RENEWABLE ENERGY

BOB SARIL
PT. PLN (Persero)
WILAYAH SULSELRABAR

PLN

ELECTRICITY DEVELOPMENT MASTER PLAN 2017-2026

INDONESIA ELECTRICITY INFRASTRUCTURE DEVELOPMENT

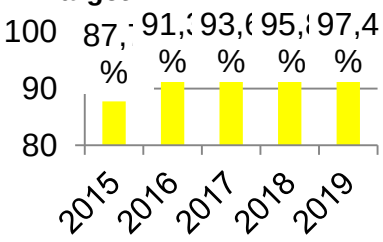
The current Installed Capacity is able to cope only the need of Electricity 90,5%, Lower than i Singapura (100%), Brunei (99,7%), Thailand (99,3%), Malaysia (99%), Vietnam (98%),

Within next 5 years, electricity demand grown in average 0f 8,6% / Annum, With electrification ration targeted to reach 97,4% by the end of 2019

Capacity & Electrification Ratio

Present Condition	Unit	Jumlah
Elektrification Ratio	%	90,5
Capacity	MW	51.860

Elektrification Ratio Target[2)]

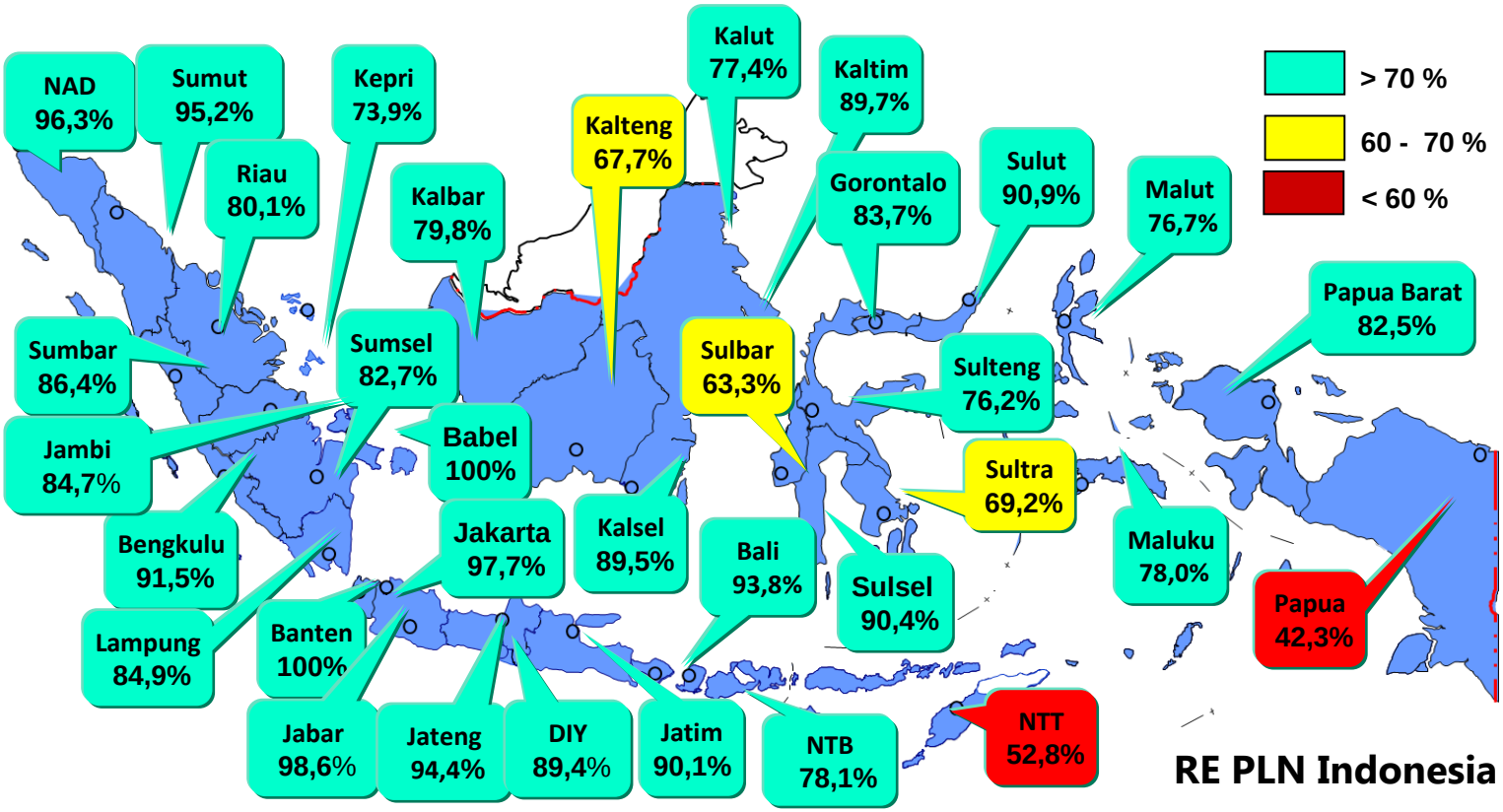


To meet the ever growing demand and electrification ration and the Usage electricity per capita, The installed capacity needs to be added 77,9 GW by 2016-2025

77.9 GW Program

Source
[1)] Global Status Report 2014, GIZ, Data 2013
[2)] RUPTL 2017-2026

ELECTRIFICATION RATIO PER PROVINCE

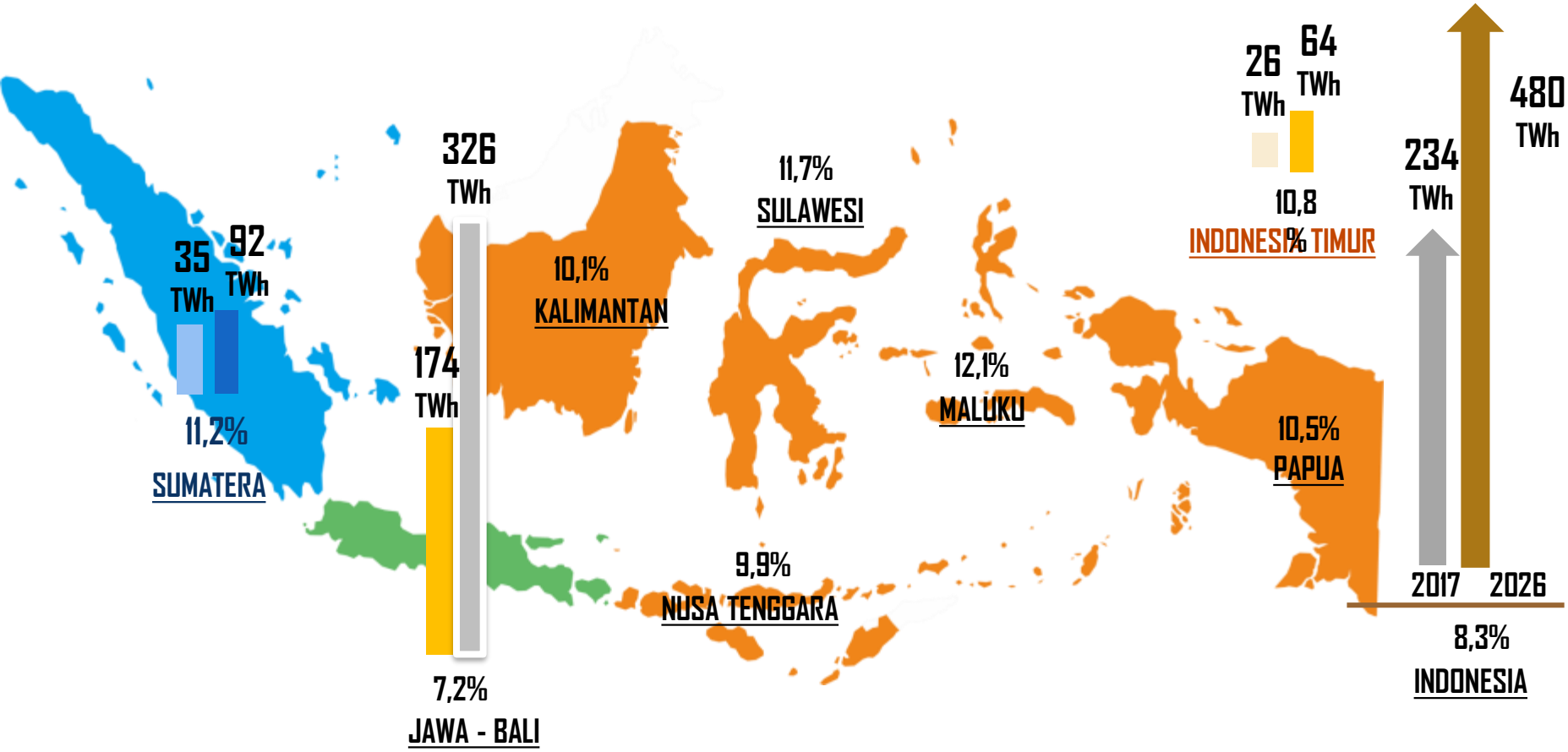


RE PLN Indonesia : 90.5%

Status Mei 2017

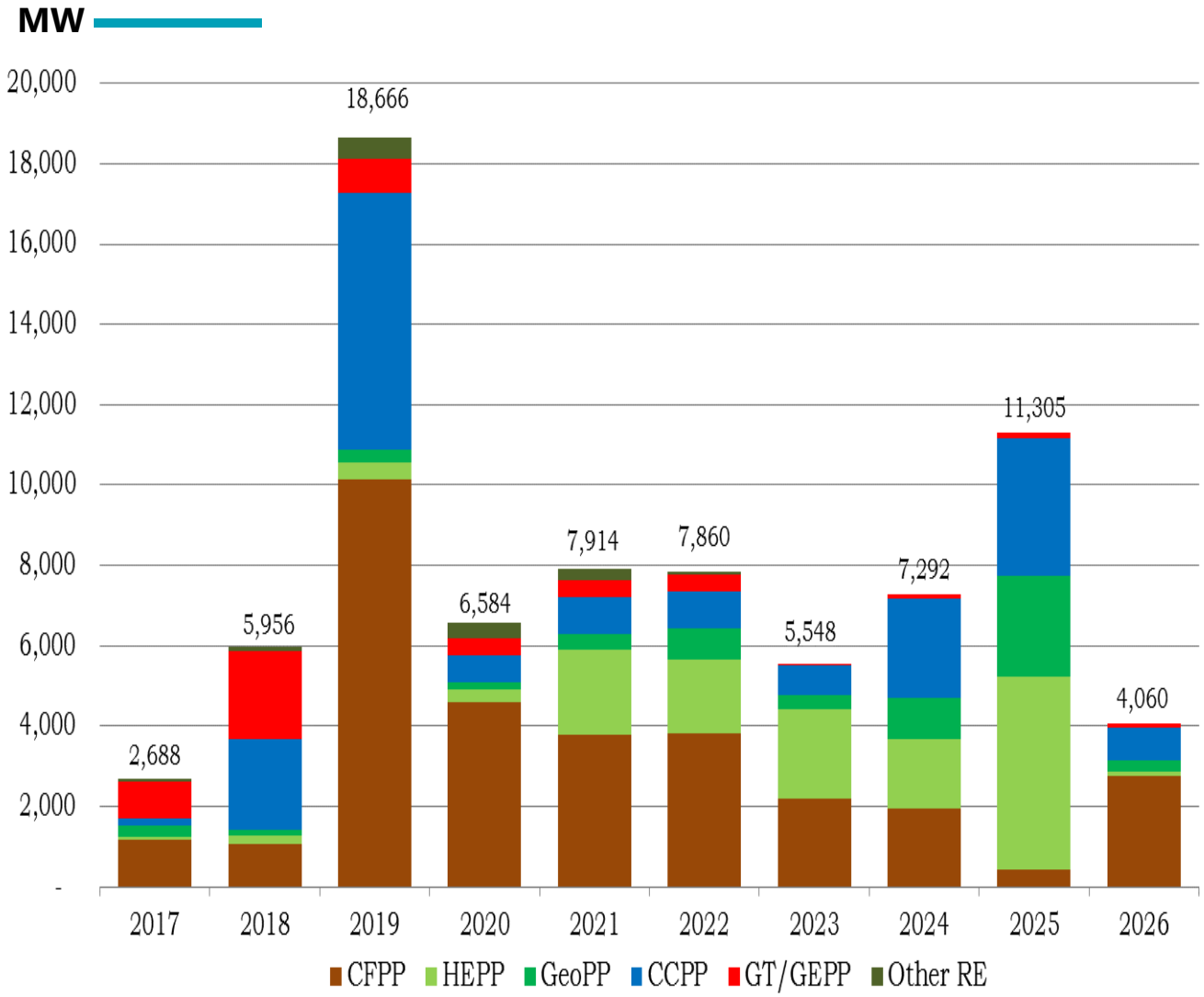
Note : Just PLN Resedential Customer Included; (Jumlah Rumah Tangga berlistrik PLN / Jumlah Rumah Tangga) x 100%

