is allowed after the fulfillment of Domestic Market Obligation. It means that gas infrastructure is a key factor in increasing domestic gas supply in the future (Picture 4.15).

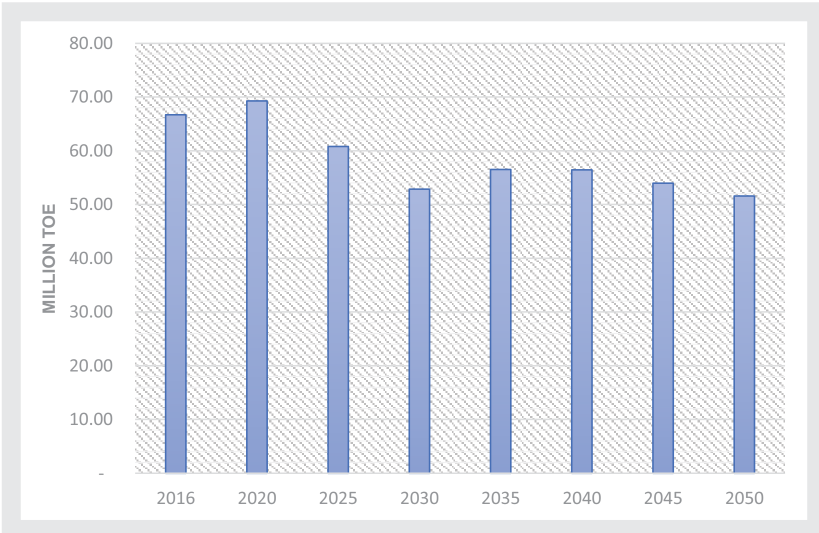


Picture 4.15 Primary Energy Supply-Gas

In 2016-2050, gas supply (including LPG and LNG) increases at the rate 4.6% per year from 69.5 million TOE in 2016 to 184.4 million TOE in 2050. Gas supply growth rate is predicted to be lower than the following years due to conservation and efficiency energy.

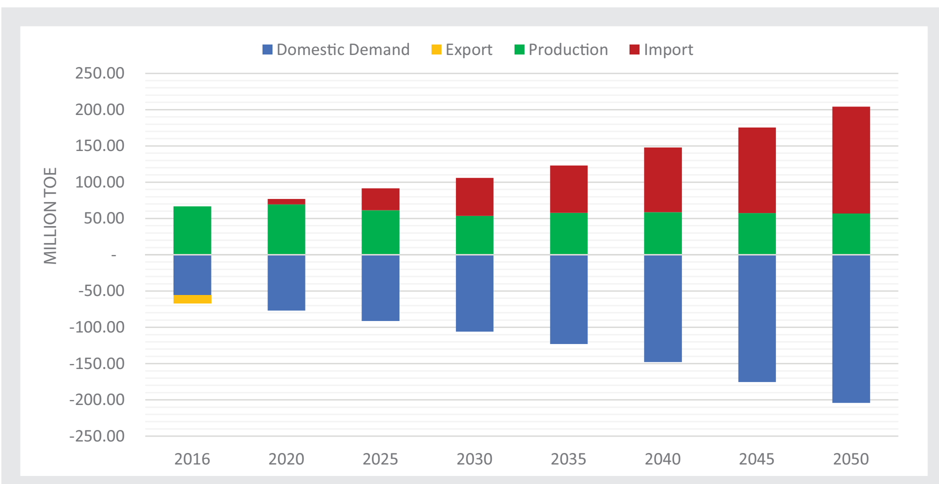
4.3.5 Gas Production

Indonesia gas production is better than oil production. In the last five years, Indonesia gas production has increased 0.2% per year. However, in the long term, gas production is projected to decline if there is no new field discovery (Picture 4.16).



Picture 4.16 Gas Production Assumption

Gas production is projected to decline at the rate of 0.5% per year from 66.7 million TOE in 2016 to 56.8 million TOE in 2050 (Picture 4.7). It is predicted that in 2019, Indonesia would import gas up to 1.7 million TOE and increase up to 147 million TOE in 2050 (Picture 4.17).



Picture 4.17 Gas Balance

It takes a serious action to develop gas production to control gas import. Currently, there are ten major gas fields namely Total E&P Indonesie, BP Berau LTD, ConocoPhillips (Grissik LTD), PT Pertamina EP, JOB Pertamina–Medco Tomori Sulawesi, ConocoPhillips Indonesia INC. LTD (Natuna Sea Blok B), Kangean Energy Indonesia LTD, Vico, Premier Oil Natuna SEABV, and Pertamina Hulu Energi ONWJ LTD. Besides these ten fields, there are also new developed fields to maintain gas lifting in the future such as fields in East Natuna and Masela.

Besides developing new production fields, there is also the development of alternative gas such as shale gas since Indonesia has quite significant potential of shale gas.

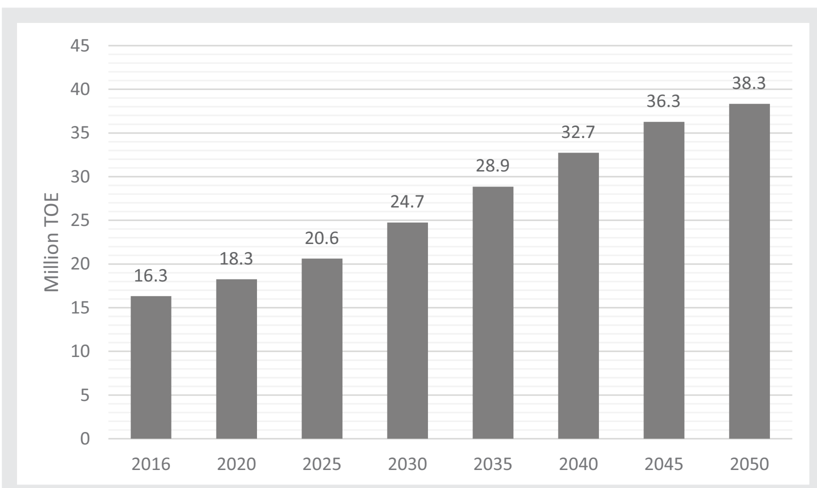
4.4 Coal

Indonesia has abundant coal reserve but its utilization is not optimal since most of it is exported to other countries such as China and India.

Today, coal utilization receives some critics from many parties since it is considered pollutive to the environment and it is not in line with the world's commitment to reduce emission. To make coal utilization in parallel with the globalization, it requires efficient and environmentally friendly technology.

4.4.1 Coal Demand by Sector

Coal is only consumed by industry and power plant. Coal demand in Indonesia is predicted to reach 18.3 million TOE in 2025 and 38.3 million TOE in 2050 (Picture 4.18).

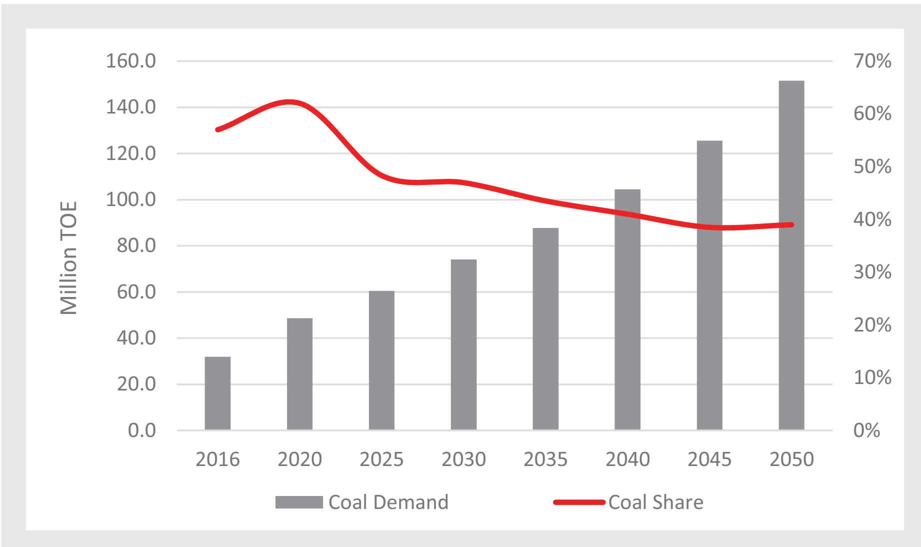


Picture 4.18 Coal Demand in Industry Sector

Coal is generally utilized by cement and non metals industry, basic steel industry, as well as pulp and paper industry. In the future, coal in fertilizer industry will be directed as the raw material through gasification process.

4.4.2 Coal Input to Power Plant

Coal input to power plant in 2025 is around 60 million TOE and increase to 142 million TOE, equal to 36% total primary energy input for power plant. In the projection of coal energy mix as power plant fuel, coal share in power plant energy mix declines from 48% in 2025 to 39% in 2050. Besides that, coal power plant will dominate additional power plant capacity until 2050 (Picture 4.19).



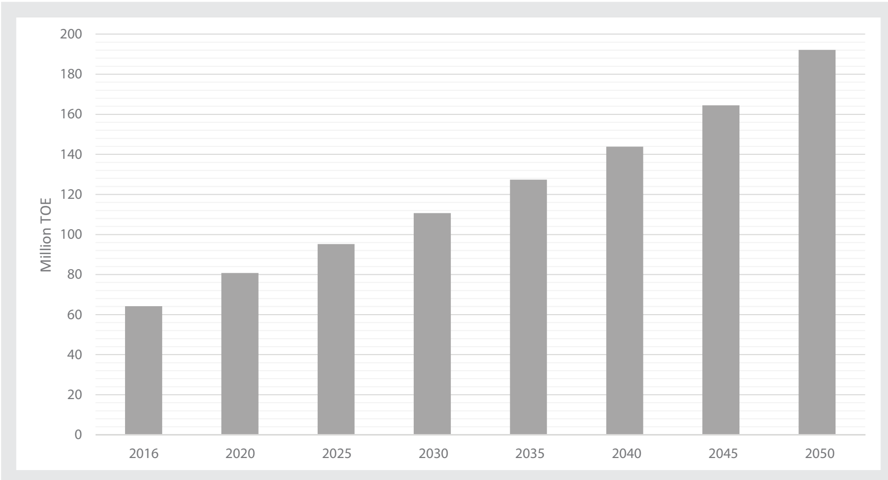
Picture 4.19 Coal Input to Power Plant

4.4.3 Briquette

Besides for industry and power plant, coal is also transformed into briquette in a very small amount. Briquette utilization in 2025 is 9 thousand TOE and will increase to 20 thousand TOE in 2050.

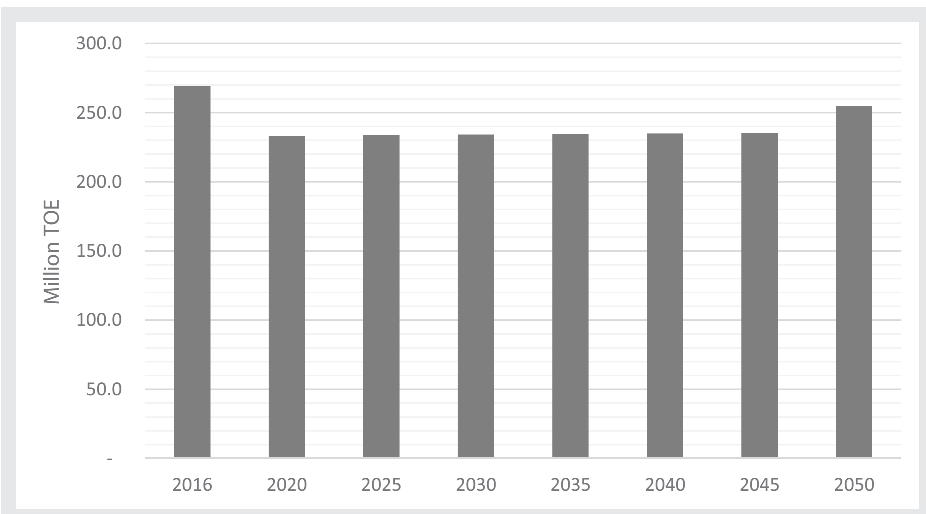
4.4.4 Coal Primary Energy Supply

During the period of 2016-2050, coal energy supply is predicted to increase at the average of 3.3% per year from 95.3 million TOE in 2025 to 192 million TOE in 2050 (Picture 4.20).



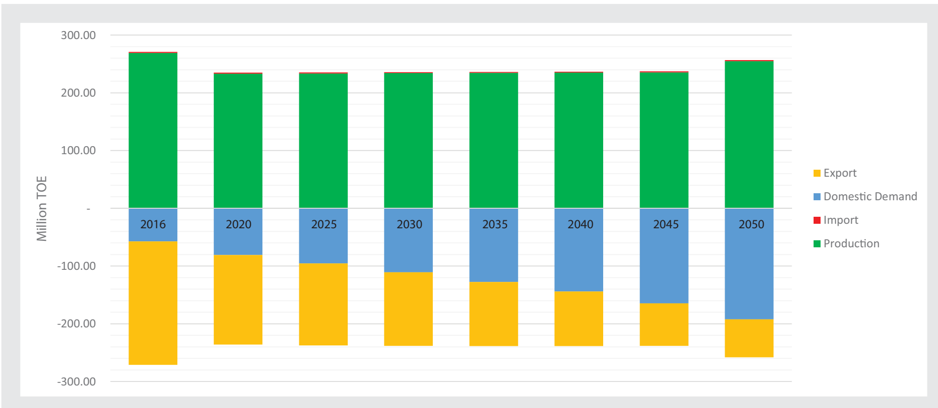
Picture 4.20 Primary Energy Supply-Coal

Coal production projection in 2025 is 233 millon TOE or around 400 million Ton and it will increase to 254 million TOE or 432 million Ton in 2050. This condition occurs along with the government's policy to control coal production up to 400 million ton per year in 2019. The production can be increased when domestic demand exceeds 400 million Ton (Picture 4.21).



Picture 4.21 Coal Production Projection

In the future, national coal demand will be fulfilled from domestic supply since the national coal reserve is still abundant. Coal import will not increase since it is only used for specific purposes such as for reductor in metallurgy industry. Despite that coal export gives positive contribution to the national trade balance and reduces deficit in trade balance due to other imports such as fuel, coal export is predicted to decline reaching 142 million TOE in 2025 and 65 million TOE in 2050. This is due to the increasing domestic demand for industry and power plant. The development of coal production, export and import is shown in Picture 4.22.