Electricity Demand Forecast 2017-2026



Keterangan	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Pertumbuhan Ekonomi (%)	5,20	5,10	5,50	6,10	6,50	6,48	6,46	6,44	6,42	6,40	6,35
Rasio Elektrifikasi (%)	90,65	93,41	95,89	97,32	98,80	99,53	99,81	99,98	99,99	99,99	99,99

GENERATION DEVELOPMENT PLANNING

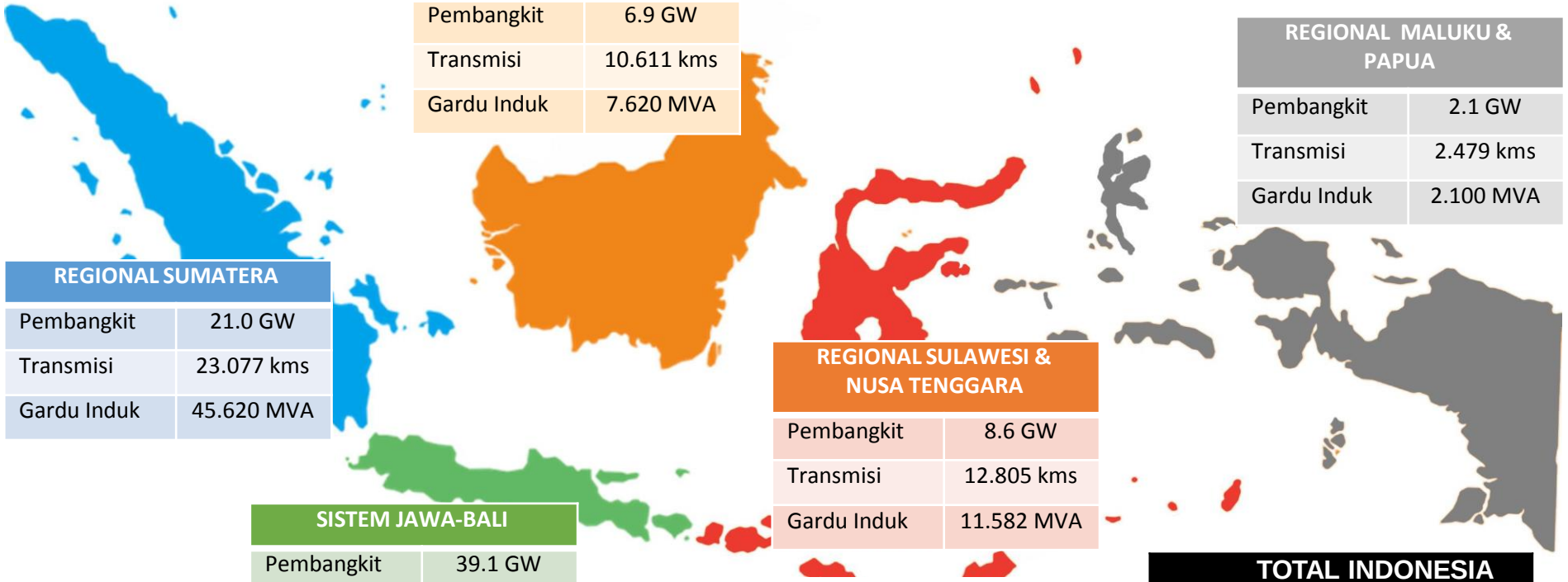


Penambahan Pembangkit:
2017-2019 : 27,3 GW
2017-2026 : 77,9 GW
- PLTU : 31,9 GW
- PLTGU : 18,8 GW
- PLTG/MG : 5,6 GW
- PLTA : 14,1 GW
- PLTP : 6,3 GW
- PLT Lain : 1,2 GW

Porsi Pembangkit
- PLN : 20.9 GW
- IPP : 42.1 GW
- Unalocated : 14.8 GW

Catatan:
- Program 7 GW yang sudah beroperasi hingga tahun 2016 sebesar 5.7 GW

THE DEVELOPMENT OF GENERATION, TRANSMISSION AND SUBSTATION PER REGIONAL 2017-2026



REGIONAL KALIMANTAN	
Pembangkit	6.9 GW
Transmisi	10.611 kms
Gardu Induk	7.620 MVA

REGIONAL MALUKU & PAPUA	
Pembangkit	2.1 GW
Transmisi	2.479 kms
Gardu Induk	2.100 MVA

REGIONAL SUMATERA	
Pembangkit	21.0 GW
Transmisi	23.077 kms
Gardu Induk	45.620 MVA

REGIONAL SULAWESI & NUSA TENGGARA	
Pembangkit	8.6 GW
Transmisi	12.805 kms
Gardu Induk	11.582 MVA

SISTEM JAWA-BALI	
Pembangkit	39.1 GW
Transmisi	18.450 kms
Gardu Induk	97.249 MVA

TOTAL INDONESIA	
Pembangkit	**77.9 GW**
Transmisi	**67.422 kms**
Gardu Induk	**164.170 MVA**

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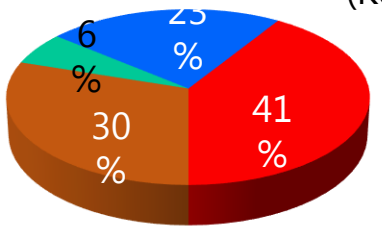
ENERGY MIX

FUEL MIX TARGET

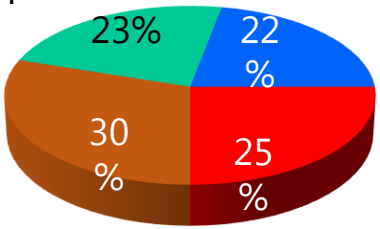
PRIMARY FUEL MIX

(Listrik dan Non Listrik)

(Kebijakan Energi Nasional, PP No.79/2014)



REALISASI 2013

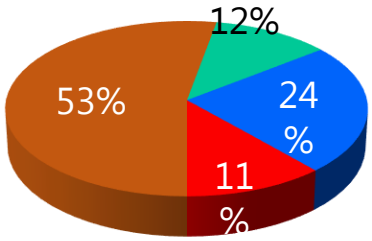


TARGET 2025

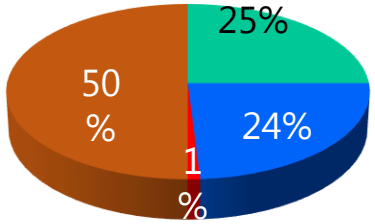
RE
OIL
Gas
COAL

ELECTRICITY GENERATION MIX

(Draft RUKN 2015-2034)