Picture 4.22 Coal Balance

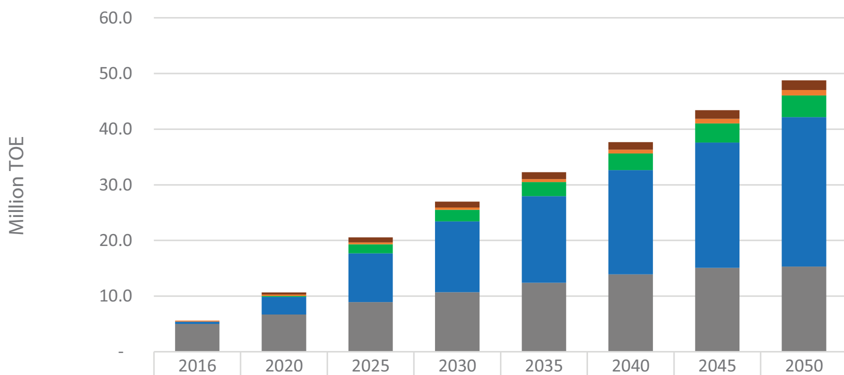
4.5 New and Renewable Energy (NRE)

NRE consists of solar, wind, hydro, ocean, geothermal, biodiesel, bioethanol, commercial biomass including agriculture and household waste, but it excludes traditional biomass for household. NRE is utilized as energy source for power plant and as energy source to replace fuel (biodiesel and bioethanol).

NRE is developed and optimized by changing the mindset that NRE is no longer an alternative energy for fossil fuel but more as a national energy supply. Based on Government Regulation number 79 of 2014 on National Energy Policy Article 9 Letter f Number 1, NRE share is at least 23% in 2025 and 31% in 2050 provided that it meets the economic. It is re-stated in Presidential Regulation number 22 of 2017 on National Energy General Planning (RUEN) in Attachment 1.

4.5.1 NRE Demand

NRE demand is projected to increase to 21 million TOE in 2025 and 49 million TOE in 2050. The biggest NRE demand in 2025 comes from transportation and industry each 8.9 million TOE. Other sectors with 0.9 million TOE, commercial sector with 0.3 million TOE, and household with 1.6 million TOE. In 2050, transportation still dominates NRE demand with 27 million TOE. NRE demand is 15.3 million TOE in industry, 1.8 million TOE in other sectors, 1 million TOE in commercial sector, and 4 million TOE in household (Picture 4.23).



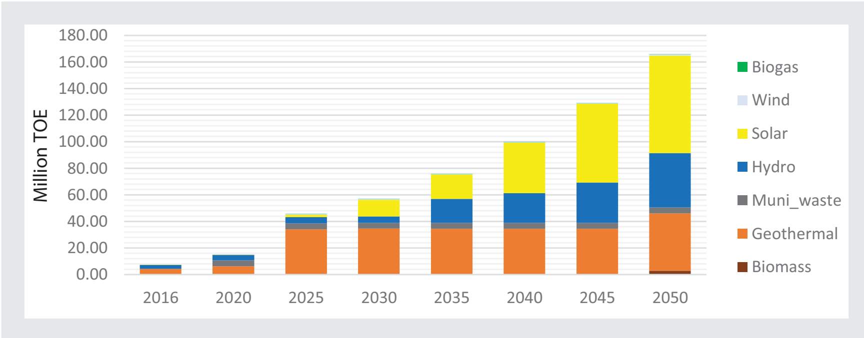
	2016	2020	2025	2030	2035	2040	2045	2050
Others sector	-	0.4	0.9	1.1	1.2	1.4	1.6	1.8
Commercial	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.0
Household	-	0.2	1.6	2.1	2.5	3.0	3.4	3.9
Transportation	0.4	3.2	8.8	12.7	15.6	18.8	22.5	26.9
Industry	5.0	6.7	8.9	10.7	12.4	13.9	15.1	15.3

Picture 4.23 NRE Demand by Sector

NRE demand increase is directed to meet energy mix target based on KEN. The high NRE demand in transportation is supported by Ministerial Regulation number 12 of 2015 on Supply, Utilization and Trade of Biofuel as Other Fuel.

4.5.2 NRE Input to Power Plant

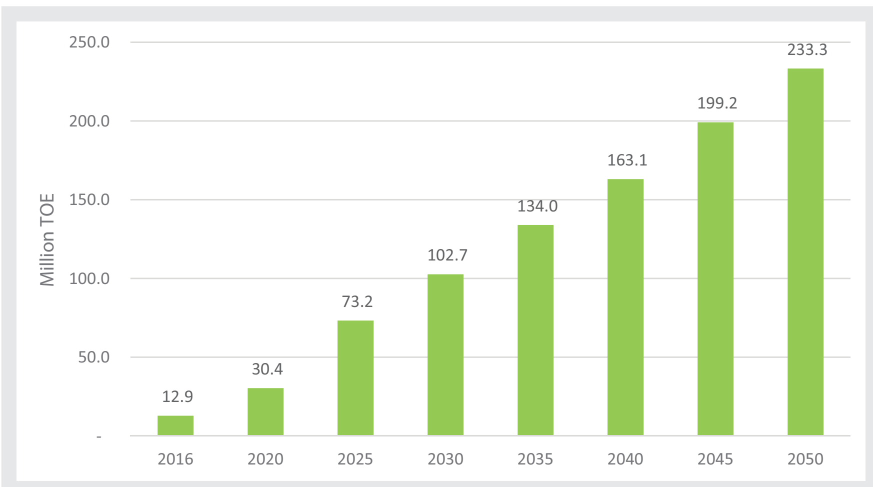
Total NRE input to power plant is 45.5 million TOE in 2025 and 166 million TOE in 2050 with the biggest share comes from geothermal, hydro and solar power. Primary energy from solar is 1.8 million TOE in 2025 and will increase sharply to 73 million TOE in 2050. Solar primary energy input is huge due to power plant efficiency based on RUEN of 25% (Picture 4.24).



Picture 4.24 NRE Primary Input to Power Plant

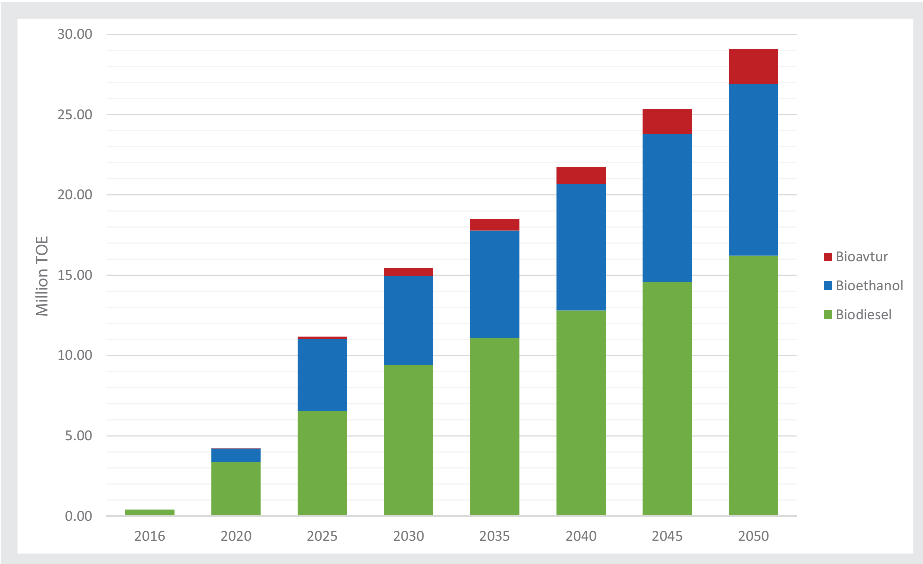
4.5.3 NRE Supply

In KS scenario, NRE supply is projected to increase to 73.2 million TOE in 2025 and 233.3 million TOE in 2050 or it grows at 8.9% per year (Picture 4.25).



Picture 4.25 NRE Supply

Biofuel demand consisting of biodiesel, bioethanol, and bioavtur increases at a rate of 2.6% per year over the projection periods. Thus, biofuel will increase to ~~11.2~~ million TOE in 2025 and ~~29.1~~ million TOE in 2050. Biofuel demand from all sectors is shown in Picture 4.26



Picture 4.26 Trend of Biofuel Demand

Biodiesel utilization will increase into 6.6 million TOE in 2025 and 16.2 million TOE in 2050 or 2.7% per year. Biodiesel utilization as diesel mixture will be regulated to reach 20% in 2016 and 30% in 2020.

Bioethanol is not yet utilized in 2016, but in 2020 it is predicted that bioethanol demand will reach 0.9 million TOE and 10.7 million TOE in 2050. Meanwhile, the demand for bioavtures in 2016 still does not exist, and is expected to be used in 2020, so that demand will increase to 0.15 million TOE by 2025 and to 2.17 million TOE in 2050. Explaination related the electricity sector will be discussed in sub-chapters of electricity.

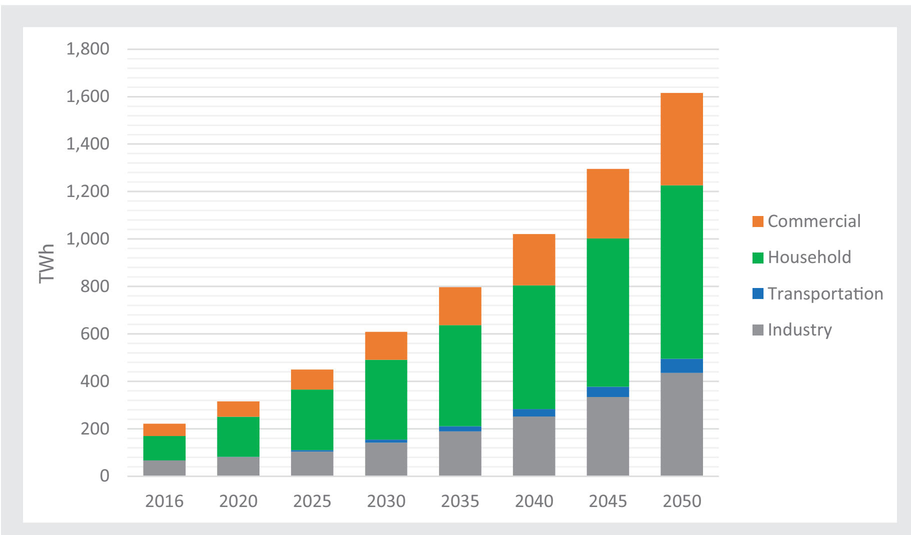
4.6 Electricity

The operating power plant in Indonesia consists of power plant owned by PLN, private sector (IPP) and captive power located in all PLN region. The additional power plant capacity depends on high power demand growth, economic growth, and electrification ratio target.

4.6.1 Power Demand

Power demand always grows higher than other energy sources. Power demand growth in KS scenario is projected to reach 450 TWh in 2025 and 1616 TWh in 2050. Power demand growth rate is around 6.1% per year during 2016-2050.

Power consumption pattern during projection period is the same with the previous one in which the biggest consumer is household followed by industry, commercial and transportation. In 2025, electricity demand in household is 255 TWh (57%) from the total national power demand. Electricity in industry is 104 TWh (23%) and in commercial sector is 85 TWh (19%). The rest of demand is from transportation of 6 TWh (1%). In 2050 electricity demand in household is 731 TWh (45%) from the total national power demand. Electricity demand in industry is 436 TWh (27%) and in commercial sector is 390 TWh (24%). The rest of demand is from transportation of 59 TWh (4%). Power demand per sector is seen in Picture 4.27.



Picture 4.27 Electricity Demand by Sector

Power demand in electricity starts to increase since 2019 especially for electric train in Jabodetabek as well as MRT, LRT, and monorail. Electric car will grow by around 1% of total car in 2025 and 10% in 2050. The penetration of electric motor cycle is higher than electric car with the increase of 5% in 2025 and 20% in 2050.

Power demand elasticity toward GDP is around 1.1 which shows that during projection period, power demand growth is still higher than GDP growth. In developed countries, the average elasticity is below 0.5 which shows that its economic growth is twice higher than electricity demand growth.

4.6.2 Power Supply

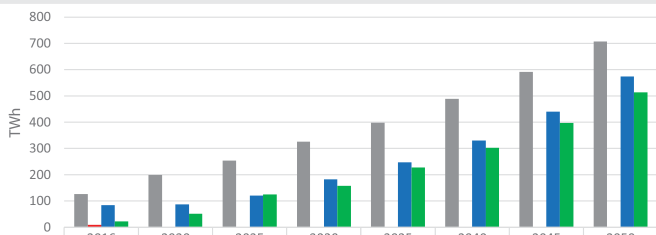
a. Power Production

Power production during projection period is predicted to reach 500 TWh in 2025 and 1,800 TWh in 2050 with the assumption that the loss in transmission and distribution is around 10%.

Coal power plant is still dominant in meeting power demand in the future, but the share in national total power production will decrease around 51% in 2025 and 39% in 2050. On the other hand, the share of production from NRE power plant will increase 25% in 2025 and 29% in 2050.

Power production from fuel power plant is very small or below 0.1%. It is based on the plan to stop building fuel power plant and to substitute diesel to NRE power plant, except in remote areas and frontier islands.

The rest of power is produced from gas power plant. Power production share from gas power plant is around 24% in 2025 and increases into 32% in 2050. Power production by energy source can be seen in Picture 4.28.



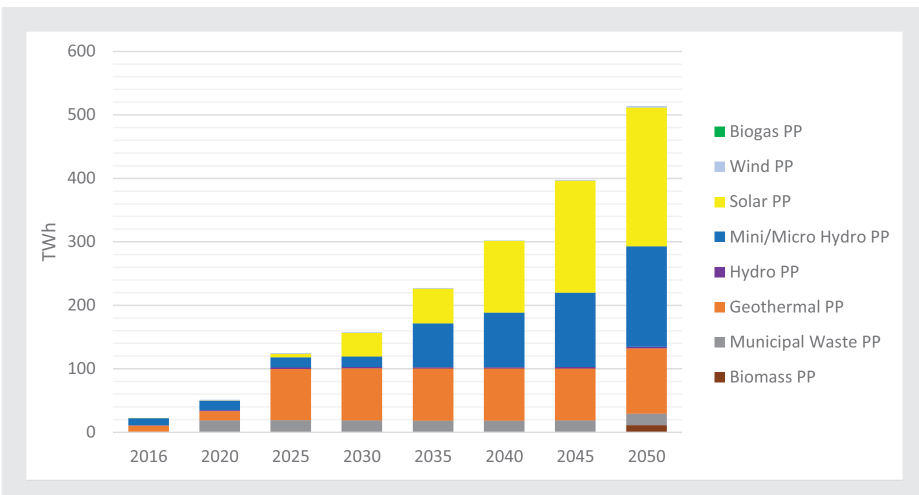
	2016	2020	2025	2030	2035	2040	2045	2050
COAL	126	199	254	326	398	489	592	708
OIL	9	0	0	0	0	0	0	0
GAS	84	87	121	182	247	330	440	574
NRE	22	51	125	158	227	303	398	514

Picture 4.28 Electricity Production by Energy

The potential NRE PP is biomass power plant (biomass PP, mill waste PP, municipal solid waste PP), reservoir PP, mini and micro hydro power plant (run-off river PP), solar PP, wind turbine power plant and geothermal power plant (medium to high temperature). From the total NRE power plant production in 2025, the production share is dominated by geothermal power plant (64%), municipal solid waste power plant (15%) and hydro power plant (13%).