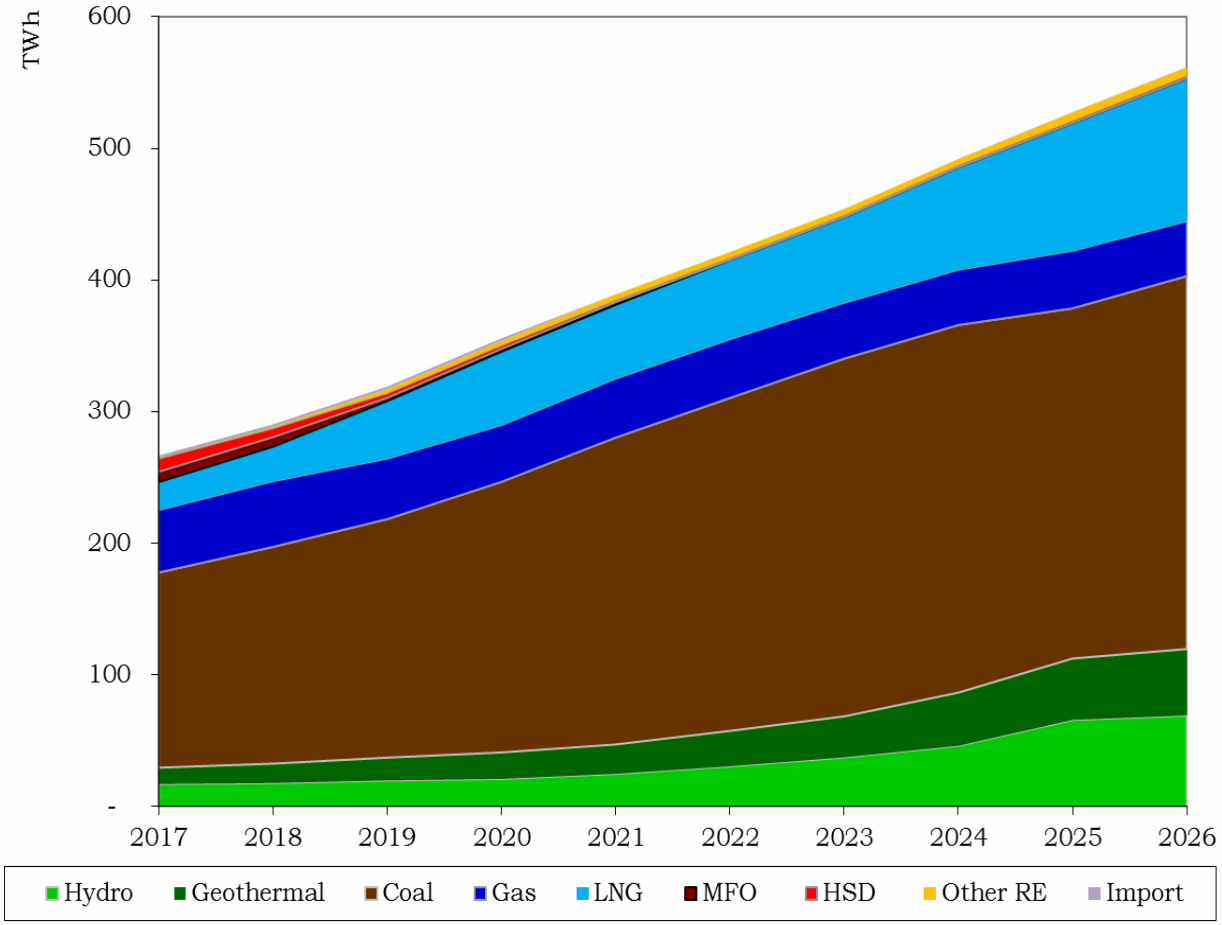


REALISASI 2014

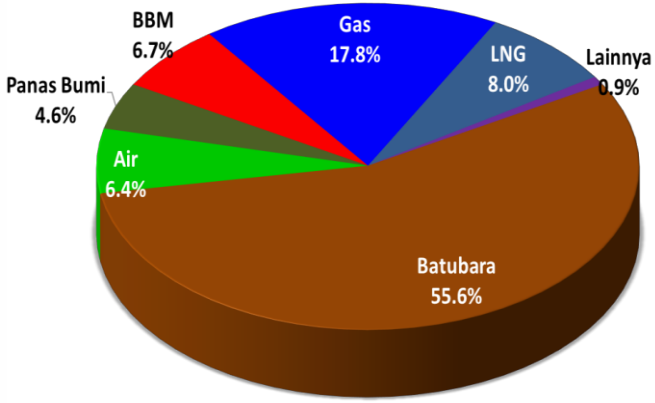


TARGET 2025

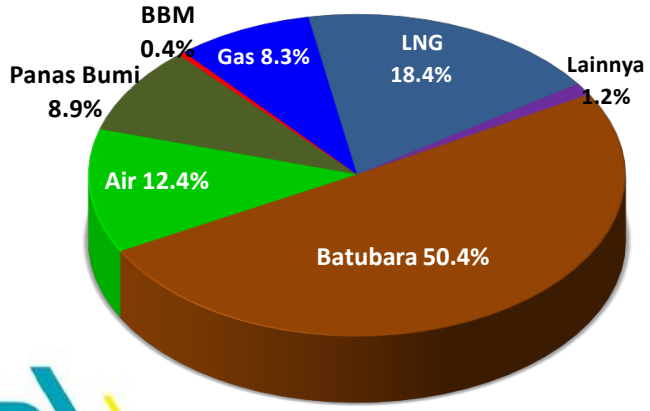
ENERGY MIX PROJECTION 2017 - 2026



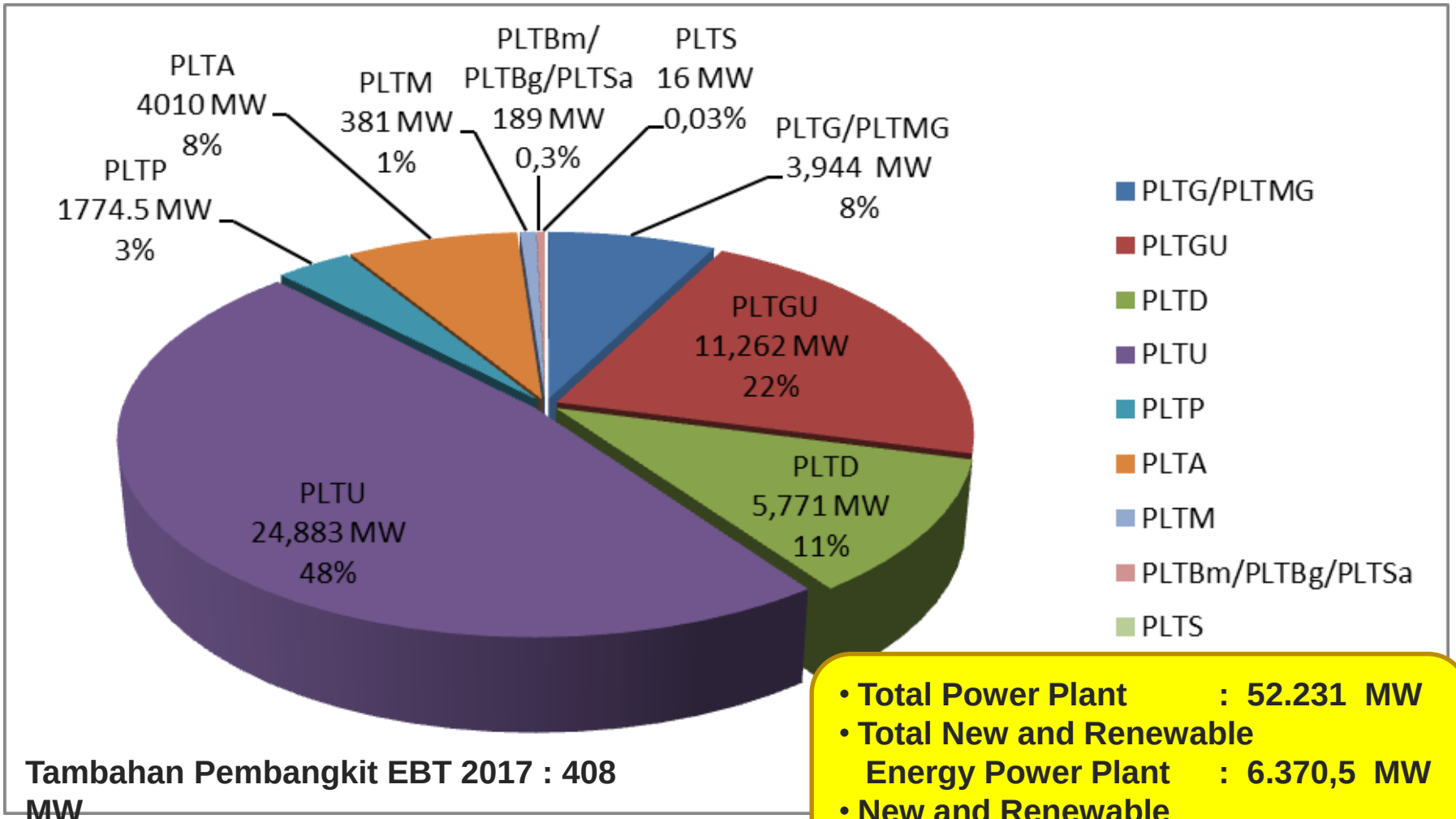
EBT : 11.9%
GAS: 25.8% 2017



EBT : 22.5%
GAS: 26.6%2026



POWER PLANT COMPOSITION 2017



Tambahan Pembangkit EBT 2017 : 408 MW

- **Total Power Plant : 52.231 MW**
- **Total New and Renewable Energy Power Plant : 6.370,5 MW**
- **New and Renewable Energy Percent : 12 %**

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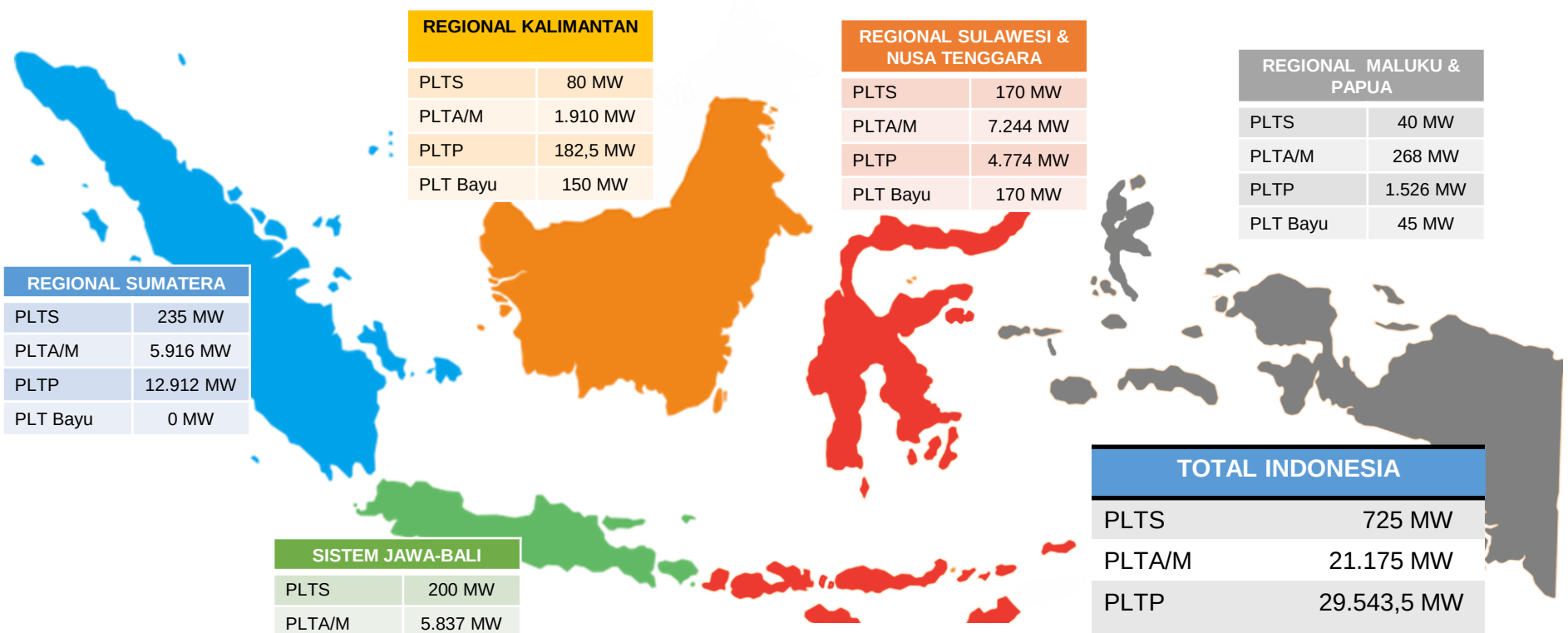
RENEWABLE ENERGY DEVELOPMENT

RENEWABLE ENERGY DEVELOPMENT

(Rencana Usaha Penyediaan Tenaga Listrik 2017-2026)



REGIONAL KALIMANTAN	
PLTS	80 MW
PLTA/M	1.910 MW
PLTP	182,5 MW
PLT Bayu	150 MW

REGIONAL SULAWESI & NUSA TENGGARA	
PLTS	170 MW
PLTA/M	7.244 MW
PLTP	4.774 MW
PLT Bayu	170 MW

REGIONAL MALUKU & PAPUA	
PLTS	40 MW
PLTA/M	268 MW
PLTP	1.526 MW
PLT Bayu	45 MW

REGIONAL SUMATERA	
PLTS	235 MW
PLTA/M	5.916 MW
PLTP	12.912 MW
PLT Bayu	0 MW

SISTEM JAWA-BALI	
PLTS	200 MW
PLTA/M	5.837 MW
PLTP	10.149 MW
PLT Bayu	250 MW

TOTAL INDONESIA	
PLTS	725 MW
PLTA/M	21.175 MW
PLTP	29.543,5 MW
PLT Bayu	615 MW

LEGEND	
PLTS	SOLAR
PLTA/M	HYDRO
PLTP	GEOTHERMAL
PLT Bayu	WIND

NEW RENEWABLE ENERGY ADDITION 2017-2026

Total Indonesia

No	Pembangkit - EBT	Kapasitas	Jumlah
1	PLTP	MW	6,290
2	PLTA	MW	12,342
3	PLTMH	MW	1,694
4	PLT Surya	MWp	57
5	PLT Bayu	MW	615
6	PLT Biomass/Sampah	MW	552
7	PLT Kelautan	MW	-
8	PLT Bio-Fuel	Ribu Kilo Liter	3,041
Jumlah		**MW**	**21,549**

Reg. Kalimantan

No	Pembangkit - EBT	Kapasitas	Jumlah
1	PLTP	MW	-
2	PLTA	MW	1,056
3	PLTMH	MW	10
4	PLT Surya	MWp	-
5	PLT Bayu	MW	150
6	PLT Biomass/Sampah	MW	41
7	PLT Kelautan	MW	-
8	PLT Bio-Fuel	Ribu Kilo Liter	548
Jumlah		**MW**	**1,257**

Reg. Maluku & Papua

No	Pembangkit - EBT	Kapasitas	Jumlah
1	PLTP	MW	75
2	PLTA	MW	118
3	PLTMH	MW	43
4	PLT Surya	MWp	-
5	PLT Bayu	MW	45
6	PLT Biomass/Sampah	MW	10
7	PLT Kelautan	MW	-
8	PLT Bio-Fuel	Ribu Kilo Liter	375
Jumlah		**MW**	**290**

Reg. Sumatera

No	Pembangkit - EBT	Kapasitas	Jumlah
1	PLTP	MW	3,305
2	PLTA	MW	4,284
3	PLTMH	MW	983
4	PLT Surya	MWp	5
5	PLT Bayu	MW	-
6	PLT Biomass/Sampah	MW	274
7	PLT Kelautan	MW	-
8	PLT Bio-Fuel	Ribu Kilo Liter	958
Jumlah		**MW**	**8,851**

Reg. Sulawesi & Nusa Tenggara

No	Pembangkit - EBT	Kapasitas	Jumlah
1	PLTP	MW	400
2	PLTA	MW	2,323
3	PLTMH	MW	221
4	PLT Surya	MWp	52
5	PLT Bayu	MW	170
6	PLT Biomass/Sampah	MW	21
7	PLT Kelautan	MW	-
8	PLT Bio-Fuel	Ribu Kilo Liter	686
Jumlah		**MW**	**3,186**

Reg. Jawa-Bali

No	Pembangkit - EBT	Kapasitas	Jumlah
1	PLTP	MW	2,510
2	PLTA	MW	4,562
3	PLTMH	MW	437
4	PLT Surya	MWp	-
5	PLT Bayu	MW	250
6	PLT Biomass/Sampah	MW	206
7	PLT Kelautan	MW	-
8	PLT Bio-Fuel	Ribu Kilo Liter	474
Jumlah		**MW**	**7,965**

RE in 10 years Master Plan (RUPTL 2017 – 2026)

No	Pembangkit - EBT	Kapasitas	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Jumlah
1	PLTP	MW	305	165	315	186	365	790	345	1,015	2,510	294	6,290
2	PLTA	MW	18	87	323	154	1,800	1,555	2,035	1,697	3,675	1,000	12,342
3	PLTMH	MW	68	112	163	198	388	326	178	30	150	81	1,694
4	PLT Surya	MWp	20	13	24	-	-	-	-	-	-	-	57
5	PLT Bayu	MW	-	-	215	280	120	-	-	-	-	-	615
6	PLT Biomass/Sampah	MW	43	76	243	93	91	6	-	-	-	-	552
7	PLT Kelautan	MW	-	-	-	-	-	-	-	-	-	-	-
8	PLT Bio-Fuel	Ribu Kilo Liter	930	731	331	263	197	108	112	116	123	129	3,041
Jumlah		**MW**	**453**	**453**	**1,282**	**911**	**2,764**	**2,676**	**2,557**	**2,742**	**6,335**	**1,375**	**21,549**

RENEWABLE ENERGY DEVELOPMENT STATUS per DEC 2017

Status	PLTP (MW)	PLTA (MW)	PLTM (MW)	PLTBm/PLT Bg (MW)	PLTSampah (MW)	PLTB (MW)	PLT AL (MW)	PLTD CPO (MW)	PLTS (MW)	PLTHybrid (MW)	Total (MW)
Operasi	1,774.5	4,010	381.0	171.4	17.6	-	-	-	16.0	-	6,370.5
Konstruksi	330	2,192	230.0	24		75	-	-	4	-	2,855
PPA/Proses FC	55	200	451.0	75.0		60	-	-	45	-	886
Eksplorasi (PLTP)	2,651	-	-	-		-	-	-	-	-	2,651
Proses PPA	-	1,057	54.0	113.0	11.0	-	-	5	5	-	1,245
Tender oleh Pemerintah	1,775	-	-	-		-	-	-	-	-	1,775
Studi, Pendanaan dan pengadaan	1,204	9,493	98.0	110.0		270	-	-	0	899	12,074
Proposal	-	7,950	1,232.0	26.0		503	12	2	800	482	11,007
Total	7,789.5	24,902	2,446	519	29	908	12	7	870	1,381	38,864

THE CHALLENGE(1)

- COGS (Cost Og Good Production) in several Regions is relatively low (Economic Feasibility??) Some area has good potential of The HEPP but The COGS is relatively low. The feed in tariff is tagged to BPP. Is it still encourage the RE Development Interest?.
- Some Region is not economically and operationally viable to build RE due to over capacity (Over Suppy), especially in the regions that have big proportionate production contributed by IPPs (which hav “Take or Pay” term of Contract.
- Many areas have the installed capacity is relatively lower, so that intermittent RE developed is given a small portion/Quota (realibility concern)

THE CHALLENGE (2)

- The Exploration cost of Geothermal (especially drilling) is very high and success story of many of exploration is deemed very small.
- The capacity of Geothermal Power Plant is usually much lower than that of forecasted potential.

THE STRATEGY

- Maximizing RE Development with big promising potential, such HEPP, Geothermal PP.
- Local RE Potential to be developed and fostered to improve the Electrification Ratio, especially in the eastern region of Indonesia (remote and Scattered Island).
- Developing Hybrid Terchnogy System , in the area alredy supplied by Diesel Gensets and the 12 hours or under .
- Developing Smart Grid and Improved ‘art of state’ Control System in order to handle a lot of intermittent RE
- Replacing HSD with of biofuel for existing Diesel Genset.

PLN

PLTB SIDRAP GRID ISSUES

Proper Emas 2017
PLTU Paiton 1 & 2

www.pln.co.id

Wind Power Plant

OVER VIEW

- *Wind as intermittent energy*
- Some of the basic issues regarding to the integration of wind turbine generator to the grid
- Issues that effect to the transmission limit
- Electrical System Conditions in Indonesia
- The influence of energy generated from the wind to the transmission performance
- *Existing wind technology in use*

WIND TURBINE GENERATOR GRID CONNECTION ISSUES

❑ Customer requirements

- Voltage should be appropriate with costumers voltage needed depend on quality service levels (TMP in Indonesia)
- Electricity should always available when its needed
- Price of electricity should be affordable

❑ Power Plant owner requirements

- Need standart of voltages in the interconnection node
- Need stabilities of Power electricity system
- Produce the electricity when wind available for running wind turbine

❑ Grid owner requirements

- Increase the contribution of renewable energy to the grid while maintaining the stability of the transmission network for security and customer service

WIND, INTERMITTEN ENERGY

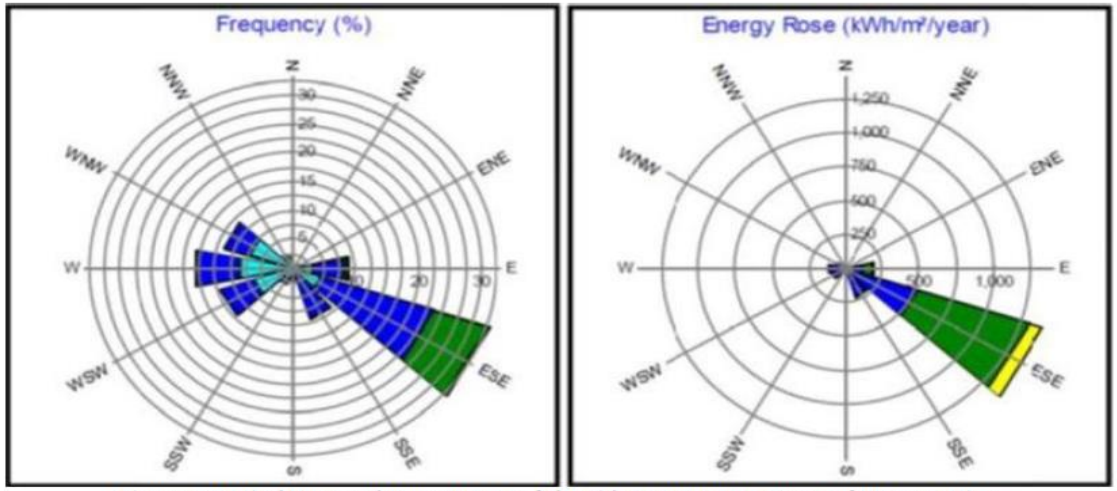


Figure 74: Wind Rose and Energy Rose of the Sidrap 50 m Met Tower after Correction

- Fluctuations of power generattion output, need spinning reserve
- Wind energy sources dominated by One Specific Direction (East south East)
- Energy Storage techology is expensive and not reliable enough become a follower
- The implementation of smart grid requires a great expense and effort to make it hap
- Challenges service to premium customers

TRANSMISSION LIMITS

1. **THERMAL LIMIT , relation to conductor and voltage variations**
2. **VOLTAGE STABILITY , Bus Voltage normal after and before fault (normal condition)**
3. **TRANSIENT STABILITY, the ability of the system grid to withstand after tansmission disturbance/fault**
4. **Wind Turbine characteristics that influence transmission constraints :**
   - ❑ **No reactive power generation, resulting in a lagging system at the connection point**
   - ❑ **During and after system fault**
     - Variable wind speed will release from the connection/grid to protect the converter
     - Variable wind speed will use a lot of reactive power from system to start the Turbine, need more time to recover.