In 2050, there will a change of condition in which the share of hydro power plant in the total NRE power plant production will be higher than geothermal power plant reaching 31% and 20% respectively. It occurs since geothermal production has reached maximum potential starting in 2025. Geothermal production can be increased but with a more challenging location and higher development cost compared to hydro power.

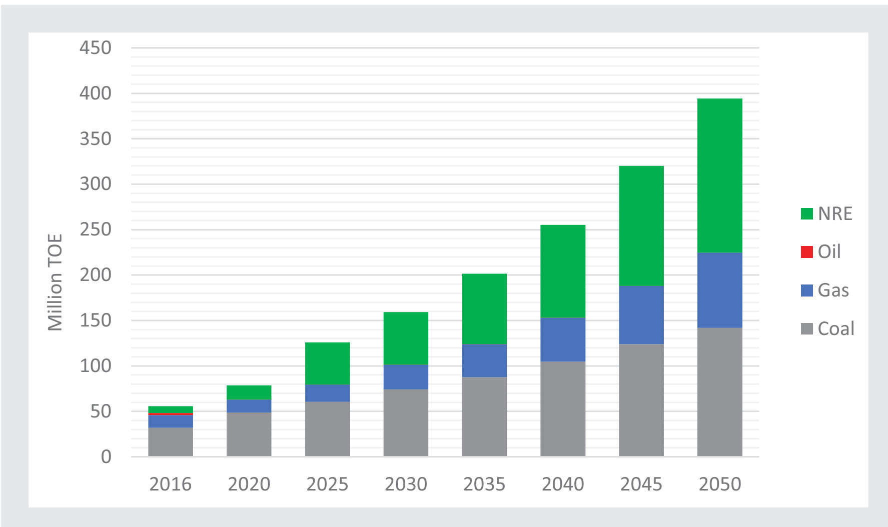
Power production from municipal solid waste power plant will decrease into 4% since solar PV penetration is faster than municipal solid waste power plant. Power production from solar PV will increase with programs such as rooftop solar, energy saving solar lamp, and cheaper component price from year to year. The details of NRE power plant will be discussed in NRE Chapter. Production composition from NRE power plant toward total power production from NRE is shown in Picture 4.29



Picture 4.29 Power Production from NRE Power Plant by Source

b. Primary Energy Input to Power Plant

Primary energy input to power plant in 2025 is 126 Million TOE with the biggest portion comes from 60 Million TOE (48%) from coal, 47 Million TOE (37%) from NRE, and 19 Million TOE (15%) from gas. The high coal input to power plant is due to the Steam Power Plant development based on 35 GW power plant acceleration program, in 2050, primary energy input to power plant is 394 Million TOE with the biggest portion from 170 Million TOE (43%) from NRE, 142 Million TOE (36%) from coal, and 83 Million TOE (21%) from gas. The big NRE portion in power plant is conducted to achieve the target of NRE energy mix of 23% in 2025 and 31% in 2050. Oil input to power plant is reducing drastically up to 57% in 2050 (Picture 4.30).



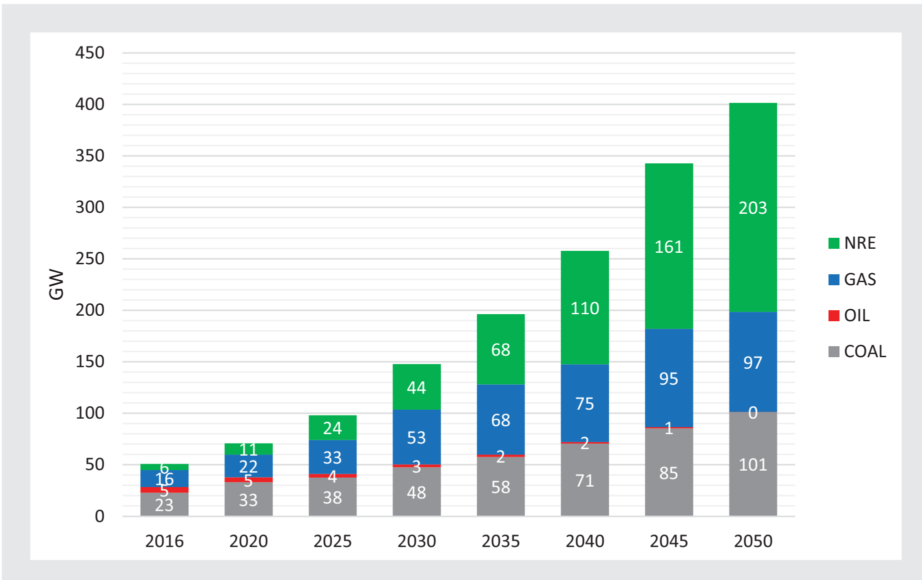
Picture 4.30 Primary Energy Input to Power Plant

c. Total Power Plant Capacity

The option to choose power plant types to produce power during projection period is based on least cost or cost effective principles with Balmorel model. The least cost is achieved by minimizing net present value of all power supply cost consisting of investment, fuel, operation and maintenance cost. This principle is also applied by PT PLN in formulating RUPTL (Electricity Supply Business Plan). The formulation of KS scenario in IEO 2017 also uses Least Cost Principle and accommodates capacity addition as formulated in RUPTL 2017-2026 with the status of projects in construction and feasibility study stage.

The total power plant capacity in KS scenario will reach 98 GW in 2025 consisting of 38 GW coal power plant, 33 GW of gas fueled power plant, 24 GW of NRE power plant and 4 GW of fuel power plant.

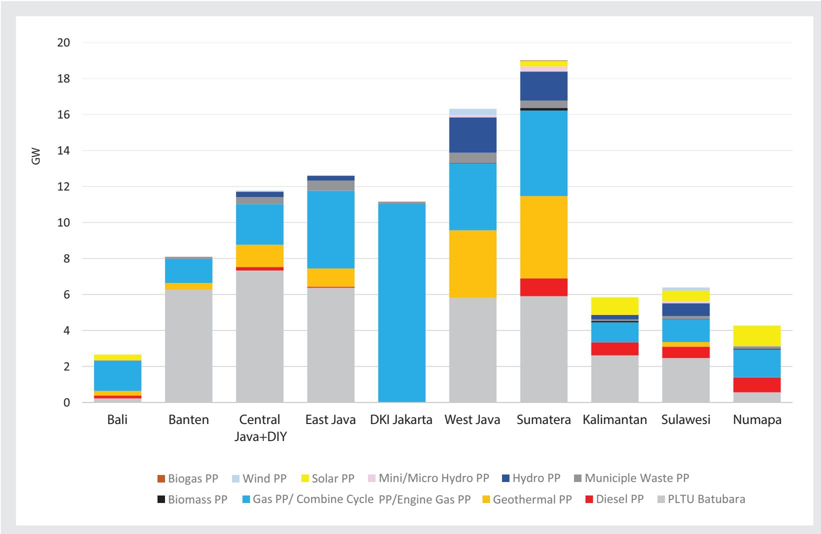
In 2050, total power plant capacity will increase to 402 GW in which NRE power plant capacity (203 GW) is still dominant compared to coal power plant (101 GW) and gas power plant (97 GW) (Picture 4.31).



Picture 4.31 Total Capacity of Power Plant by Energy Source

From its power plant distribution, coal power plant is mostly located in Java-Bali (26 GW) and the rest is located in other areas especially in Sumatera (6 GW). For gas power plant, the total capacity in Java-Bali is 24 GW.

NRE power plant with the total capacity of 24 GW is mostly located in Java-Bali (12 GW) especially in East Java in which 4 GW is geothermal power plant capacity while 2 GW is hydro power plant capacity. Around 7 GW from the total NRE power plant capacity is located in Sumatera and the rest is spread in Kalimantan and other island. The distribution of power plant in several provinces in 2025 is shown in Picture 4.32.

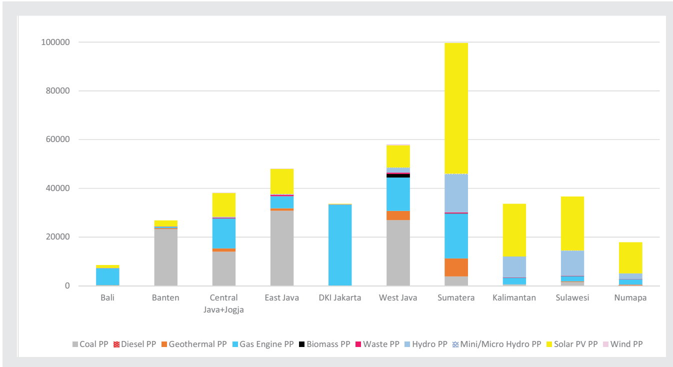


Picture 4.32 Power Capacity Distribution by Region and Energy Source 2025

In 2050, where KS scenario tries to achieve national primary mix based on RUEN, most electricity demand is predicted to be fulfilled by NRE power plant especially outside Java-Bali (Picture 4.34). From the total NRE power capacity of 203 GW in 2050, around 77% (156 GW) is outside Java-Bali. The total capacity of NRE power plant in Sumatera is 77 GW while the rest 79 GW is spread in Kalimantan, Sulawesi and other islands.

The limitation of solar power plant potential utilization per region refers to Presidential Regulation on RUEN. Total solar power plant capacity reaches 143 GW consisting of 5 GW in Sumatera especially North Sumatera (12 GW) and other region outside Java-Bali (57 GW). Solar power potential in Java and Bali is potential to be increased since solar PV cost is decreasing. Other NRE power plant of around 54 GW consists of geothermal power plant (15 GW), biomass power plant (2 GW), hydro power plant (39 GW), and wind power plant (1 GW).

For fossil fueled power plant, coal power plant capacity is only 101 GW in 2050. From this total capacity, around 94% is spread in Java-Bali. Gas fueled power plant will also be dominant in Java-Bali of around 72 GW while the rest 25 GW is spread in Sumatera (18 GW) and other islands (7 GW). Power plant distribution by region and energy source in 2050 is shown in Picture 4.33.



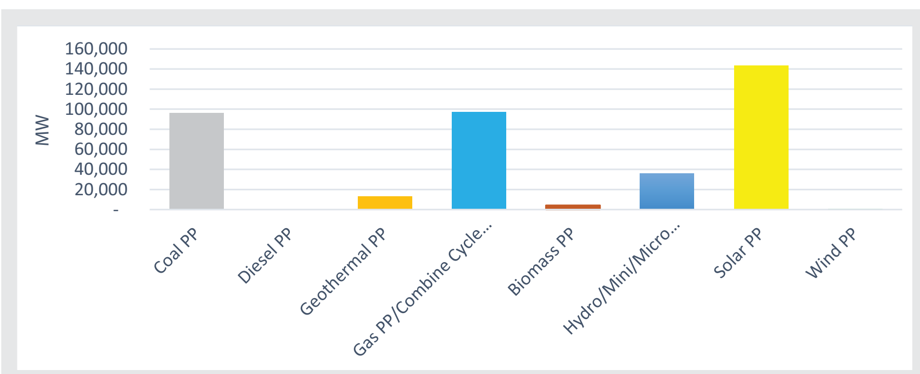
Picture 4.33 Power Plant Capacity Distribution by Region and Energy Source 2050

Among coal power plants, most of them are Ultra Super Critical (USC) and Ultra Critical (UC). Both coal power plant types are included in KS scenario to meet carbon reduction of energy sector in NDC.

d. Additional Power Capacity

Parts of installed capacity is operating power plant in 2016 while the rest is new installed capacity. This analysis considers that not all operating power plant installed capacity in 2016 will be available in the end of projection year. Thus, residual capacity from power plants during projection period needs to be calculated. Generally, the new power plant lifetime is assumed to be around 30 years.

The result of calculation shows that additional power capacity in 2016-2025 is around 52 GW in which most of it is additional capacity from coal (15 GW) and gas (20 GW). The details oby power plant type can be seen in Picture 4.34.

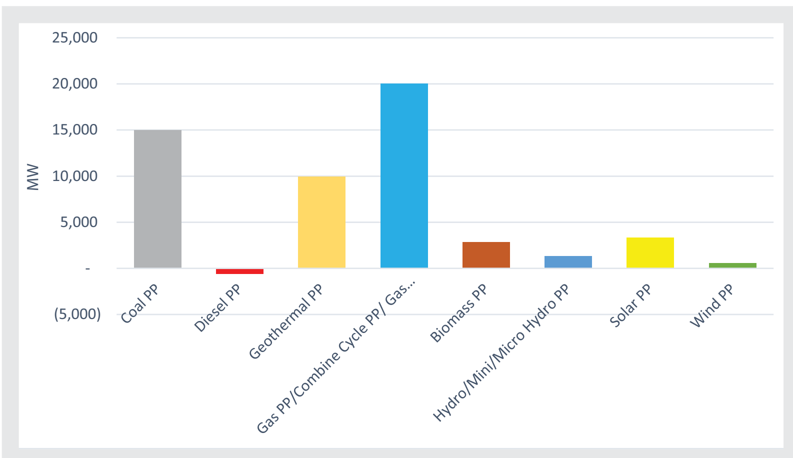


Picture 4.34 Power Plant Additional Demand 2016-2025

The total additional capacity from NRE power plant during 2016-2025 is around 18 GW. The biggest contributor is geothermal power plant (10 GW), followed by biomass power plant (3 GW), hydro and mini hydro power plant (1.3 GW), solar PV (3.3 GW) and wind power plant (0.5 GW).

During 2016-2025, the total additional capacity is 103 GW from coal power plant, while the 96 GW from gas power plant, and 5 MW from diesel power plant.

In total, NRE power plant additional capacity during projection period is around 197 GW. It is very significant since KS scenario includes efforts to reach KEN and NDC mix. The biggest NRE power plant additional capacity is derived from solar PV reaching 143 GW. Additional capacity from mini hydro or hydro and biomass power plant is 36 GW and 4 GW. Additional capacity from geothermal power plant is almost 13 GW, while additional capacity from wind turbine power plant is only 0.8 GW due to the less potential in Indonesia. The power plant additional capacity during projection period is shown in Picture 4.35.