CONDITION OF POWER SYSTEM INDONESIA

- Power system and its network designed for clear/continue energy resource power plant and predictable
- Generally gases,hydro,diesel power plant as load follower
- Indonesia dont have wind energy resource likes Denmark and UK where between wind power plant can cover fluctuation of electricity production.
- Not all of grid system has a large margin of ± *30 %*, wind power generation capacity are advised not to exceed the reserve margin so that system settings can be done well and suggested operating on reserve area, is not as base load.
- No regulation about ancillary service to maintain the reliable of transmission system ; scheduling and dispatch, reactive control, loss compesation, load following, system protection, spinning reserve

EFFECT WIND POWER PLANT TO POWER SYSTEM

- Voltage Variation : effect of production in wind power plant is unstable/fluctuation
- Fixed speed wind turbine can produce oscillation between grid impedance and shunt capacitor bank
- Variable wind turbine can produce the harmonic
- Transient effect, if wind power plant Start-Stop
- Wind power plant with asynchronous machine will absorb much VAR to start power plant so will increase ‘loses’ in network

WIND POWER PLANT'S TECHNOLOGY TO SUPPORT POWER SYSTEM

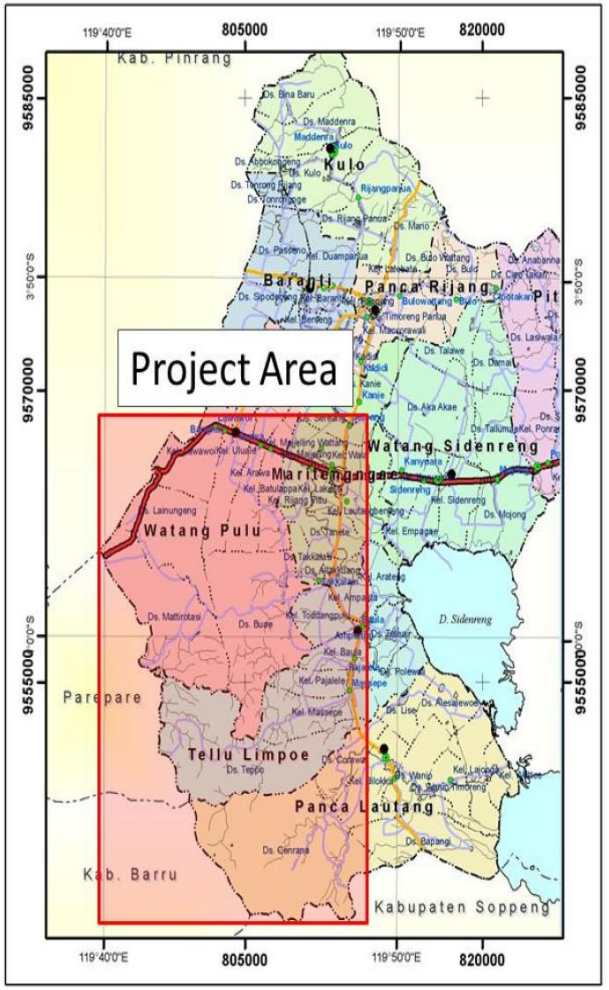
- There is regulation about voltage and guaranty of power factor on interconnection node.
- Wind Farm management system, give early warning when output of wind power plant has change, and give information to RCC to control power system Grid (voltage, power, and reactive power).
- *Power curtailment capability*
- Low Voltage Ride Trough (LVRT) , is wind power plant's capability to stand still when voltage 'Dip' happened because of power system fault on time set

PLTB SIDRAP – 70 MW , PPA 19 AGUSTUS 2015

PT UPC SIDRAP BAYU ENERGI
as SELLER
sebagai PENJUAL

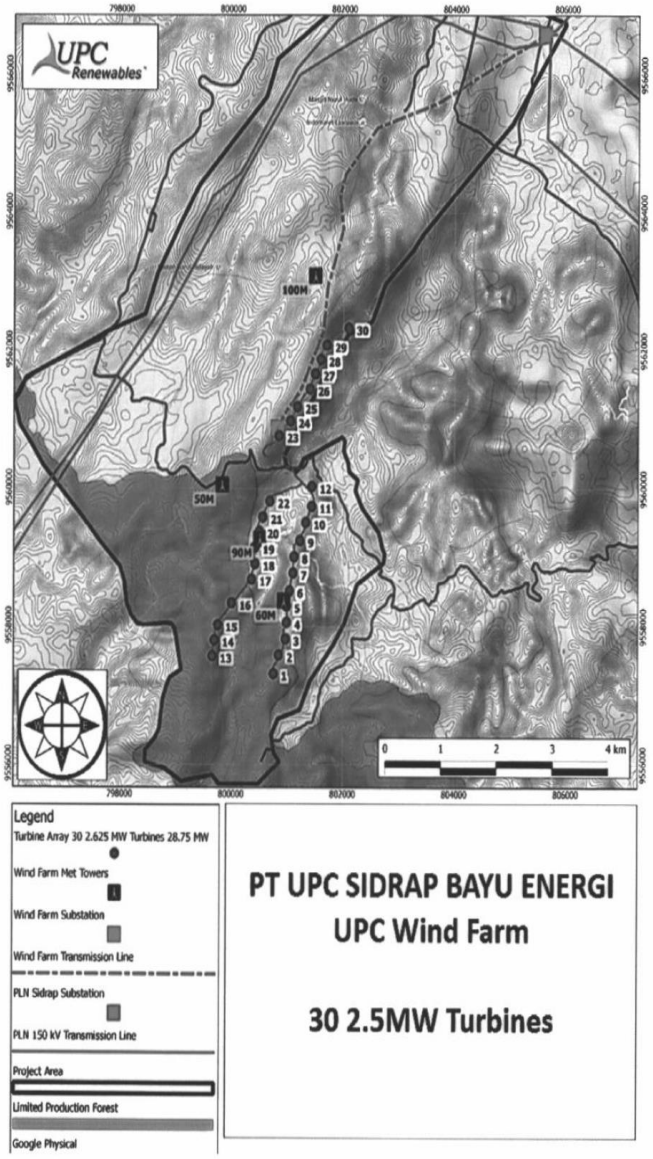
PROJECT AREA

Figure 15: Map of the PT UPC Sidrap Bayu Energi Wind Farm Project



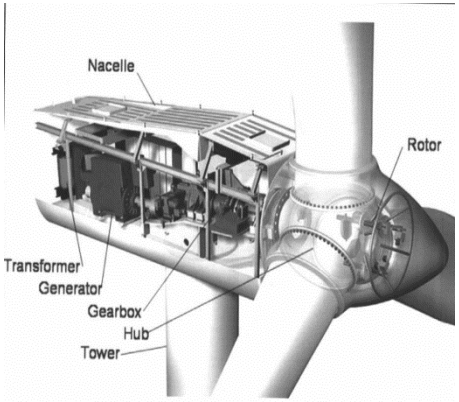
PROJECT FACT

- ✓ Project area, Sidrap Sulawesi Selatan
- ✓ Maximum energy generated 77 MW
- ✓ Consist 30 Wind Turbine Generator (TAG)
- ✓ Gamesa G114 blade class IIA
- ✓ Turbine size 2.5 MW , Features Power Max 2.65 I
- ✓ Tower's height 80 M
- ✓ Double circuit transmission 25 towers
- ✓ Incomer @GI Sidrap 2 bay (*special facilities*)
- ✓ Have SCADA system in own substation of power
- ✓ Average of wind speed is 7.4 m/s in height 80 M



TECHNICAL LIMIT OF WIND POWER PLANT

- **Operational frequency is 49,5 Hz-50.5 Hz**
- **No grid release on 30 seconds on frequency 47,5 Hz until 52 Hz**
- **Range of operational voltage -10% until - 5% Vnom, it will be release automatically from Grid if out of operational voltage.**
- **VAR setting 0.95 lag until 0.95 lead (-5% until 5% Vnom)**
- **Have facilities LVRT (low voltage Ride-Through)**
- **Operation mode :**
  - *Free active power production*, output depend on wind
  - *Limiting power generation* on set point 20 %-100% Pnom range min 5 minutes
  - **Increasing as gradien of active power suitable wind speed and set point from load controller with minimum limit 20% Pnom per minute or 50% Pnom per 10 minute (Ramping Rate)**



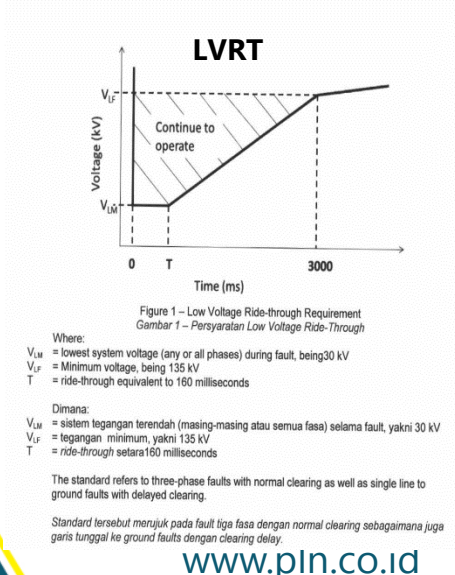


Figure 1 – Low Voltage Ride-through Requirement
Gambar 1 – Persyaratan Low Voltage Ride-Through

Where:
V_{LM} = lowest system voltage (any or all phases) during fault, being30 kV
V_{LF} = Minimum voltage, being 135 kV
T = ride-through equivalent to 160 milliseconds

Dimana:
V_{LM} = sistem tegangan terendah (masing-masing atau semua fasa) selama fault, yakni 30 kV
V_{LF} = tegangan minimum, yakni 135 kV
T = *ride-through* setara160 milliseconds

The standard refers to three-phase faults with normal clearing as well as single line to ground faults with delayed clearing.

Standard tersebut merujuk pada fault tiga fasa dengan normal clearing sebagaimana juga garis tunggal ke ground faults dengan clearing delay.

PLN

ELECTRICITY SYSTEM IN SOUTH SULAWESI (SULBAGSEL)

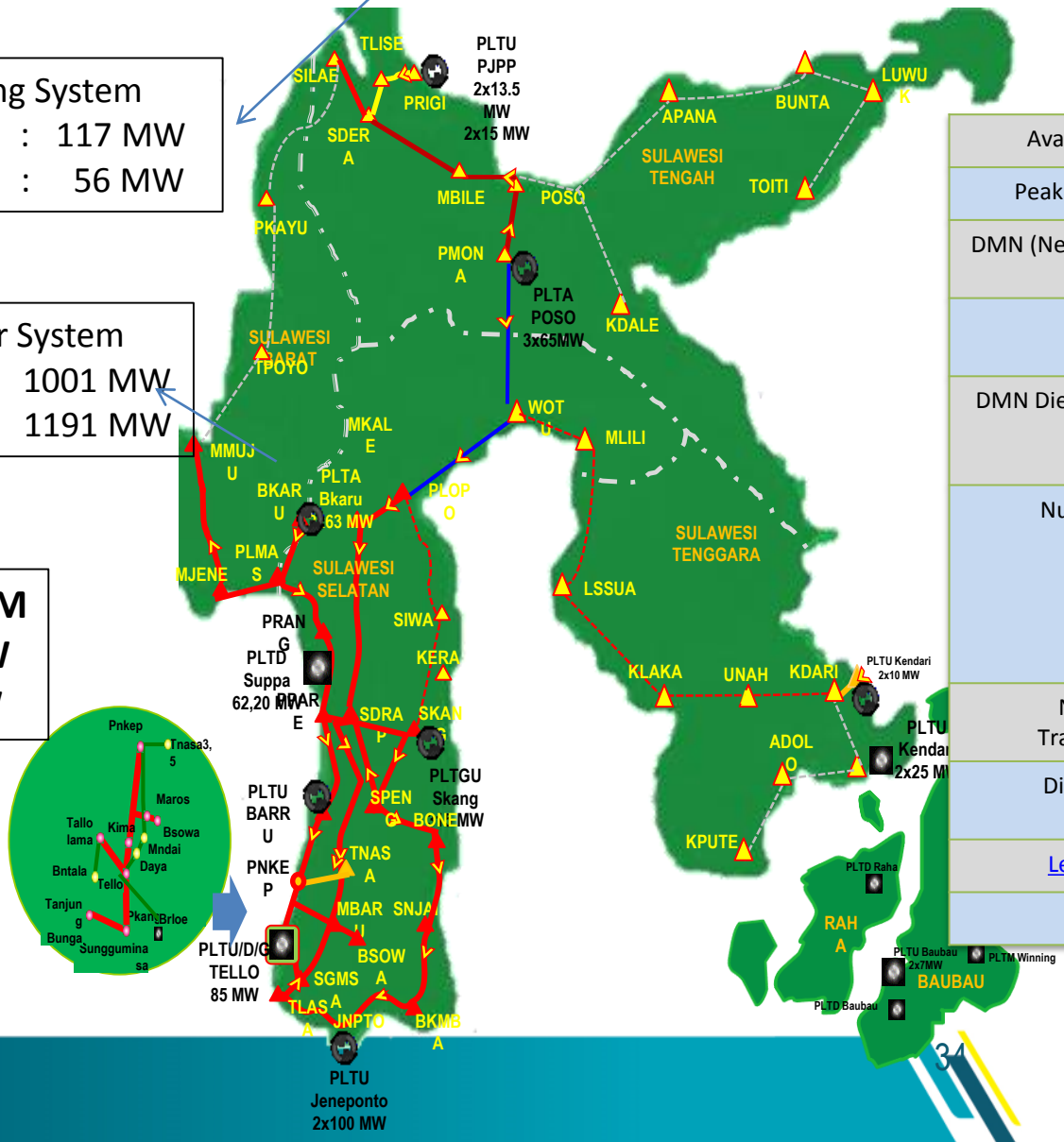
SYSTEM OF SULBAGSEL'S TOPOPLOGY

PLN

Sulteng System
BP : 117 MW
DMP : 56 MW

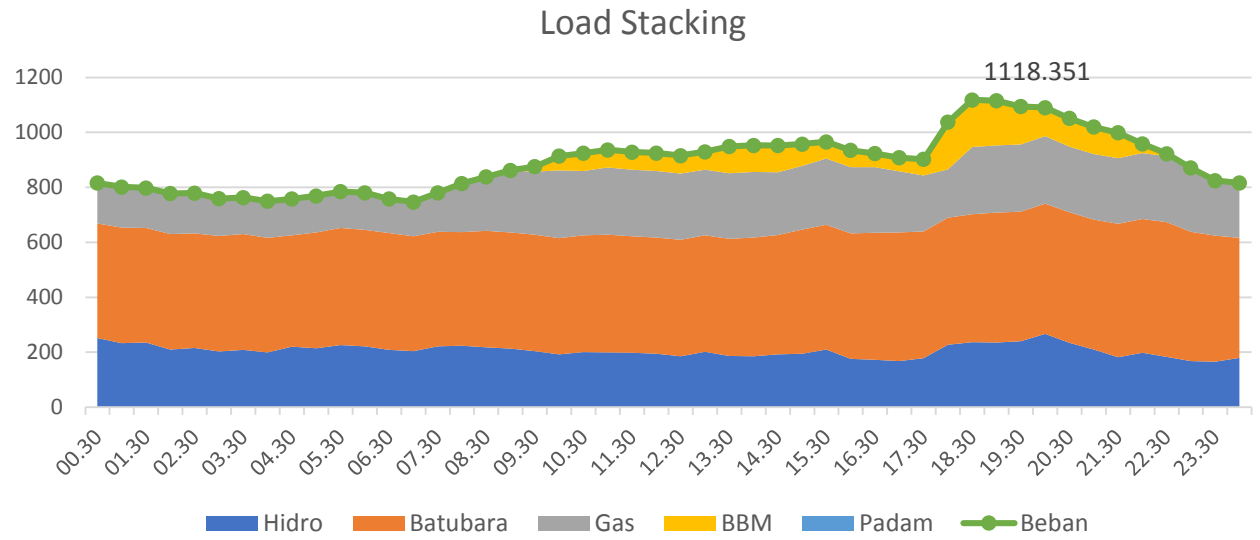
Sulselbar System
BP : 1001 MW
DMP : 1191 MW

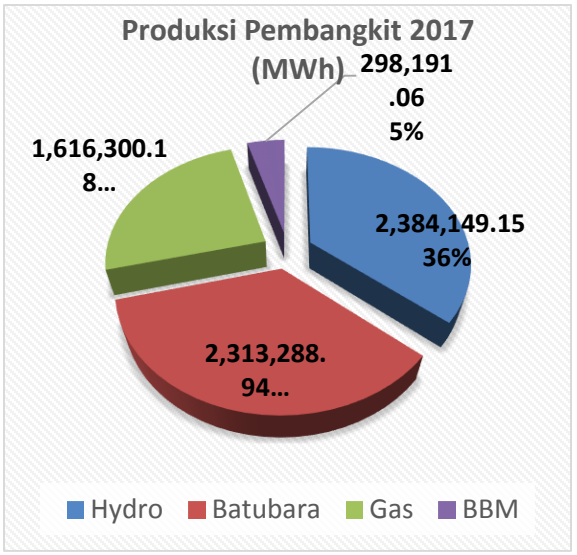
SULBAGSEL SYSTEM
BP : 1118 MW
DMP : 1247MW

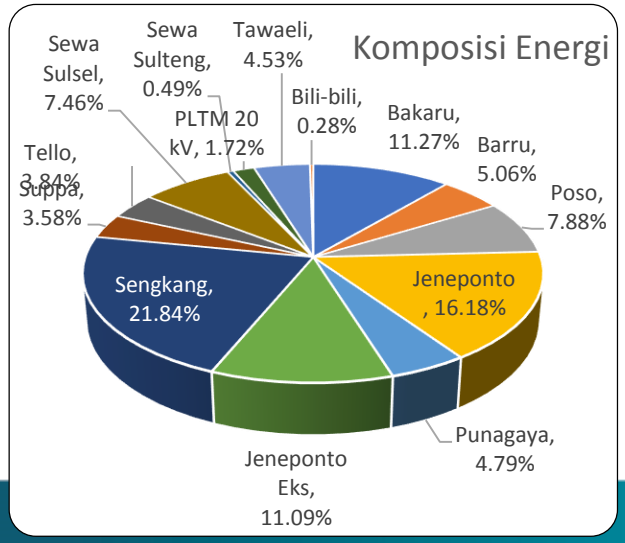


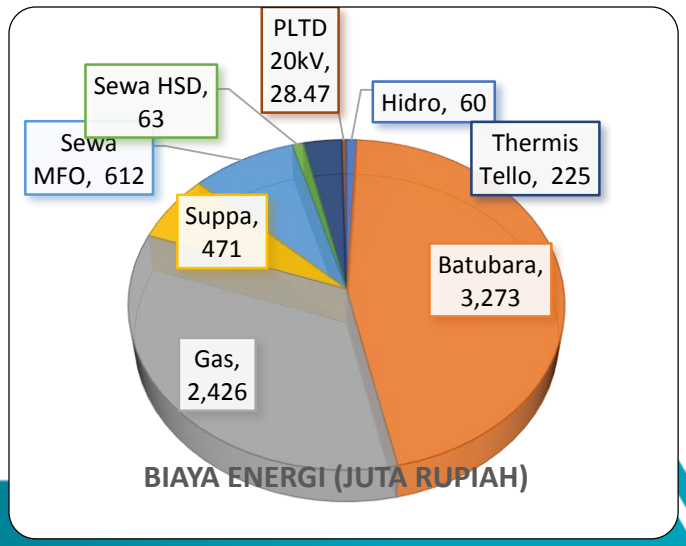
Availability Power Supply[1]:	1.196.7 MW
Peak Demand Maret 2017[2]:	1070 MW
DMN (Net Power Output) PLN :	332 MW (23 %)
DMN IPP + Excess :	891 MW (62 %)
DMN Diesel Power Plant lease :	218 MW (15 %)
Number of Substations[3] :	46 Substations
Number of Distribution Transformer Substations:	76 Unit
Distribution Transformer Capacity:	1.837,5 MVA
Length of Transmission :	2.642,8 kms
Total Tower :	4.760 tower

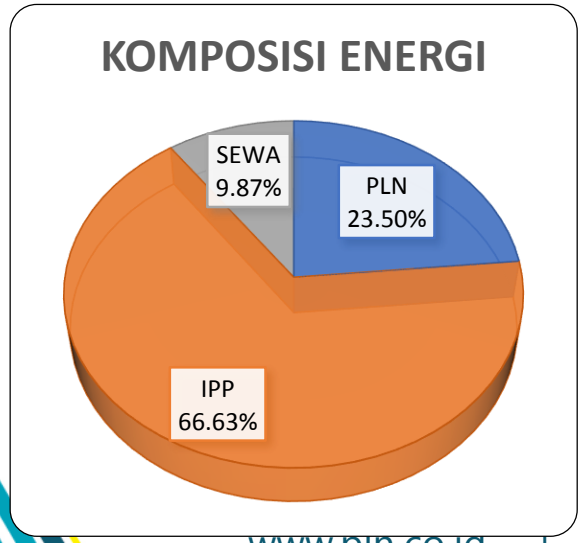
Load Stacking & Komposisi Pembangkit Beban Tertinggi 13 Oktober 2017











DAILY'S OPERATION PLANT

PT. PLN (PERSERO) WILAYAH SULSEL, SULTRA & SULBAR
UPB SULSELRABAR
Jl. Letjen Hertasning Makassar, 90222 - Tlp 440066 - Fax 440022.