Picture 4.35 Power Plant Additional Demand 2016-2050

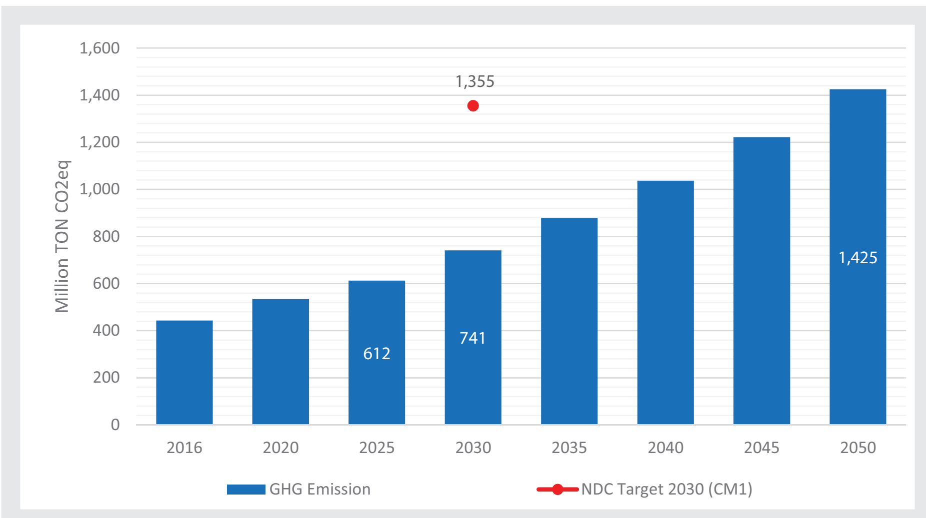
4.7 GHG Emission

The population growth and living standard improvement will be followed by the increasing energy demand. If it is not followed by low carbon fuel as well as efficient and environmentally friendly technology, CO_2 emission from energy source combustion will be very high. CO_2 emission release to atmosphere from energy in commercial sector, household, industry, transportation, power plant and other sectors in certain volume will affect global warming. Reducing global warming can be conducted through energy technology efficiency and low carbon energy utilization. CO_2 emission is calculated based on IPCC methodology (Intergovernmental Panel on Climate Change), 2006.

Indonesia is targeting to reduce 29% of GHG emissions from base scenario condition by 2030 or 41% with assistance from developed countries.

Based on NDC document from Indonesia to UNFCCC, emission target in energy sector in 2030 is 1,355 million ton CO_2 for CM1 scenario (without International aid) or 1,271 million ton CO_2 for CM2 scenario (with international aid).

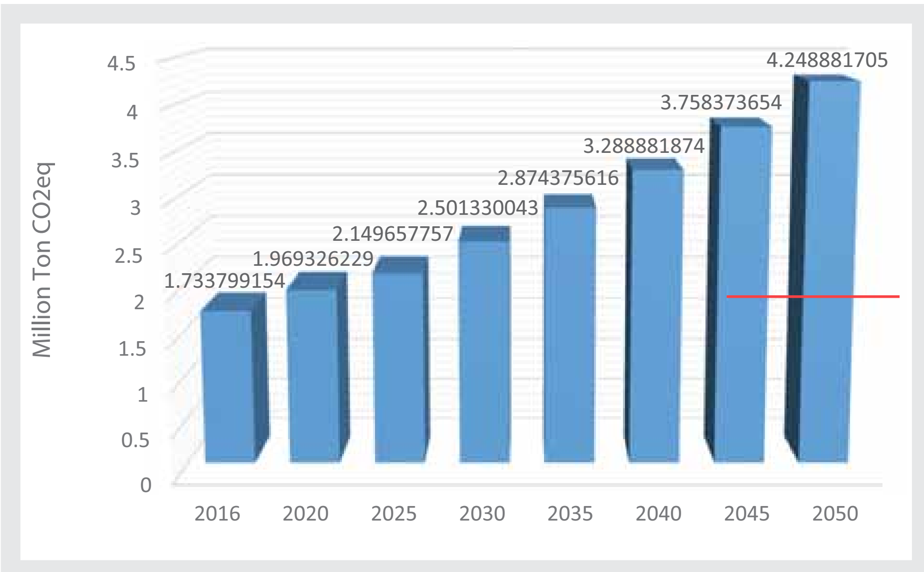
This Outlook projection shows that total emission in 2016 is 442 Million Ton CO_2eq, and will increase into 612 Million Ton CO_2eq, in 2025 and 1.4 billion Ton CO_2eq, in 2050. GHG emission rate in 2030 reaches 741 million Ton CO_2. This projection is lower than NDC target for energy sector. This Outlook projection is also lower than emission target in Attachment of Presidential Regulation on RUEN which says that total emission in 2025 is 893.4 Million Ton CO_2eq, and in 2050 is 1.9 Billion Ton CO_2eq, since this Outlok uses lower economic growth assumption (Picture 4.36).



Picture 4.36 GHG Emission 2016-2050

4.7.1 Emission per Capita

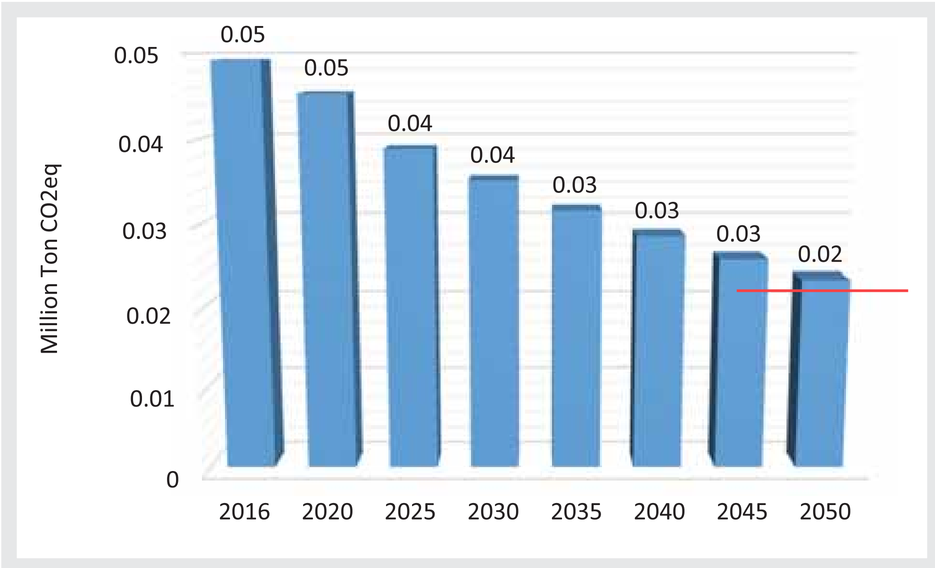
Indicator which describes CO_2 emission in a country is to predict the correlation between CO_2 emission volume with population and economy. CO_2 emission per inhabitant (Ton/Capita) will grow from 1.73 Ton CO_2/capita in 2016 into 2.15 Ton CO_2/capita in 2025 and 4.25 Ton CO_2/capita in 2050 or increases two and a half times in the next 34 years. This occurs since emission growth is higher compared to population growth (Picture 4.37)



Picture 4.37 Emission by Capita

4.7.2 Emission per GDP

In 2016, total emission per GDP is 0.05 Ton CO_2 per Million Rupiah and decreases to 0.04 Ton CO_2 per Million Rupiah in 2025 and 0.02 Ton CO_2 per Million Rupiah in 2050. This is due to efficient energy usage which causes lower energy consumption growth. This condition creates slower emission growth compared to GDP growth (Picture 4.38).



Picture 4.38 Emission by GDP

CHAPTER V

NRE OPTIMIZATION AND ENERGY EFFICIENCY SCENARIO

Indonesia Energy OUTLOOK 2017

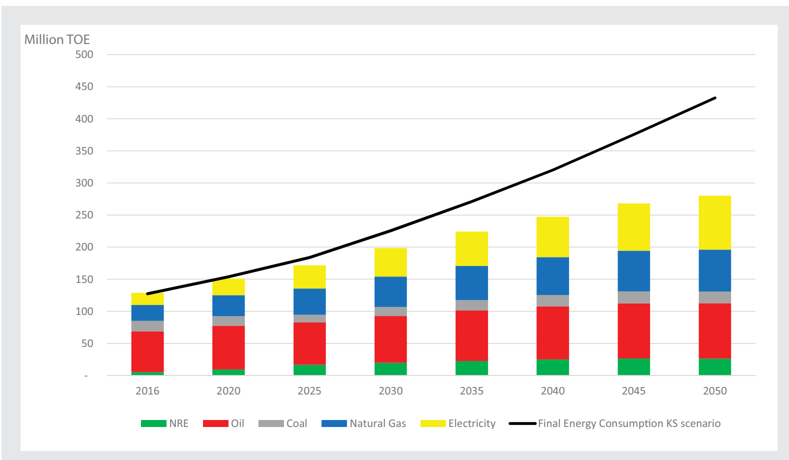
V NRE OPTIMIZATION AND ENERGY EFFICIENCY SCENARIO

5.1 Final Energy Demand

NRE Optimization and Energy Efficiency (OEE) scenario is a decarbonization scenario. This scenario is purposed to find out how far the decarbonization can be implemented in Indonesia and to identify maximum efforts to reduce energy growth rate to the lowest level.

In OEE scenario, maximum implementation of energy efficiency in transportation, industry, household, and other sectors will increase energy efficiency in each sector by around 40% in 2050 compared to KS scenario.

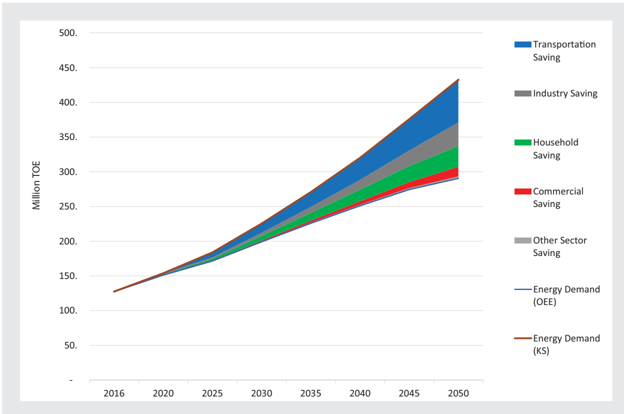
Final energy demand in OEE scenario is 171 million TOE in 2025 and 280 million TOE in 2050. It grows 6.6% per year. Compared to final energy demand in KS scenario, there is a saving of 7% in 2025 and 35% in 2050 (Picture 5.1).



Picture 5.1 Final Energy Demand by Energy Source

Final energy demand in transportation is 48 Million TOE in 2025 and 72 Million TOE in 2050. Final energy demand in industry is 63 Million TOE in 2025 and 106 Million TOE in 2050. Final energy demand in household is 31 Million TOE in 2025 and 48 Million TOE in 2050. Final Energy demand in commercial sector is 8 Million TOE in 2025 and 23 Million TOE in 2050.

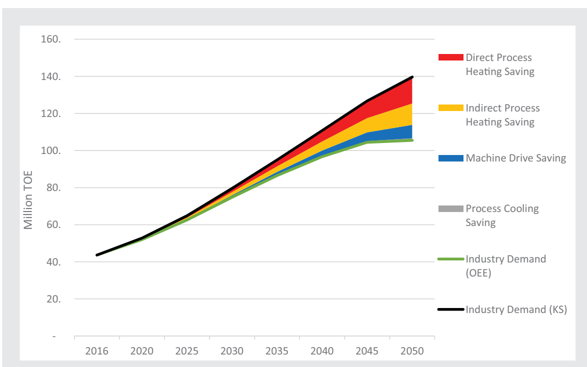
Compared to KS scenario, the biggest saving comes from transportation and industry with the contribution around 30-43%, followed by household with 17-24%, commercial sector with 5 to 10% and other sector with 1-2% until 2050. The effort of each sector in decarbonization will be explained in details (Picture 5.2).



Picture 5.2 Final Energy Saving

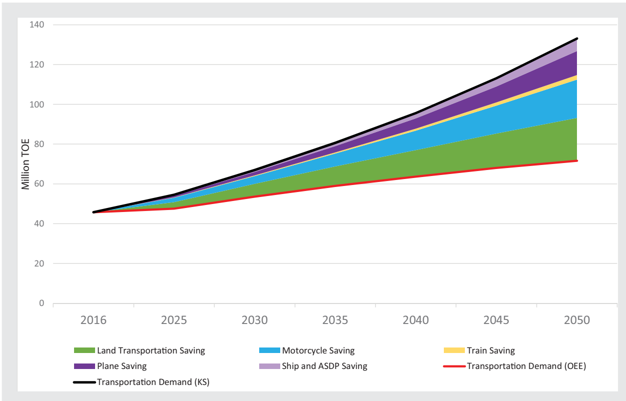
Efficiency in industry is mostly conducted in heating process, both direct and indirect heating process as well as motor driven. In direct heating, the efforts to reduce heat loss are conducted by implementing regenerative burner reheating furnace. In indirect heating, efficiency is conducted through waste heat recovery implementation or with highest efficiency boiler. The use of driven motor with premium class National electrical Manufacturers Association (NEMA) classification for fan, blower, compressor or pump is expected to significantly save the energy.

Energy saving in industry in 2050 is derived from direct heating process (14 Million TOE), indirect heating process (12 Million TOE), machine drive (7 Million TOE) and cooling process (1 Million TOE) (Picture 5.3).



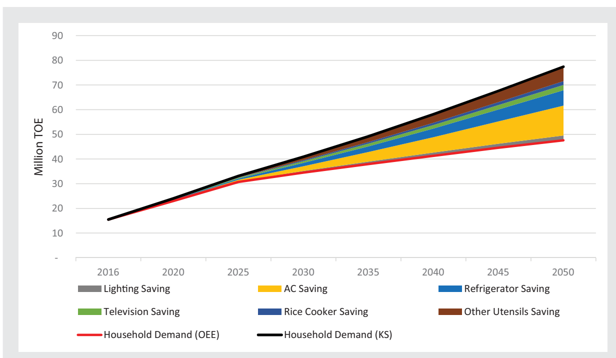
Picture 5.3 Final Energy Saving in Industry

The biggest saving in transportaton is due to the utlization of electric motor cycle up to 50% from the total motor cycle in 2050. Thus, it saves 19 Million TOE. The biggest saving also comes from road transportation (car, bus and truck). This saving is due to the shifting from road transportation to train (Picture 5.4).



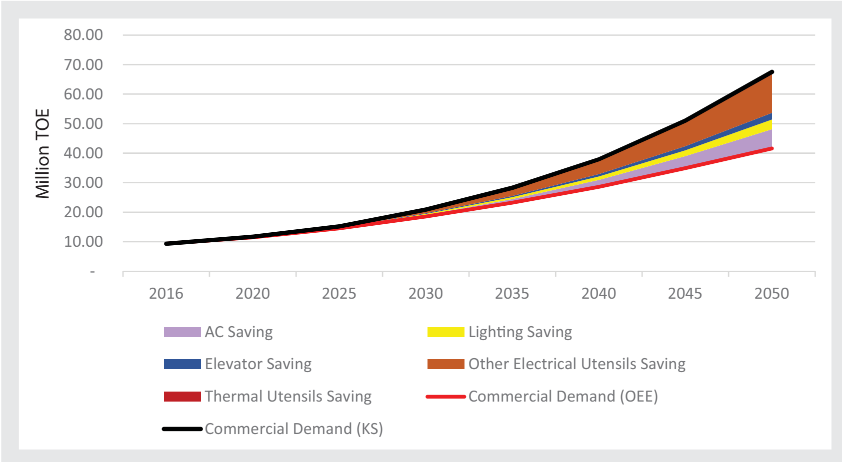
Picture 5.4 Final Energy Saving in Transportation

In household in 2050, the energy saving is 12 Million TOE from inverter AC, 6.3 Million TOE from refrigerator, and 6 Million TOE from other household appliances such as water pump, iron, dispenser, fan and others. The high utilizaton of inverter technology in OEE scenario contributes energy saving in household up to 90% (Picture 5.5).