RENCANA HARIAN PEMBANGKITAN SISTEM SULSELRABAR

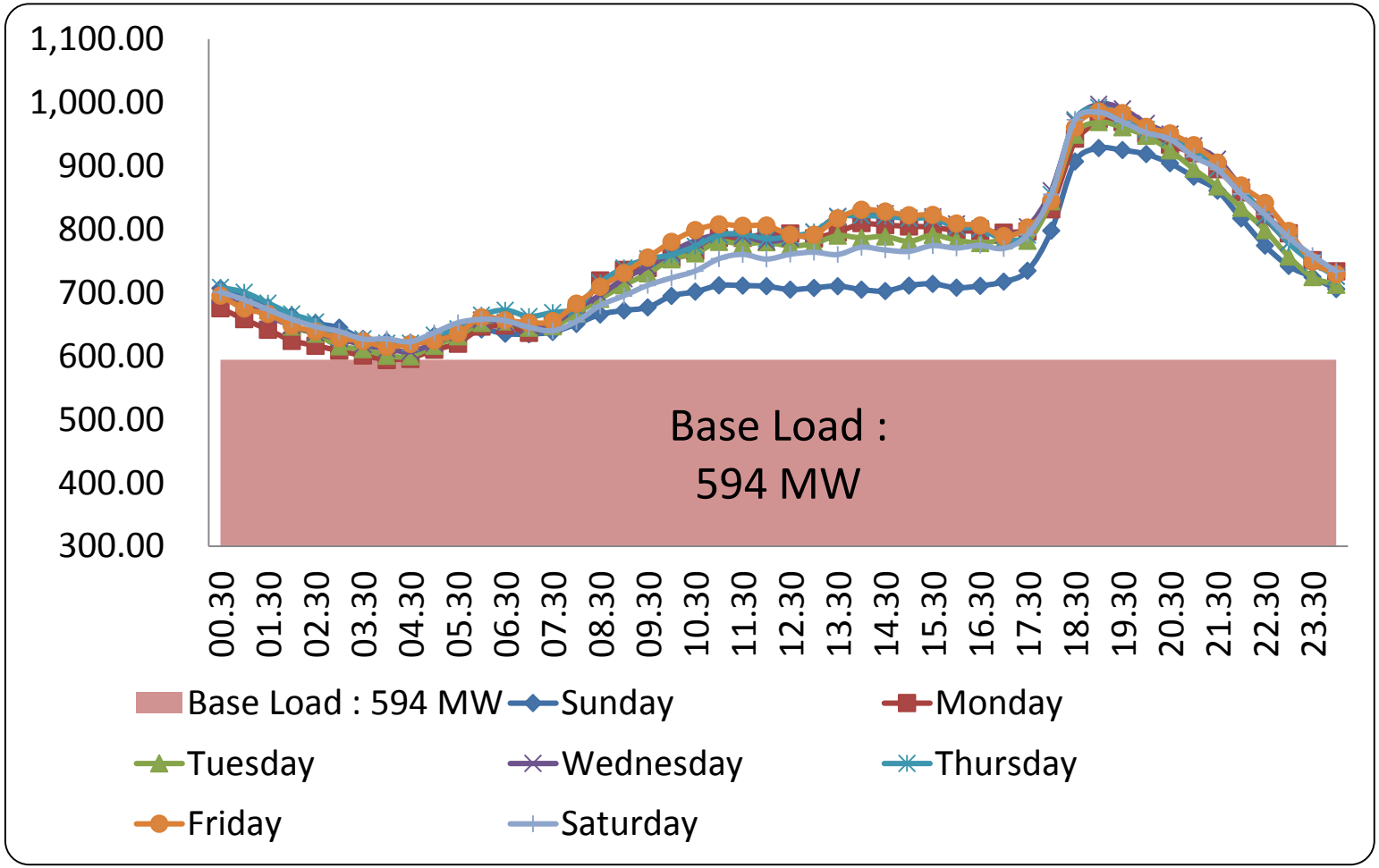
HARI : Jumat
TANGGAL : 07 April 2017

	UNIT PEMBANGKIT	MW MAMPU	PEMBEBANAN TIAP JAM (MW)																									
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	18.3	19	19.3	20	20.3	21	21.3	22	23	24
HIDRO	BAKARU 1	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0
	BAKARU 2	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	62.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0	63.0
	TOTAL	126	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	125.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0	126.0
TERMIS TELLO	PLTU BARRU 1	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
	PLTU BARRU 2	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
	GE 1	25.0																											
	GE 2	28.0																											
	MITSUBISHI 1																												
	MITSUBISHI 2	5.0																				5.0	5.0						
	S W D 1	8.0											8.0	8.0						8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0		
	S W D 2	8.0																				8.0	8.0						
	TOTAL KIT TELLO	134.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	68.0	68.0	60.0	60.0	60.0	60.0	60.0	68.0	68.0	81.0	81.0	68.0	68.0	68.0	68.0	60.0	60.0
IPP	PLTGU SKANG BLOK 1	120.0	105.0	70.0	55.0	55.0	55.0	75.0	60.0	110.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0
	PLTGU SKANG GT#21	45.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	25.0	40.0	45.0	40.0	40.0	45.0	45.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	45.0	45.0	45.0	35.0	22.0
	PLTGU SKANG GT#22	45.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	25.0	40.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	40.0	45.0	45.0	45.0	45.0	35.0	22.0
	PLTGU SKANG ST 2B	45.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	30.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	35.0	26.0
	PLTU JENEPONTO#1	105.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	90.0
	PLTU JENEPONTO#2																												
	PLTD SUPPA	55.0										15.0	15.0	11.0	22.0	11.0			55.0	55.0	55.0	55.0	55.0	55.0	45.0	45.0	42.0		
	PLTA TANGKA MANIPI	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
	PLTA POSO#1	65.0	55.0	59.0	58.0	55.0	55.0	56.0	59.0	56.0	58.0	55.0	56.0	57.0	56.0	56.0	56.0	57.0	55.0	55.0	54.0	56.0	57.0	54.0	54.0	56.0	55.0	56.0	55.0	55.0
	PLTA POSO#2	55.0	55.0	55.0	55.0	49.0	55.0	55.0	55.0	53.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0
	PLTA POSO#3	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	PLTA MALEA	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
KIT SEWA	PLTD SUNGGUMINASA	20.0																			20.0	20.0	20.0	20.0	20.0	20.0			
	PLTD TALLO LAMA	15.0																			15.0	15.0	15.0	10.0					
	PLTD BAKARA																												
	PLTD TALLASA 1	33.0																		22.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0		
	PLTD TALLASA 2	20.0																			20.0	20.0	20.0	20.0	16.0				
	PLTD TALLASA 5	20.0																			20.0	20.0	20.0	20.0	20.0	20.0	8.0		
	TOTAL IPP & KIT SEWA	699	411.0	380.0	364.0	355.0	361.0	382.0	370.0	415.0	474.0	516.0	542.0	538.0	533.0	549.0	538.0	523.0	521.0	598.0	683.0	685.0	681.0	678.0	664.0	645.0	612.0	569.0	496.0	446.0
PLTD 1 HT 20KV	BILI-BILI # 1	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
	BILI-BILI # 2	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
	SAWITTO	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	SIMBUANG	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	MASAMBA SWTMA & AGRECO	7.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	7.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	SITEBA	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	PLTM BUNGIN	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
TOT. INTERKONEKSI 20 KV		33.5	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	33	29	29	29	29	29	29	29	29
PLTU	TAWAELI#1	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
	TAWAELI#2	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
	TAWAELI#3	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
	TAWAELI#4	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
PLTD	PLTD SILAE	11.5																				11.5							
	SEWA SILAE#1																												
	SEWA SILAE#3	1.5																											
	SEWA SILAE MFO																												
	SEWA TALLISE#1	5.4																											
	SEWA TALLISE#2																												
TOT. SULTENG		73.4	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	67	55	55	55	55	55	55	55	55
TOTAL SISTEM		1065.9	771	772	771	771	771	771	772	771	806	807	836	835	827	837	827	806	806	891	977	1006	991	972	958	939	907	866	806	791
PRAKIRAAN BEBAN (MW)		991.5	681	651	634	625	631	652	641	685	744	787	821	816	803	818	808	793	791	876	961	992	973	956	942	923	890	847	766	716
REALISASI BEBAN MINGGU LALU (MW		976.7	702	657	651	629	637	647	647	686	743	789	817	824	816	802	777	783	802	886	956	977	961	947	929	908	875	829	745	700
CADANGAN PUTAR		MW	90	121	137	146	140	119	131	86	62	20	15	19	24	19	19	13	15	15	16	14	18	16	16	16	17	19	40	75
Cabang Makassar		64.60%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cabang Watampone		7.10%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cabang Bulukumba		6.50%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cabang Pare-Pare		7.40%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cabang Pinrang		3.80%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cabang Palopo		6.30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cabang Mamuju		4.40%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1. TONASA SEMEN		42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
2. BOSOWA SEMEN		12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
3. INDOFOOD		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. BARAWAJA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

POWER PLANTS	REAL POWER OUTPUT (MW)	INFORMATION
PLTA BAKARU	126	Base Load
PLTU BARRU	70	Base Load FTP 1 China Factory
PLTGU SENGKANG	256	Base Load, derating due to a deacrease gas pressure in gas wells, Real Power Output (315 MW)
PLTU JENEPONTO	200	Base Load, IPP BE
PLTU TAWAELI	54	Base Load, IPP
PLTA POSO	190	Load Follower, IPP
PLTD	200	Peaker
PLTG GE	52	Peaker Load Follower
PLTMH	50	Base Load

LOAD DURATION CURVE (LDC)



Merit Order Januari 2018

No.	Unit Pembangkit	DMN	Harga Beli Energi								Keterangan
			Komp A	Komp B	Komp C	Komp D	Komp E	Fix Cost	Var Cost	All Cost	
			Rp/kWh	Rp/kWh	Rp/kWh	Rp/kWh	Rp/kWh	Rp/kWh	Rp/kWh	Rp/kWh	
1	Bakaru	126.00	467.02	34.46	10.00	-	-	501.48	10.00	511.48	Must Run
2	Bili bili	20.00	90.87	-	10.00	-	-	90.87	10.00	100.87	Must Run
3	Sawitto	1.70	90.87	-	10.00	-	-	90.87	10.00	100.87	Must Run
4	Balla	0.70	90.87	-	10.00	-	-	90.87	10.00	100.87	Must Run
5	Kaluku	1.40	90.87	-	10.00	-	-	90.87	10.00	100.87	Must Run
6	Budong	2.00	90.87	-	10.00	-	-	90.87	10.00	100.87	Must Run
7	Bonehau	4.00	90.87	-	10.00	-	-	90.87	10.00	100.87	Must Run
8	PLTM Bambalo	2.00	90.87	-	10.00	-	-	90.87	10.00	100.87	Must Run
9	PLTA Poso	195.00	814.61	24.66	10.00	6.61	213.17	1,052.45	16.61	1,069.06	Must Run
10	PLTB Sidrap	70.00	1,435.86	164.41	-	-	44.59	1,644.85	-	1,644.85	Must Run
11	PLTA Tangka	9.67	761.24	99.95	10.00	14.83	-	861.18	24.83	886.01	
12	Sengkang I	135.00	298.96	87.12	429.52	43.82	9.40	395.49	473.34	868.83	
13	Jeneponto	200.00	558.01	40.27	473.33	13.422	-	598.28	486.75	1,085.03	
14	"PLTA Poso"	195.00	-	-	500.00	-	-	-	500.00	500.00	**Di Atas ECE**
15	PLTU Tawaeli 3 & 4	30.00	679.89	96.37	487.07	14.49	-	776.26	501.55	1,277.81	
16	Jeneponto Ekspansi	125.00	631.50	60.78	510.90	15.77	-	692.28	526.67	1,218.96	
17	PLTU Tawaeli 1 & 2	25.00	432.88	114.51	556.32	19.31	-	547.38	575.63	1,123.01	
18	PLTU Punagaya	200.00	631,6	189,61	562.00	10,84	-	890.88	562.00	1,452.88	
19	PLTU Barru	100.00	401.42	130.07	574.16	10.84	-	531.49	585.00	1,116.49	
20	PLTA Malea	9.22	-	-	593.92	-	-	-	593.92	593.92	
21	Sengkang II	180.00	505.18	41.16	665.00	20.72	-	546.34	685.71	1,232.05	
22	Simbuang	3.00	-	-	787.00	-	-	-	787.00	787.00	
23	Siteba	7.00	-	-	787.00	-	-	-	787.00	787.00	
24	Salunoa	2.00	-	-	787.00	-	-	-	787.00	787.00	
25	"Jeneponto"	30.00	-	-	971.60	-	-	-	971.60	971.60	**Di Atas 200 MW**
26	Bungin	3.00	-	-	1,020.00	-	-	-	1,020.00	1,020.00	
27	Tombolo	2.00	-	-	1,020.00	-	-	-	1,020.00	1,020.00	
28	Rantebala	2.40	-	-	1,020.00	-	-	-	1,020.00	1,020.00	
29	Suppa	62.20	37.01	110.52	1,192.80	5.00	-	147.53	1,197.80	1,345.33	
30	PLTD Sungguminasa	20.00	312.70	-	1,172.48	42.78	-	312.70	1,215.26	1,527.96	
31	Pongbatik	3.00	-	-	1,290.00	-	-	-	1,290.00	1,290.00	
32	Mitsubishi 1 MFO	8.00	200.82	-	1,348.09	(58.03)	-	200.82	1,290.06	1,490.88	
33	Mitsubishi 2 MFO	8.00	200.82	-	1,348.09	(58.03)	-	200.82	1,290.06	1,490.88	
34	Bantaeng	4.20	-	-	1,320.00	-	-	-	1,320.00	1,320.00	
35	Mitsubishi 1 HSD	8.00	200.82	-	1,694.49	(58.03)	-	200.82	1,636.46	1,837.28	
36	Mitsubishi 2 HSD	8.00	200.82	-	1,694.49	(58.03)	-	200.82	1,636.46	1,837.28	
37	PLTD Masamba	11.00	200.82	-	1,637.50	-	-	200.82	1,637.50	1,838.32	
38	PLTD Tallo Lama 10 MW	10.00	315.64	-	1,733.79	-	-	315.64	1,733.79	2,049.43	
39	PLTD Agreko	5.00	236.20	-	1,735.75	56.32	-	236.20	1,792.07	2,028.27	
40	PLTD Silae	18.00	-	-	1,824.83	-	-	-	1,824.83	1,824.83	
41	SWD 2 MFO	8.00	200.82	-	1,267.32	617.98	-	200.82	1,885.29	2,086.11	
42	SWD 1 MFO	8.00	200.82	-	1,380.92	617.98	-	200.82	1,998.89	2,199.71	
43	Mits 40 MW	40.00	-	-	2,163.47	-	-	-	2,163.47	2,163.47	
44	SWD 2 HSD	8.00	200.82	-	1,592.96	617.98	-	200.82	2,210.94	2,411.75	
45	SWD 1 HSD	8.00	200.82	-	1,735.75	617.98	-	200.82	2,353.73	2,554.54	
46	GE 1	25.00	57.82	-	2,757.55	939.50	-	57.82	3,697.05	3,754.87	
47	GE 2	28.00	57.82	-	2,825.02	939.50	-	57.82	3,764.52	3,822.33	
48	Alsthom 1	16.00	57.82	-	3,551.41	939.50	-	57.82	4,490.91	4,548.73	