Picture 5.5 Final Energy Saving in Household

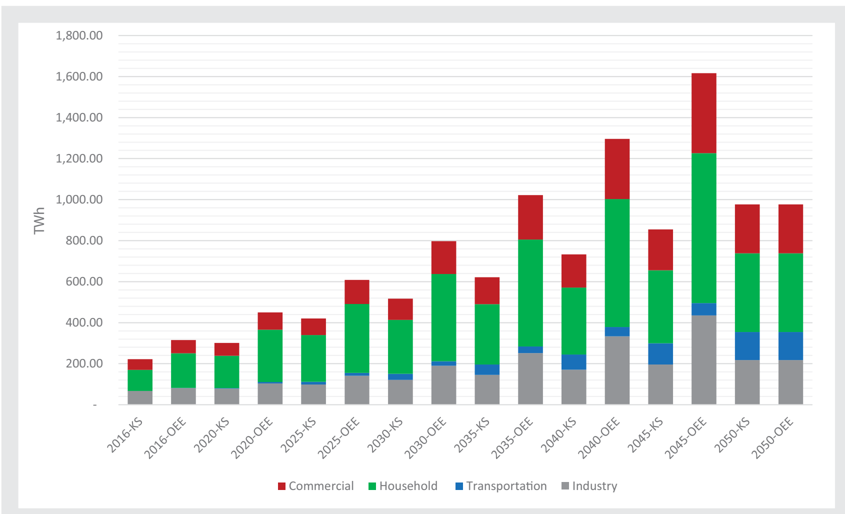
In commercial sector in 2050, the biggest saving is from AC up to 6.5 Million TOE due to the implementation of inverter technology. AC is an appliance in commercial building which uses significant amount of energy reaching 50 to 60% of the building's total energy consumption. Lighting as the second biggest energy consumer in the building contributes energy saving up to 3.3 Million TOE. The utilization of energy saving lamp such as LED or TL5 can reduce significant energy demand. The use of energy saving elevator in commercial sector can also reduce energy demand up to 2.2 Million TOE (Picture 5.6).



Picture 5.6 Final Energy Saving in Commercial Sector

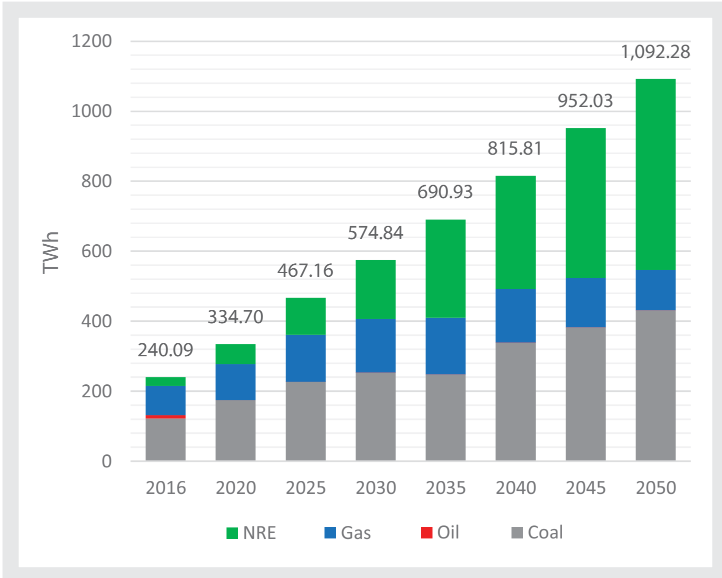
5.2 Power Supply

Final energy demand saving in various sectors in OEE scenario causes lower power production. In OEE, power demand in 2025 will be 7% lower than in KS scenario. In 2050, the saving reaches 39.6% (Picture 5.7).



Picture 5.7 Power Demand

Power demand saving in 2025 causes power production with OEE scenario to be slightly lower of around 30 TWh from 500 TWh in KS scenario to 470 TWh. In 2050, power demand saving reaches 39.6%. Thus, power production in OEE will be only 1100 TWh compared to 1800 TWh in KSI scenario. Picture 5.8 shows power production in OEE scenario by fuel types.



Picture 5.8 Power Production

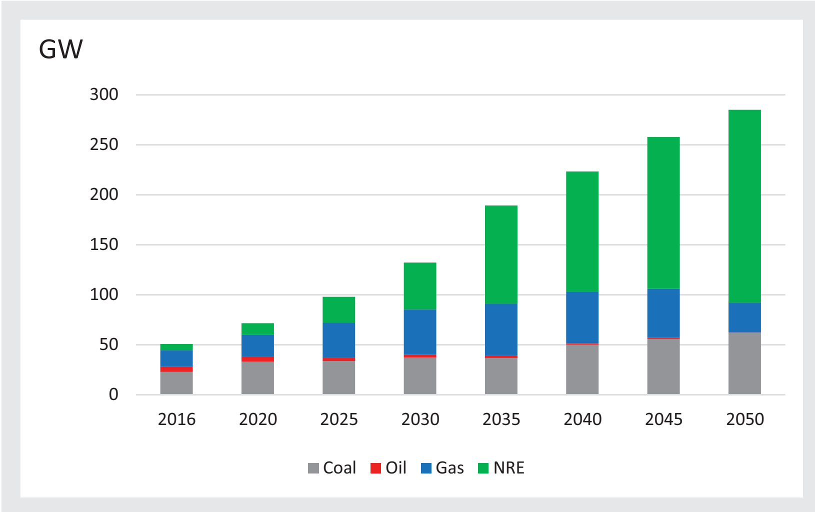
Total power plant installed capacity in OEE scenario is predicted to reach 99 GW in 2025 and 285 GW in 2050. Compared to KS scenario, there will saving on additional power plant capacity during projection periode. In 2025, the saving on total power plant capacity will be around 26 GW and will be bigger in 2050 of around 112 GW (Picture 5.9).

The share of fossil fuel power plant capacity is still dominant in 2025 of around 73 GW in which 34 GW is coal power plant capacity and 35 GW is gas power plant capacity. The rest is oil fueled power plant capacity operating especially outside Java.

NRE power plant operating in 2025 is predicted to be dominated by solar PV with the capacity of 9 GW and geothermal power plant of 7 GW. Hydro power plant capacity will be around 6 GW and biomass power plant including 3 GW of municipal solid waste power plant.

In 2050, the share of coal power plant in the total power plant capacity will be around 22% or around 62 GW while the share of gas power plant will be around 11% from 36% in 2025. Diesel power plant will still be operating but the share is very low.

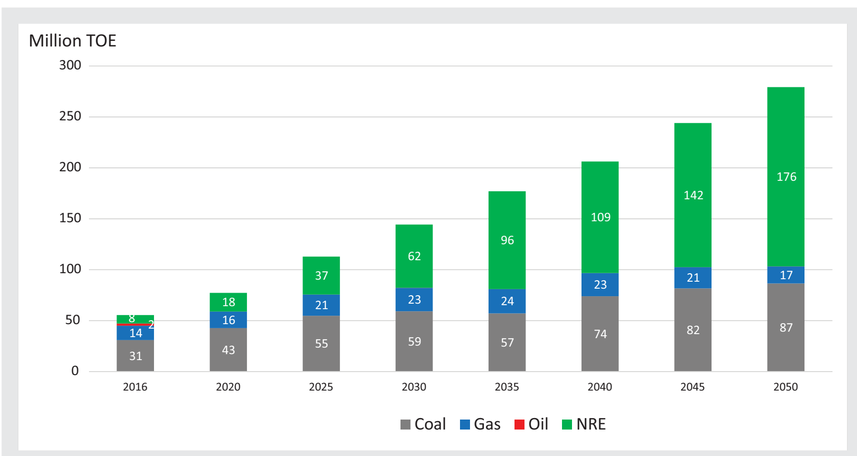
NRE power plant share will increase to 67% of the total capacity in 2050. Solar PV share is predicted to be the biggest with 45%, while hydro power plant share is 11% and geothermal power plant share is 5%. Biomass power plant capacity is predicted to reach 17 GW in 2050.



Picture 5.9 Power Plant Capacity

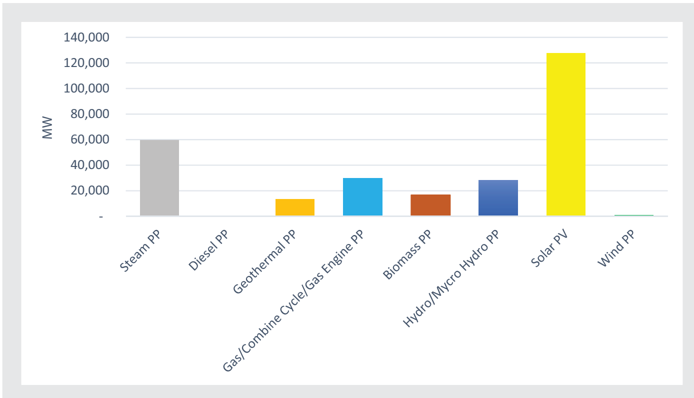
Energy utilization for power plant will reach 113 MTOE in 2025 with the share of 48% coal, 19% gas and 33% NRE. For diesel power plant, since its utilization is still limited and tends to decline, the demand is also only around 0.07 MTOE. In 2050, energy demand increases almost 280 MTOE with a very significant NRE share in producing electricity. Thus, coal and gas share will be lower of about 31% for coal and 6% for gas.

Energy utilization for solar PV is the biggest among other NRE power plants. The use of solar power reaches 22% from the total power plant energy demand, while geothermal use is around 16%, hydro is around 12% and biomass is around 11% (Picture 5.10).



Picture 5.10 Input Primary Energy for Power Plant

Total additional power plant capacity during the period of 2016-2050 is 276 GW with the biggest portion of 127 GW from Solar PV, 59 GW from Steam Power Plant, 30 GW from Gas Power Plant and 28 GW from Hydro Power Plant. The rest capacity is derived from Biomass Power Plant and Geothermal Power Plant (Picture 5.11).

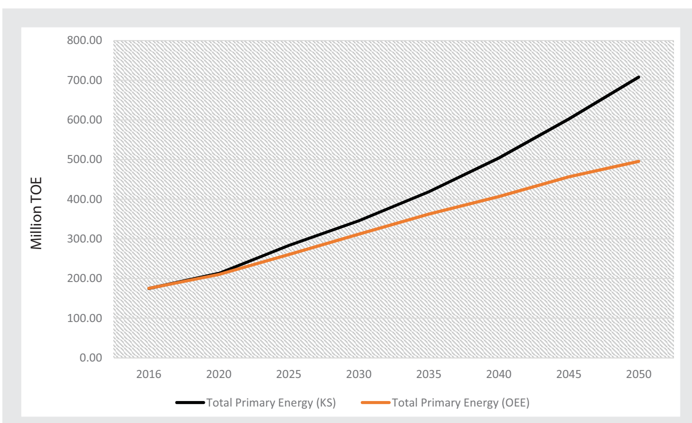


Picture 5.11 Additional Power Plant Capacity 2016-2050

5.3 Primary Energy Supply

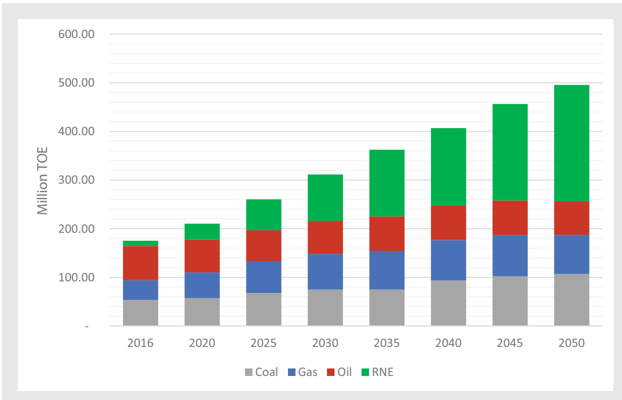
In 2016-2050, total primary energy supply for OEE scenario is predicted to increase with the average growth rate of 8.6% per year into 261 Million TOE in 2025 and 495 Million TOE in 2050.

OEE scenario results lower primary energy supply projection than KS scenario. This is due to aggressive energy saving assumption in all consumer sectors, including transportation, industry, household and commercial sector. The development of primary energy supply in 2016-2050 for both scenarios is shown in Picture 5.12.



Picture 5.12 Primary Energy Supply

Primary energy source which will dominates energy supply mix in 2025 in OEE scenario is oil followed by coal, gas and NRE. Energy saving, biofuel mandatory and electric car in transportation is not yet able to catch up fossil fueled vehicles growth as the biggest contributor in oil primary energy mix. Additional NRE power plant is relatively small. Thus, power supply still counts on fossil fuel power plant from coal and gas. Oil and coal share into 24.6% and 26.1%, while gas share is relatively constant in 24.9%. Meanwhile, NRE share increases into 24.4%. NRE sources which will grow very fast are biofuel, hydro and geothermal (Picture 5.13).



Picture 5.13 Primary Energy Supply by Energy

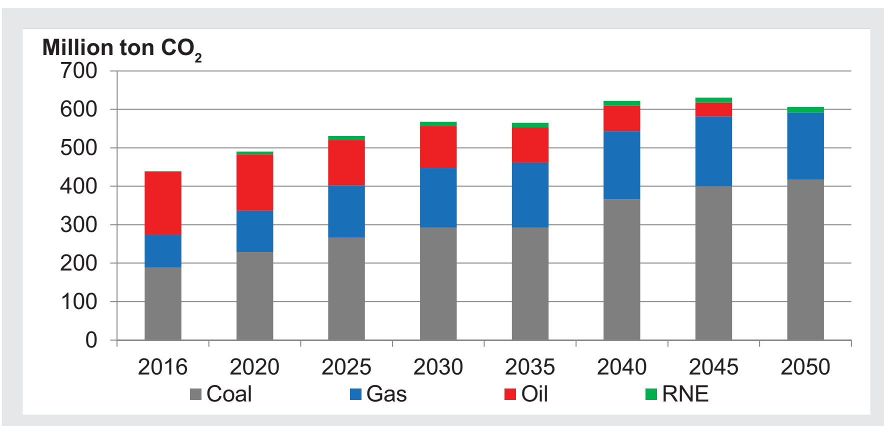
In 2050, there will be a significant shift in which NRE supply will be dominant followed by gas, coal and oil. Electric vehicle penetration is relatively high since 2025 which is able to reduce significant oil supply. Besides that, biofuel utilization higher than the Biofuel road map gives major contribution to NRE role. In power sector, the role of coal power plant is replaced by NRE and gas power plant which is more environmentally friendly. Thus, NRE share will increase into 48% in 2050. Meanwhile, the share of gas, coal and oil is 16%, 22% and 14%.

In KS scenario, fossil primary energy such as coal, gas and oil dominates the primary energy mix. The primary energy mix in OEE scenario shows a condition where NRE dominates the primary energy mix. As explained earlier, OEE scenario is decarbonization scenario in which carbon emission is reduced maximally. The efforts in carbon emission reduction include energy conservation and efficiency as well as fuel switching from fossil to NRE.

5.4 Green House Gas Emission (GHG)

In controlling Green House Gas Emission, Indonesia in 2004 has ratified Kyoto Protocol (KP) as stipulated in Law number 17 of 2004 on the Ratification of Kyoto Protocol to United Nations Framework Convention on Climate Change. Indonesia's commitment in handling global climate change issue has been declared in G-20 Summit in Pittsburg, United States on 25 September 2009 which resulted in Green House Gas Emission National Action Plan. In this Action Plan, Indonesia commited to reduce GHG emission up to 26% by 2020 without International aid and 41% with international aid. This commitmen is re-declared with the ratification of Paris Agreement as stated in Law number 16 of 2016 where Indonesia is commited to reduce GHG emission up to 29% by 2030 without international aid and 41% with international aid. Referring to First Nationally Determined Contribution (First NDC), GHG emission rate in energy sector in 2030 is targeted to reach 1,669 Million Ton CO_2eq (BaU), 1,355 Million Ton CO_2eq (without international aid/CM 1), and 1,271 Million Ton CO_2eq (with international aid/CM2).

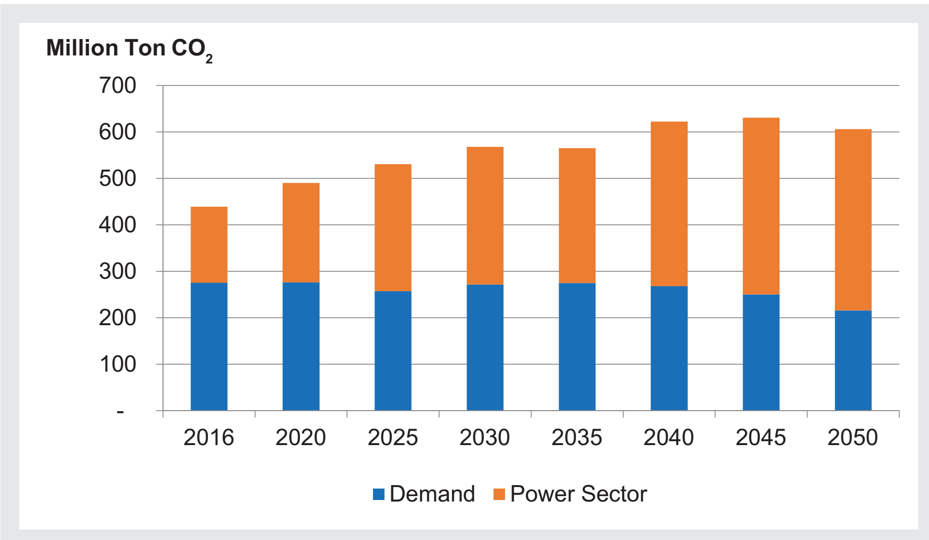
OEE scenario projection shows that in the next 35 years, green house gas emission will increase from 442 Million Ton CO_2eq in 2016 to 606 Million Ton CO_2eq in 2050 or increases 0.8% per year. Based on energy source which contributes to GHG, coal is the biggest energy source which contributes GHG up to 43% in 2016 and 69% in 2050. Quantitatively, GHG emission from coal increases with the growth rate of 2.3% per year (189 Million Ton in 2016 and 417 Million Ton in 2050). GHG emission from coal is mostly contributed from coal burnt in power plant (65-85%). The second biggest emission contributor is oil by 37%. GHG emission from oil is mostly derived from final energy used in transportation. However, emission from oil is declining along with the decilining utilization of oil in transportation and the shifting to biofuel, gas and electricity. Meanwhile, GHG emission from gas contributes 19% in 2016 and increases to 26% in 2050. GHG emission from gas reaching 60%-75% is derived from final energy in industry and transportation. Quantitatively, GHG emission from gas increases from 85 Million Ton CO_2eq in 2016 into 174 Million Ton CO_2eq in 2050 or increases 2.1% per year. The GHG emission development based on energy source is shown in Picture 5.14.



Picture 5.14 GHG Emission by Energy Source

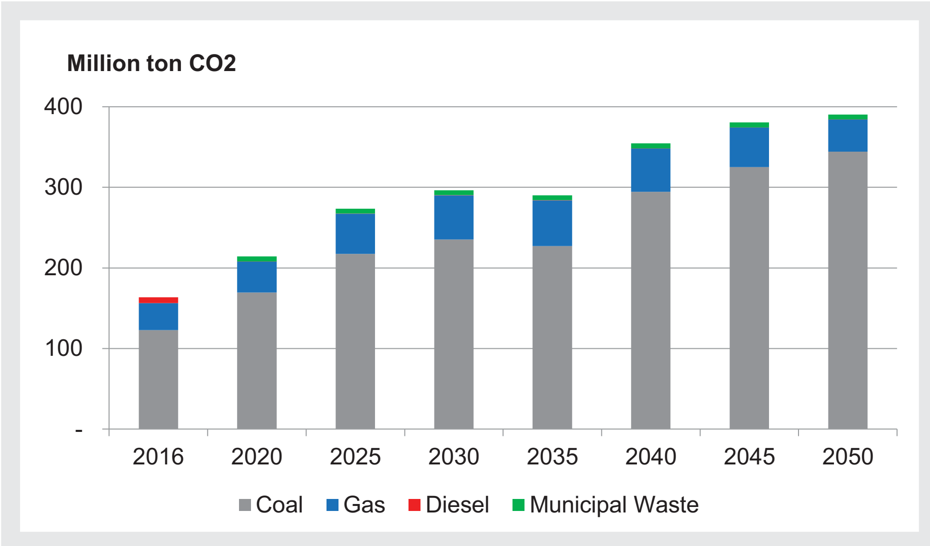
From the group of energy supply-demand in 2016, 63% GHG emission is derived from direct fuel (final energy) in appliances in demand side and 37% GHG emission is derived from fuel in power plant (primary energy). From 63% GHG emission in final energy, 31% of it comes from transportation, 25% comes from industry and 8% comes from other sectors.

Compare 2016, GHG emission contribution from final energy can be reduced into 49% (2030) and 36% (2050). From 33% emission in 2050, 23% comes from industry and 4% comes from transportation. Generally, the low emission contribution from final energy is due to replacement of energy consuming appliances with energy saving appliances and clean fuel substitution in transportation such as biofuel and electric car. In industry, most emission is derived from coal. GHG development in consumer and power plant is described in Picture 5.15.



Picture 5.15 Green House Gas Emission Projection by Consumer and Power Plant

In electricity, GHG emission is projected to increase from 163 Million Ton CO_2eq in 2016 to 390 Million Ton CO_2eq in 2050 or increases 2.5% per year. From this emission, 75%-88% is derived from coal power plant. Despite that future power plant has used efficient technology such as supercritical and ultra critical, the increasing power plant capacity will also increase emission contribution from power sector. Meanwhile, the share of emission from gas power plant is declining from 21% in 2016 to 10% in 2050, but the quantity of the emission is increasing 2.5% per year. Gas power plant still becomes the option since it is cheap and clean. The prioritized gas power plant technology is Combined Cycle Gas Turbine Power Plant with 90%. GHG emission projection in power plant is shown in Picture 5.16.



Picture 5.16 Power Plant Emission Projection

Compared to current policy scenario, GHG emission in NRE optimization and energy efficiency scenario can be reduced 23% by 2030 and 56% by 2050 from the emission in current policy scenario. GHG emission reduction in OEE scenario compared to in KS scenario is shown in table 5.1.

Table 5.1 Green House Gas Emission by Scenario (million Ton CO_2)

Scenario	2016	2020	2025	2030	2035	2040	2045	2050
KSI	442	534	612	741	879	1.037	1.222	1.425
OEEE	442	490	531	568	565	622	631	606
Reduction		44	82	174	314	415	592	819
% Reduction		8%	13%	23%	36%	40%	48%	57%

Referring to First Nationally Determined Contribution (NDC), GHG emission in OEE scenario in 2030 can be reduced 55% from BaU NDC scenario. GHG emission reduction in OEE scenario compared to emission reported in First NDC is influenced by the implementation of all policies in the form of regulation and planning such as RUEN, RUPTL, biofuel mandatory, NRE utilization, and energy saving technology penetration.

Based on emission indicator per capita and emission per GDP, CO_2 emission per habitant (Ton/capita) will grow from 1.7 Ton CO_2/capita in 2016 into 4.26 Ton CO_2/capita (KS scenario) and 1.86 Ton CO_2/kapita (OEE scenario) in 2050. GHG emission projection based on indicator per capita and per million rupiah GDP is shown in table 5.2.

Table 5.2 GHG Emission by Indicator per Capita and per Million Rupiah GDP

CO_2 Emission per capita (tons/kap)								
Scenario	2016	2020	2025	2030	2035	2040	2045	2050
KSI	1.71	1.97	2.15	2.50	2.87	3.29	3.76	4.25
OEEE	1.71	1.81	1.86	1.92	1.85	1.97	1.94	1.81
CO2 Emission per million rupiah GDP (tons/million rupiah)								
KS	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.02
OEE	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01

With 2015-2050 national GDP growth assumption of 5.63% per year, every 1 million rupiah of national GDP, energy use will contributes 0.05 Ton of CO_2 emission in 2016 and it will decrease into 0.02 Ton (KS scenario) and 0.01 Ton (OEE scenario) in 2050. CO_2/GDP emission reduction shows the tendency that energy is utilized more as productive commodity rather than as consumptive commodity.

5.5 Technology Intervention

Global CO_2 emission reduction and global climate change mitigation have been a consensus of all countries in the world. The technology to reduce greenhouse gas emission can be grouped into two categories. They are emission reduction in consumer sector through the utilization of energy saving appliances and the implementation of demand side management. The technology implementation is conducted through a more efficient conversion program which is able to reduce final energy intensity. The second category is greenhouse gas emission reduction in power plant through energy saving technology which is able to reduce primary energy intensity and convert high emission energy into low emission energy. The example of this technology is sub-critical into super-critical and ultra super-critical in steam fueled power plant. Besides that, increasing the use of renewable energy such as hydro and geothermal power plant for GHG mitigation is also another example since NRE can produce power without combustion. Hydro power plant can be said to be GHG emission-free while geothermal power plant only contributes one sixth from GHG emission in gas power plant. In general, technology penetration or implemented technology to reduce GHG emission is shown in Table 5.3.

Table 5.3 Energy Saving Technology and Clean Technology Penetration

Sector	Technology	Note
Industry	Direct Heating Process	Energy intensity decreases 4% per year
	Indirect Heating Process	Energy intensity decreases 4% per year
	Cooling Process	Energy intensity decreases 2% per year

Table 5.3 Energy Saving Technology and Clean Technology Penetration

Sector	Technology	Note
Transportation	Machine Drive	Energy intensity decreases 2% per year
	Electric car	2,3% (2020) 25% (2050)
	Hybrid car	17,5% (2020) 40% (2050)
	Electric motor cycle	4% (2025) 43% (2050)
	Bio Solar	25% (2020) 30% (2050)
	Bioethanol	14% (2020) 85% (2050)
	Bio Avtur	50% (2025) 100% (2050)
Household and Commercial	Electric Stove	0,9% (2015) 20% (2050)
	DME Stove	0,4% (2020) 9,6% (2050)
	LED Lamp	4,7% (2015) 40% (2050)
	AC_Split Inverter	5% (2015) 60% (2050)
	Refrigerator inverter	10% (2015) 40% (2050)
	Other efficient equipments	5,7% (2020) 40% (2050)
Power Plant	Super critical	34% (2020), 20% (2050)
	Ultra super critical	27% (2030)
	Gas CCGT	100% (2050)
	Geothermal	7,2 GW (2025) 13,1 GW (2050)
	Hydro Reservoar	5,1 GW (2025) 25,3 GW (2050)
	Hydro RVR	0,6 GW starting in 2025
	Pumped Storage	1 GW starting in 2025
	Biomas	0,24 GW (2020) 23,5 GW (2050)
	Munipical Waste	2,6 GW starting in 2020
	Solar PV	0,6 GW (2025) 81 GW (2050)
	Wind	0,4 GW (2020) 0,6 (2050)
	Biogas	1 MW starting in 2020

5.6 Required Policy

Indonesia is potential to develop NRE which is not yet developed optimally. Current NRE energy mix is 7.7% while in 2025 KEN targeted to achieve NRE mix at 23%. It means that the remaining 16% should be achieved in 8 years. The slow development of NRE is due to the lack of institutional support, regulation challenges, and the uncompetitive NRE economic value compared to fossil energy. Besides that, most NRE technology is still dependent on developed countries. There is also the lack of human resources capability in NRE technology as well as lack of incentive and financial mechanism for investor.

NRE utilization target can be achieved with policies on fiscal side, institutional management and capacity building. In general, energy price from NRE is relatively more expensive than fossil energy when externality cost is not considered. Thus, fiscal energy plays an important role. Fiscal policy should includes selling price, subsidy shifting from fossil energy to NRE, incentive certainty and NRE financial facility for investor.

NRE development is partly used to meet power demand in remote areas with separated management and institution from PT PLN and IPP which often faces obstacles. Generally, institutional obstacle occurs when the established management is not involving the society. Thus, there is a need of institution which is technically and administratively liable and responsible on the operation of NRE power plant. It is expected that this institution will support a more coordinated and directed NRE power plant operation. Thus, power supply security to consumer is safe.

Currently, most components in energy industry is imported. To support energy independence and technology mastery, policy to protect domestic industry is needed. The improvement of human resources in NRE is also required.

CHAPTER VI

SPECIAL TOPIC
SOLAR PV PENETRATION
KUPANG AND GORONTALO
SOLAR PV CASE STUDY

Indonesia Energy
OUTLOOK
2017

VI SPECIAL TOPIC SOLAR PV PENETRATION KUPANG AND GORONTALO SOLAR PV CASE STUDY

6.1 Solar Energy Potential and Development in Indonesia

As a tropical country with sun exposure in the whole year almost in all areas, Indonesia has huge potential in developing solar PV. Solar energy potential is recorded 4.8 Kwh/m^2 or equivalent to 112,999 GWp with the classification for Western Indonesia (KBI) of around 4.5 Kwh/m^2 with the monthly variation of 10%; and for Eastern Indonesia (KTI) of around 5.1 Kwh/m^2 with monthly variation of 9%.