SYSTEM OPERATIONAL OF SULBAGSEL

- Availability of power suply 1247 MW with peak demand 1118 MW
- Reserve power 100 MW, base on standard of reserve margin, reserve should from 300-400 MW
- Power plant composition are almost equal : Gas, Hydro, Steam and Diesel
- Load Follower , Poso Hydro Power Plant 3x65 MW (Regulation 10-20 MW)
- There is no LFC (Load Frequency Control), frequency control by dispatcher (Load following)
- Setting UFR Existing (IKS 50 MW/Hz Power System stifness)

Setting island : 48 Hz (5 island)

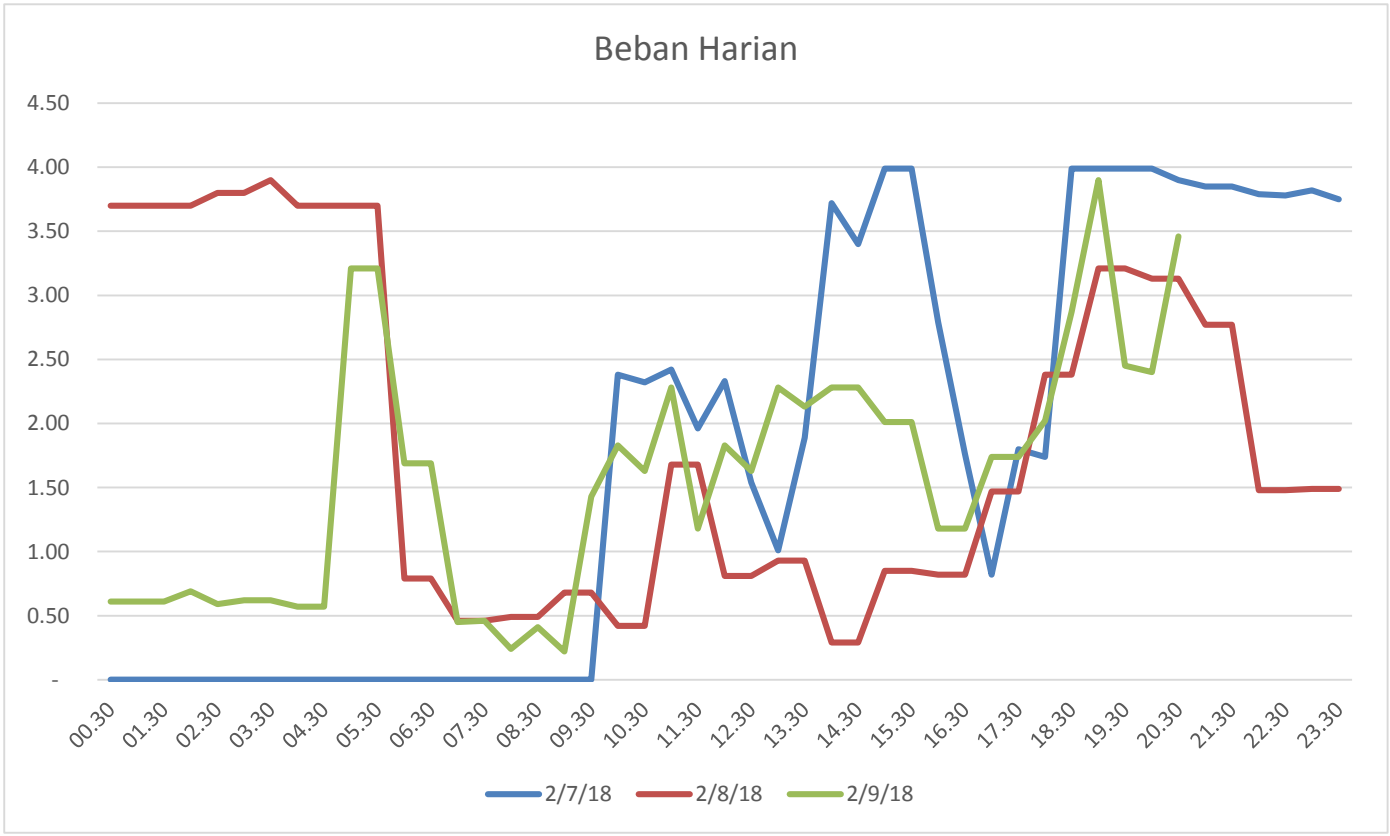
TAHAP	Frekuensi (Hz)	Waktu (ms)	Rekomendasi Makassar (MW)
1	49.20	< 100	41
2	49.00	< 101	43
3	48.80	< 102	40
4	48.60	< 103	38
5	48.40	< 104	42.5
TOTAL			204.5

ISSUES RELATED TO PLTB SIDRAP

SPECIFICATION OF PLTB

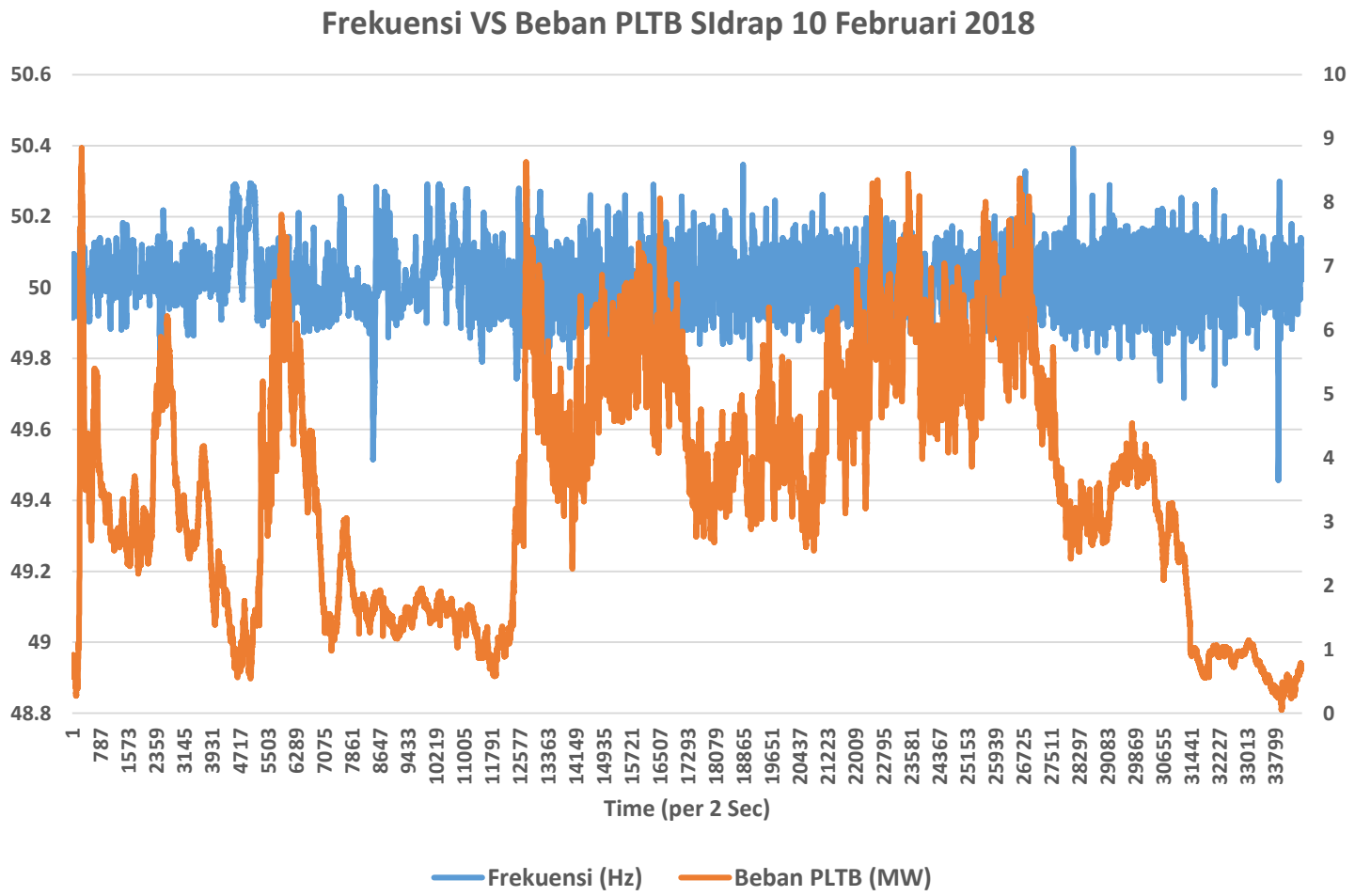
- Type of wind turbine generator (Sync/Async) relate in compensation of reactive power
- VAR setting 0.95 lag until 0.95 lead (-5% until 5% Vnom) : system losses and var control
- Availability of LVRT and how's characteristic and setting relatiion to system defense scheme
- Range of operational voltages ; impact to system protection and stability
- Variable or fix speed wind turbine; harmoic issues
- Wind Turbine technology related to SCADA System ; especially windspeed, wind angle, wind predictive, real wind data information

PLTB SIDRAP CONNECTED TO THE GRID DATA 7-9 FEBRUARI 2018



POWER OUTPUT (MW)

FREQUENCY VS WTG POWER OUTPUT



PLN

Thank You

Single line Sistem Sulsel