Despite of huge potential, solar energy is only developed of around 16 MWp or 0.03% from the potential with the total production of 21.09 GWh. Most of its utilization is to electrify rural areas with small scale Solar Home System (SHS) with the capacity of 150-300 Wp. Meanwhile, the number of solar PV is still limited. The biggest solar PV with the capacity of 1 MW or above in Indonesia currently is in Oelpuah, Kupang, East Nusa Tenggara with 5 MW capacity, in Gorontalo with 2 MW capacity, and in Karangasem and Bali with 1 MW capacity each. Solar PV potential is shown in table 6.1.

Table 6.1 Solar PV Potential in Indonesia

PROVINCE	The intensity of solar radiation (kWh/m^2/day)					Theoretical potential (MW)	Technical potential (MW)
	< 4,21	4,21-4,40	4,41-4,60	4,61-4,80	4,81-500		
Bali	2.180	1.707	2.820	3.741	889	11.337	1.701
Bangka Belitung	4.126	16.847	10.634	1.782	-	33.389	5.008
Banten	1.350	1.972	6.584	9.914	129	19.949	2.992
Bengkulu	10.640	6.334	21.330	3.271	-	41.575	6.236
DI Yogyakarta	-	68	873	3.645	2.306	6.892	1.033
DKI Jakarta	-	1	285	1.149	88	1.523	228
Gorontalo	11.112	4.937	2.219	882	-	19.150	2.872
West Papua	78.030	46.462	41.440	19.502	458	185.892	27.884
Jambi	18.347	32.307	40.030	7.339	-	98.023	14.703
West Jawa	22.360	11.200	10.184	19.584	6.561	69.889	10.483
Central Jawa	11.205	13.176	18.638	18.872	6.651	68.542	10.281
East Jawa	20.142	16.127	22.791	27.720	3.781	90.831	13.625

Table 6.1 Solar PV Potential in Indonesia

PROVINCE	The intensity of solar radiation (kWh/m²/day)					Theoretical potential (MW)	Technical potential (MW)
	< 4,21	4,21-4,40	4,41-4,60	4,61-4,80	4,81-500		
West Kalimantan	60.215	165.539	54.059	6.839	-	286.652	42.998
South Kalimantan	5.952	47.982	13.865	6.639	-	74.438	11.165
Central Kalimantan	49.026	122.879	111.243	16.943	-	300.091	45.014
East Kalimantan	91.504	154.179	94.019	34.077	24	373.803	56.070
Riau Island	-	2.030	9.153	8.251	-	19.434	2.915
Lampung	8.446	8.148	36.062	15.657	1.354	69.667	10.450
Maluku	23.300	14.467	24.844	26.233	3.959	92.803	13.920
North Maluku	16.887	16.239	15.464	16.614	-	65.204	9.780
Aceh	44.894	16.742	38.821	8.815	-	109.272	16.391
NTB	3.128	6.223	11.091	12.170	8.657	41.269	6.190
NTT	5.477	9.291	21.173	32.086	31.747	99.774	14.966
Papua	177.126	228.587	152.793	95.074	1.683	655.263	98.289
Riau	1.145	79.215	105.853	8.170	-	194.383	29.157
West Sulawesi	13.125	3.468	6.488	2.880	424	26.385	3.958
South Sulawesi	25.746	11.089	14.833	22.487	11.601	85.756	12.863
Central Sulawesi	55.991	21.141	14.564	7.759	446	99.901	14.985
South East Sulawesi	25.517	15.686	14.068	13.240	-	68.511	10.276
North Sulawesi	12.984	4.332	3.960	4.674	-	25.950	3.892
West Sulawesi	37.744	13.461	23.749	1.288	-	76.242	11.436
South Sulawesi	23.154	38.663	62.683	49.137	-	173.637	26.045
North Sumatera	41.644	22.227	54.286	24.782	-	142.939	21.441
TOTAL	902.767	1.152.726	1.060.899	531.216	80.758	3.728.366	559.266

Solar PV in Indonesia is in sufficient level. Thus, it can be used as a reference to formulate solar PV energy source planning in the future. Based on potential map, the biggest solar exposure intensity is in northern coastal areas of Banten, southern coastal areas of West java, north Central Java, Nusa Tenggara and Papua. However, technically and theoretically, areas with the biggest potential is Papua, East Kalimantan, and Central Kalimantan. But generally, the potential in all Provinces are relatively high.

Solar PV installed capacity in the last four years has been increasing four times, despite that the increase in the last three years is less significant. The interesting thing is the role of private sector in 2016 which contributed 58% or 5 MW from solar PV in Kupang, while PLN only contributed 42% (Table 6.2).

Table 6.2 Installed Capacity and Energy Production from Solar PV

Year	Installed capacity	Production (GWh)		
	MW	PLN	IPP & PPU	Total
2010	0.19	0.50	0.02	0.52
2011	1.16	0.72	0.05	0.77
2012	4.09	2.85	0.16	3.01
2013	9.02	5.48	0.02	5.50
2014	9.02	6.81	0.00	6.81
2015	9.02	5.28	0.00	5.28
2016	16.02	8.78	12.31	21.09

6.2 Solar PV Technology Implementation

Solar module application in the system can be grouped into stand-alone system or off-grid system and grid-connected system (on-grid). On-grid is solar modul system which connects to PLN network system. Stand Alone system consists of individual (or panel) photovoltaic modules with 12 volt as well as 50 and 100 watt power output. This PV modul is then combined into one to produce the need power output. This system usually produces power to recharge battery in the day to be used at night when there is no solar power. If needed, this system can also be combined with power from resources other than solar module such as fuel generator, wind power and battery. This system is called hybrid system. Stand alone PV system is ideal for remote rural areas and it is suitable to be used in areas without energy resources to power lighting, appliances and other uses.

The most advanced solar PV technology is wafer based-crystal silicon (c-Si). C-Si Technology has entered into the market 50 years ago and recorded the biggest market share (around 93.5%). Non-silicon PV technology such as CIGS (copper indium gallium (di) selenide) and CdTe (kadmium telluride) contribute each 6.5% share. Since then, the producer has reduced the cost and increased the content significantly.

The cost of solar panel is in price per watt ($/Watt). The ten cheapest solar panels are shown in Table 6.3.

Table 6.3 The Cheapest Solar Panel in the Market

Num	Model	Power	Price	Price per Watt
1	TP660P-235	235W	$183.30	$0.75
2	CS6P-235PX	235W	$190.35	$0.81
3	E156P/60-230W	230W	$204.70	$0.89
4	E156P/60-240BB	240W	$213.60	$0.89
5	E156P/72-280W	280W	$249.20	$0.89
6	TP660PB-240	240W	$220.80	$0.92
7	TP660PB-245	245W	$225.40	$0.92
8	MPV285	285W	$262.20	$0.92
9	JKM-235P	235W	$230.30	$0.98
10	ECO230S156P-60	230W	$227.70	$0.99

The above price is based on minimum purchase of 25 modules added by 10-20% is it sold per panel basis.

Solar panel efficiency depends on its cell type. Table 6.4 shows example of solar power efficiency.

Table 6.4 Solar Panel Efficiency

Model	Type of Cell	Efficiency (%)
X21-345	Mono	21.5
X21-335-BLK	Mono	21.1
KSIR-343J-WHT-D	Mono	21.0
KSIR-343NJ-WHT-D	Mono	21.0
KSIR-445J-WHT-D	Mono	20.6
KSIR-445NJ-WHT-D	Mono	20.6
VBHB195DA03	Mono	20.5
PS320PB-24/T	Poly	16.5
TKSG-29001	Poly	16.4
TS-M419JA1	Poly	16.4
TS-M420JA1	Poly	16.4
TSM-265PA05A	Poly	16.4
TSM-265PA05A	Poly	16.4

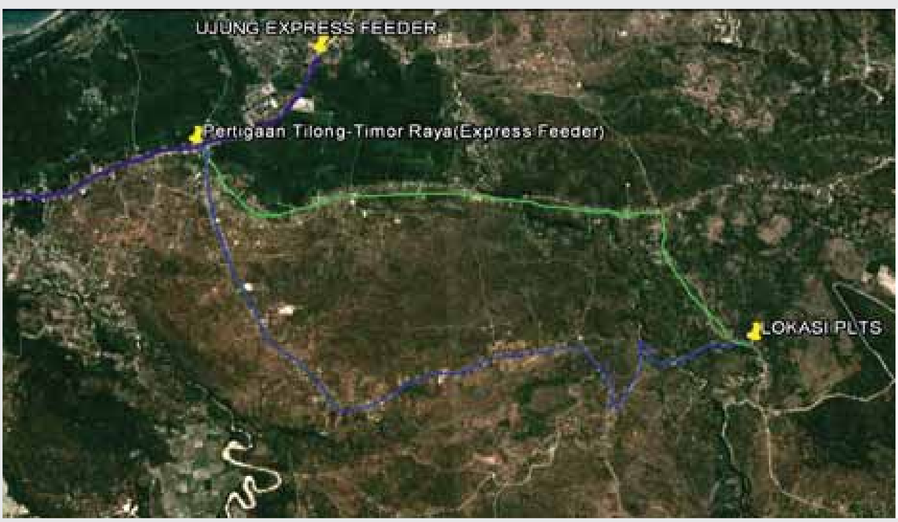
6.3 Solar PV Prospect

Globally, in the last five years, PV installed capacity has doubled every two and half year. In the end of 2016, PV cumulative capacity increases more than 75 GW up to 303 GW or around 33% compared to in 2016. This increase contributes 1.8% supply from the total world power consumption. Five countries as the biggest solar energy suppliers in 2016 are China (78 GW), Japan (42.8 GW), Germany (41.2 GW), US (40.3 GW) and Italia (19.3 GW). In another country, such as Honduras has supplied 12.5% from solar power to its national power. Germany and Greek have produced 7%-8% from domestic electricity demand.

IEA (International Energy Agency) predicted that solar PV will be the main power plant in the future. Its installed capacity in the world is projected to increase 2 to 3 times reaching more than 500 GW in 2016-2020. In 2050, solar power is projected to be the biggest electricity resources in the world with solar PV and solar power each contributes 16% and 11%. The abundant resources, its environmentally friendly nature, and low risk have supported solar power to be an interesting option among other renewable energy resources.

6.4 Kupang Solar PV

PT LEN Industri is stipulated as the winner in 5 MWp Kupang Solar PV tender in January 2014. Then it is followed up with power purchasing agreement with PT PLN in January 2015 with $ US 0,25/kWh for 20 years and COD on 1 March 2016. This solar PV is located in Delpuah village, Kupang in the area of 7.5 hectare, 6.38 solar exposure intensity, and 5.52 (kWh/m^2/day) at the lowest. The connection position to grid system is shown in Picture 6.1.



Picture 6.1 Connection Position to PLN on Grid System

PT LEN Industri produces 22,008 PV modules from polichrystalin type consisting of 24 module series and 917 parallel circuits with 230 Wp of power per unit. There are 250 inverters and type of string inverter. The PV module circuit is shown in Table 6.5.

Tabel 6.5 Solar PV Modul Configuration in Kupang

Modul PV	
Orientation Azimut / Tilt	10º/0º
Total PV Modul	22,008
Jumlah Series	24 modules
Jumlah Parallel	917 strings
Nominal Power per unit	230 Wp
Tipe	Polycristalline
Inverter	
Total Inverter	250
Nominal Power per unit	20.00 kW
Type	String Inverter

Source: PT LEN Industri (Persero)

Power production from Solar PV is assumed to decline due to the declining equipment's durability through the time. The projection of power production from Kupang Solar PV for the next 20 years is shown in the following Table 6.6.

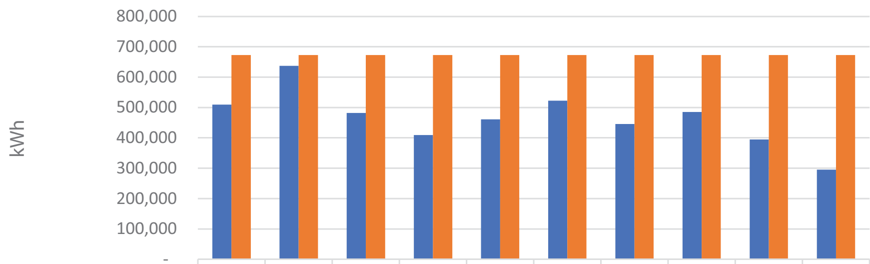
Table 6.6 Power Production Projection from Kupang Solar PV in 20 Years

Year to-	Electricity generation at installed capacity	
	MWh	Capacity factor
1	8.069.852	18,4%
2	8.029.503	18,3%
3	7.989.355	18,2%
4	7.949.409	18,2%
5	7.909.662	18,1%
6	7.870.113	18,0%

Table 6.6 Power Production Projection from Kupang Solar PV in 20 Years

Year to-	Electricity generation at installed capacity	
	MWh	Capacity factor
7	7.830.763	17,9%
8	7.791.609	17,8%
9	7.752.651	17,7%
10	7.713.888	17,6%
11	7.675.318	17,5%
12	7.636.942	17,4%
13	7.598.757	17,3%
14	7.560.763	17,3%
15	7.522.959	17,2%
16	7.485.345	17,1%
17	7.447.918	17,0%
18	7.410.678	16,9%
19	7.373.625	16,8%
20	7.336.757	16,8%

In normal condition, the capacity of Kupang Solar PV is less than 10% of the system capacity. However, when the high scale power plant experiences disturbance, the solar PV capacity will be 10% from the system capacity. Besides that, the under frequency relay setting is above grid code (49.5 Hz). SCADA and dispatching system is not yet perfect. Consequently, Kupang solar PV could not work maximally in the first year. Power production target and realization of 5 MWp Kupang solar PV in 2016 is shown in Picture 6.2.



	March	April	May	June	July	August	September	October	November	December
Realization	509,384	637,200	482,184	409,614	461,275	522,677	445,432	485,384	395,080	295,040
Target of Declaration	672,487	672,487	672,487	672,487	672,487	672,487	672,487	672,487	672,487	672,487

Picture 6.2 Energy Production Target and Realization 2016 (in kWh)

Power production from Kupang solar PV is highly dependent on weather and sun position in latitude. The profile of 5 MWp Kupang Solar PV in 2016 is shown in Table 6.7.

Table 6.7 Profile of 5 MWp Kupang Solar PV 2016

Annual Production Declaration: 8.069.852 kWh										
Month	Poduction declaration (kWh)	kWh Meter PLTS (kWh)			kWh Meter PLN (kWh)			Losses*)	Schedule of Planned Maintenance	Power plant performance
		Delivered	Received	Total	Export	Import	Total			
January	-	-	-	-	-	-	-	-		
February	-	-	-	-	-	-	-	-		
March	672.487,67	520.897	5.791	515.106	511.624	2.240	509.384	1,11%		Constraint, Weather: Rain, Cloud
April	672.487,67	650.830	5.910	644.921	641.256	4.056	637.200	1,20%		Constraint, Weather: Rain, Cloud
May	672.487,67	486.650	1.428	485.222	483.936	1.752	482.184	0,63%		Constraint, Weather: Rain, Cloud
June	672.487,67	417.768	1.428	416.340	415.134	5.520	409.614	1,62%	Tanggal 15	Constraint, Weather: Cloudy, Cloud
July	672.487,67	470.354	4.297	466.057	465.835	4.560	461.275	1,03%		Constraint, Weather: Cloudy, Cloud

Table 6.7 Profile of 5 MWp Kupang Solar PV 2016

Month	Poduction declaration (kWh)	Annual Production Declaration: 8.069.852 kWh						Losses*)	Schedule of Planned Maintenance	Power plant performance
		kWh Meter PLTS (kWh)			kWh Meter PLN (kWh)					
		Delivered	Received	Total	Export	Import	Total			
August	672.487,67	530.439	4.315	526.124	527.237	4.560	522.677	0,66%		Constraint, Weather: Cloudy, Cloud
September	672.487,67	462.063	7.758	454.306	449.368	3.936	445.432	1,95%		Constraint, Weather: Cloudy, Cloud
October	672.487,67	489.994	3.975	486.019	489.400	4.016	485.384	0,13%		Constraint, Weather: Cloudy, Cloud
November	672.487,67	406.640	3.846	402.794	399.080	4.000	395.080	1,92%		Constraint, Weather: Cloudy, Cloud
December	672.487,67	281.490	1.089	280.401	296.504	1.464	295.040	-5,22%**)		Constraint, Weather: Cloudy, Cloud
TOTAL	6.724.878			4.677.288			4.643.270			

*) The distance between Solar PP kWh meter and PLN kWh meter is 6.5 km

*) Losses can also be caused by the quality of generators and voltage fluctuations in interconnection with other plants.

**) The difference in reading -5,22% occurs since the 220V voltage in monitored house is not stable and experiences blakouts. Thus, the undistributed energy is not recorded in Solar PV kWh meter.

6.5 Gorontalo Solar PV

Gorontalo Solar PV is administratively located in Motihelumo village, East Sumalat sub-distric, North Gorontalo regency, Gorontalo Province. The 2 MWp Gorontalo Solar PV was constructed in 8 months and conducted its commercial of date (COD) on 19 February 2016. The details capacity data can be seen in Table 6.8.

Table 6.8 MWp Gorontalo Solar PV Capacity Data

No.	Component	Total
1	Inverter 30 kWp	68 unit
	68 x 30.000 W	2.040.000 W
	1 inverter 30 kWp served by 2 Table of PV Modul	
	1 Table PV Modul = 21 x 3 = 63 unit PV modul = 15.120 W	
	Total PV Modul = 68 inv. x 2 Table x x 21 x3 = 8.568 unit PV modul	
2	Pv modul 240 Wp	8.568 unit
	8.568 x 24 Wp	2.056.320 Wp
3	Transformer 1.250 kVA	2 unit
	2 x 1.250.000 VA	2.500.000 VA

Table 6.9 Solar PV Production data

Month	Energy production (kWh)
Mar-2016	265.840
April-2016	276.600
Mei-2016	234.760
Juni-2016	228.960
Juli-2016	241.560
Agustus-2016	291.280
September-2016	246.120
Oktober 2016	247.080
November-2016	227.600
Desember-2016	209.920
Januari-2017	211.440
Februari-2017	185.160
Total	2.866.320

Capacity Factor(CF)

Production Realization (1 March 2016 to 28 February 2017) = 2,866,330 kWh
Installed capacity = 2,000 kWx 24 hours x 365 days = 17,520,000 kWh

$$CF = \frac{Production\ capacity\ (1\ year)}{Installed\ capacity\ (1\ year)}$$

CF realization = 16.36%

Power production realization of 2 MWp Gorontalo Solar PV (1 March 2016 to 28 February 2017) is 2,866,330 kWh. The installed production capacity with 24 hours/day operation assumption is 17,520,000 kWh. The capacity factor value is 16.36%. Production data of 2 MWp Gorontalo Solar PV is shown in Table 6.9.

The technical issues in Gorontalo solar PV are the blackout in PLN on grid due to network maintenance (the cause of 70% black out), natural disaster (landslide and fallen tree) as the cause of 30% blackout. In the first year, there were 276 (236+40) of black out hours or equivalent to 180,617.42 kWh or IDR 547,162,426.26. Besides that, black out also happens four times in a year (2 hours) since JTM PLN is less than 15 kV.

The investment cost of 2 MWp Gorontalo Solar PV is around IDR 50 Billion and the first year operation cost is IDR 1.8 Billion The details of investment and operation cost can be seen in Table 6.10.

Table 6.10 Investment Cost of 2 MWp Gorontalo Solar PV

No.	Description
1	Direct Cost
	Modul
	Inverter
	Balanced of System
	Civil
2	Indirect Cost

Source: PT Brantas Energi

6.6 Obstacle in Solar PV Penetration into PLN On Grid System

Solar PV has a special nature compared to other power plant. First, it is intermittent which is marked by a changing frequency and voltage as well as frequency system based on solar radiation condition. Thus, solar PV output power depends on solar radiation and system frequency depends on solar PV output power. The second nature of solar PV is non-dispatchable which means that the power volume could not be managed and planned. Thus, the installed capacity could not become the reference.

Major scale solar PV is usually integrated into on grid, but solar PV penetration still depends on spinning reserve from the system. Thus, in general, the maximum solar PV capacity is 10%-20% of the system capacity (power capacity in minimum capacity condition). Besides that, all power plant needs to be equipped with load sharing control to avoid penetration limitation not to decline less than 10%. Penetration is also influenced by short-circuit level to connect power plant in which the penetration level will be higher if the installation of power plant is spread to all system. If it is concentrated, the capability of transmission and distribution channel will limit penetration level.

The obstacle of major scale solar PV penetration to on-grid is the weak grid especially outside Java since it is built by small scale power plant (almost all in the form of genset) and dispatching system which is operated manually. Thus, it is susceptible to a sudden change in frequency and voltage. Besides that, most solar PV is not owned by PLN that makes each solar PV tends to safe its own system in case of disturbance.

6.7 Policy Recommendation Suggestion

To reduce potential obstacles in solar PV development, there are key factors that should be considered. They are land status, grid condition, master plan, regional administrative institution (such as RT, RW, regency/city), and smooth coordination with local leaders (heads of village, public figure, and youth figure).

Based on group discussion with stakeholders, there are inputs to be considered as policy recommendations.

» Improving regulations on:
  1. Obligation to provide system data for interconnection study
  2. Obligation to all power plant to participate in quality improvement of the system
  3. Obligation to cover system maintenance cost to increase solar PV penetration

» Not charging parallel cost in solar PV, especially if it does not transmit power to PLN on-grid. Eventhough it does not transmit energy to PLN network, the solar PV producer will pay for parallel cost. They will also pay for minimum energy cost (as the substitution of subscription, PLN charges minimum energy cost).

» Requiring regulation on upgrade grid cost due to solar PV penetration to on grid system.

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DEFINITION

Biodiesel (B100/pure) is Fatty Acid Methyl Ester (FAME) or Mono Alkyl Ester produced from biological raw material and other biomass which are processed through esterification.

Bioetanol (E100/pure) is ethanol product from biological material and other biomass which are processed through biotechnology.

BOE (Barrel Oil Equivalent) is energy units with a calorific value equivalent to one barrel of oil. Based on IEA conversion standard. 1 BOE is equivalent to 0.14 TOE (see definition of TOE).

BOPD (Barrel Oil per Day) is oil refinery capacity unit which describes refinery production per day.

Btu (British thermal unit) is amount unit of heat required to raise the temperature of 1 lb (one pound) of water into 1oF (Fahrenheit) at a pressure of 14.7 psi (pounds per square inch). (Conversion to MMscf and TOE. see each definition)

Energy Reserve is energy resources known for its location, volume and quality.

Proven Reserve is oil, gas and coal which are predicted to be produced from a reservoir with stipulated and measured size.

Potential Reserve is oil and gas in a reservoir.

Energy Elasticity is the comparison between energy demand growth and economic growth.

Energy is the ability to do work in the form of heat, light. Mechanical, chemical, and electromagnetic.

New Energy is energy from new energy resources.

Renewable Energy is energy from renewable energy resources.

Final Energy is the energy which can be directly consumed by end consumer.

Primary Energy is energy from nature and is not further processed.

Gas is energy type which covers gas, gas refinery products (LPG, LNG) and unconventional gas (CBM)

Natural Gas is all types of gaseous hydrocarbons produced from the well including wet mining gas, dry gas, sheathing pipeline gas, residual gas after the extraction of liquid hydrocarbons and wet gas, and nonhydrocarbon gas mixed in it naturally.

Energy intensity is the total energy consumption per unit of GDP.

Oil is class of energy that covers oil, condensate, natural gas liquid (NGL), and energy derived from petroleum (refinery gas, Ethane, LPG, aviation gasoline, motor gasoline, jet fuels. Kerosene, diesel oil, fuel oil, naphtha, lubricants and other refinery products).

Crude Oil is a mixture of various hydrocarbons contained in the liquid phase in the reservoir below ground level and which remain liquid at atmospheric pressure after passing the separator facility on the surface.

MMSFC is the amount of gas needed to fill the room of 1 (one) million cubic feet, with a pressure of 14.73 psi at 60^{o}F (Fahrenheit) in dry condition. 1 MMscf is equivalent to 1.000 Mmbtu.

Electrification ratio is the comparison between electrified household and the total household.

RON (Research Octane Number) is the number determined by CFR F1 tester engine at a speed of 600 rotations per minute; quality guidelines of anti petrol tap on low speed or light load condition.

Current Scenario (KS), is an energy demand and supply scenario with basic assumption of annual average GDP growth of 5.6%, energy mix target in KEN, RUPTL, RUEN, RIPIN, and emission reduction target in NDC.

NRE Optimization and Energy Efficiency (OEE) Scenario is a energy demand and supply projection scenario with basic assumption of Gross Domestic Product of 5.6% in average per year, higher biofuel share than in national biofuel roadmap, higher quantity of electric vehicle in transportation than in RUEN, higher efficiency in the industry, and the priority to implement new technology in power plant such as super and ultra critical in Steam Fueled Power Plant, pump storage, battery, and waste to energy processing technologies.

TOE (Tonne Oil Equivalent) is energy unit with a calorific value equivalent to one ton of petroleum. Based on IEA conversion standard, 1 TOE is equivalent to 11.63 MWh of electricity, 1.43 tons of coal, 39.68 MBtu or 10.000 MCal of natural gas.

Transformation is the process of energy conversion from one form of primary energy into final energy form. The transformation process can occur through the process of refinery, power plants, gasification and liquefaction.

APPENDIX

Num	Result of Analysis	KS Scenario						
		2020	2025	2030	2035	2040	2045	2050
1	National final energy demand (Million TOE)	154	183	225	271	320	376	433
2	Final energy demand (Million TOE)	69	73	87	102	117	134	151
3	Energy final gas demand (Million TOE)	33	42	49	58	67	76	84
4	The final energy demand of coal (Million TOE)	18	20	25	29	33	36	38
5	Final energy demand of NRE (Million TOE)	5	6	9	12	14	16	20
6	Electricity final energy demand (TWh)	27	39	52	69	88	111	139
7	The final energy demand of the industrial sector (Million TOE)	53	65	79	95	111	127	140
8	Final energy demand for transportation sector (Million TOE)	51	55	57	80	96	113	133
9	The final energy demand of the household sector (Million TOE)	24	33	41	49	58	67	77
10	The final energy demand of the commercial sector (Million TOE)	7	8	12	15	21	28	37
11	The final energy demand of other sectors (Million TOE)	3	3	4	4	5	5	6
12	Provision of primary energy (without biomass) (Million TOE)	213	283	346	419	504	602	708
13	Provision of primary energy of petroleum (Million TOE)	68	70	81	94	108	123	138
14	Provision of gas primary energy (Million TOE)	51	64	80	97	117	140	165
15	Supply of primary energy of coal (Million TOE)	67	82	100	118	139	162	183
16	Primary energy supply of NRE (Million TOE)	26	67	84	110	140	177	222
17	Primary energy supply per capita (TOE / Capita)	0.79	0.99	1.17	1.37	1.60	1.85	2.11
18	Greenhouse gas (GHG) emissions (Ton CO2 / Capita)	1.97	2.15	2.50	2.87	3.29	3.76	4.25
19	Electricity Generating Capacity (GW)	71	98	148	196	258	343	402
20	Electricity production (TWh)	337	500	666	873	1,121	1,429	1,795

Num	Result of Analysis	OEE scenario						
		2020	2025	2030	2035	2040	2045	2050
1	National final energy demand (Million TOE)	151	171	198	224	247	268	280
2	Final energy energy demand (Million TOE)	68	66	73	79	83	86	86
3	Energy final gas demand (Million TOE)	33	41	47	53	59	64	65
4	The final energy demand of coal (Million TOE)	15	12	14	16	18	19	18
5	Final energy demand for NRE (Million TOE)	10	17	20	23	25	26	26
6	Electrical final energy demand (TWh)	26	36	44	53	63	74	84
7	The final energy demand of the industrial sector (Million TOE)	52	63	75	86	97	104	106
8	Final energy demand for transportation sector (Million TOE)	50	48	54	59	64	68	72
9	The final energy demand of the household sector (Million TOE)	23	31	35	38	41	45	48
10	The final energy demand of the commercial sector (Million TOE)	6	8	10	13	16	19	23
11	The final energy demand of other sectors (Million TOE)	3	3	3	3	3	3	3
12	Provision of primary energy (without biomass) (Million TOE)	210	261	312	362	407	457	495
13	Provision of primary energy of petroleum (Million TOE)	67	64	68	71	72	71	69
14	Provision of gas primary energy (Million TOE)	53	65	73	80	83	84	80
15	Supply of primary energy of coal (Million TOE)	57	68	75	75	94	102	107
16	Primary energy supply of NRE (Million TOE)	33	63	95	137	159	198	239
17	Primary energy supply per capita (TOE / Capita)	0.78	0.91	1.05	1.19	1.29	1.40	1.48
18	Greenhouse gas (GHG) emissions (Ton CO2 / Capita)	1.81	1.86	1.92	1.85	1.97	1.94	1.81
19	Electricity Generating Capacity (GW)	72	99	132	189	223	258	285
20	Electricity production (TWh)	335	467	575	691	816	952	1,092

PLTS Gorontalo

PLTS Kupang

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