PEMODELAN ENERGI LEAP UNTUK MENDUKUNG REVISI RENCANA UMUM ENERGI NASIONAL(RUEN)

Urgensi Revisi RUEN

- RUEN (2017) belum mengadopsi visi transisi energi atau peta jalan dekarbonisasi untuk mencapai net zero emissions di tahun 2060 atau lebih cepat akibat adanya perubahan iklim dunia seperti pemanasan global.
- Kondisi makro ekonomi nasional sudah berubah sebagai akibat dari pandemi Covid-19 serta kondisi geopolitik dunia yang tidak menentu. Sebagai contoh, pertumbuhan ekonomi yang lebih rendah yang berdampak pada laju permintaan energi yang lebih lambat dan beberapa target indikator energi yang tidak tercapai.
- Perkembangan teknologi low carbon dan/atau zero carbon yang memanfaatkan EBT atau green energy lainnya seperti hydrogen tumbuh lebih cepat dibandingkan sebelumnya yang diikuti dengan nilai keekonomian yang semakin murah.
- Perkembangan teknologi digital telah menyebabkan pola konsumsi dan mobilitas manusia menjadi berubah signifikan. Hal ini menyebabkan perubahan struktur ekonomi nasional yang mana akan berdampak pada pola dan laju permintaan energi kedepan.
- Akan terbit PP KEN yang baru

Tantangan 1: Energy Supply Demand

- RUEN (2017) disusun selain untuk memetakan dan menjawab kondisi permasalahan dan/atau tantangan energi yang ada, untuk membuat perencanaan energi jangka panjang sekaligus menyiapkan '*policy respond*' dan program/proyek lintas sektor yang nyata dan layak untuk diimplementasikan. Beberapa tantangan energi waktu itu, antara lain:
  - Penurunan produksi minyak bumi,
  - Pemanfaatan energi domestik yang masih rendah,
  - Akses energi masih terbatas,
  - Ketergantungan impor BBM dan LPG,
  - Harga energi belum kompetitif dan subsidi energi tinggi,
  - Bauran energi masih didominasi minyak bumi, sedangkan energi baru terbarukan (EBT) masih rendah
  - Pemanfaatan energi belum efisien
- **Pertanyaan: Apakah tantangan (permasalahan) tersebut saat ini masih ada? Semakin berkurang atau semakin bertambah?**

Tantangan 2: PP KEN Baru

Supply:
- **Bauran Energi Primer EBT : 17% - 19%**
- Pengembangan pembangkit listrik sesuai RUPTL PLN (2021-2030)

Demand:
- Pemanfaatan biofuel: B35
- Jargas : 1 – 1,2 juta RT
- Kompor induksi/rice cooker: 700ribu RT
- Kendaraan Listrik: 1 jt mobil, 6 jt motor. KA 0,34-0,35 TWh,
- Mandatori B30 tahun 2025
- BBG : 189 ribu kendaraan, 39 unit kapal,
- Konsumsi energi final: 0,72 – 0,76 TOE/kapita
- Konsumsi listrik: 1.383 – 1.704 kWh/kapita

2025:tingkat emisi 914 - 984 juta ton CO2e **2025**

Supply:
- **Bauran Energi Primer EBT : 19% - 21%**
- Menghentikan impor bensin & LPG

Demand:
- Pemanfaatan biofuel: B35 dan E4
- Jargas 1,7 – 2 juta RT
- Kompor induksi: 2 juta - 5 juta RT
- Kendaraan Listrik: 5,5 jt mobil & 8,5 jt motor, KA 0,37-0,39 TWh
- BBG: 189 ribu kendaraan, 39 unit kapal
- Konsumsi energi final: 0,84 – 0,91 TOE/kapita
- Konsumsi listrik: 1.826 – 2.564 kWh/kapita

2030:tingkat emisi 1.074 - 1.223 juta ton CO2e **2030**

Supply:
- **Bauran Energi Primer EBT : 25% - 26%**
- *Retirement* PLTU tahap 1
- Tidak ada PLTD
- PLTN mulai beroperasi 250 MW di tahun 2032
- Pemanfaatan CCS/CCUS di pembangkitan listrik

Demand:
- Pemanfaatan biofuel: B40 dan E4
- Jargas 2,6 – 3,4 juta RT
- Kompor induksi : 10 juta RT
- Kendaraan Listrik: 6,7-7,3 jt mobil & 28,5-30,2 jt motor, 219 rb Bus, 595 rb Truk Kecil, KA 1-1,15 TWh,
- BBG: 203 ribu kendaraan, 42 unit kapal
- Hidrogen mulai dimanfaatkan untuk transportasi & industri
- Konsumsi energi final: 0,93 – 1,0 TOE/kapita
- Konsumsi listrik: 2.568 – 3.459 kWh/kapita

2035: tingkat emisi 1.150 – 1.316 juta ton CO2e **2035**

Supply:
- **Bauran Energi Primer EBT : 40% - 42%**
- *Retirement* PLTU tahap 2
- Pemanfaatan biofuel: B40 dan E10 – E40
- Pemanfaatan CCS/CCUS di pembangkitan listrik & industri

Demand:
- Jargas : 3,1 – 4 juta RT
- Kompor induksi: 15 juta RT
- Kendaraan Listrik: 12-13 juta mobil & 48,5 - 52 juta motor, 388 rb Bus, 1,3 jt Truk Kecil, KA 2,9-3,8 TWh
- BBG: 203-209 ribu kendaraan, 42-44 unit kapal
- Konsumsi energi final: 1,02 – 1,12 TOE/kapita
- Konsumsi listrik: 3.274 – 4.264 kWh/kapita

2040: tingkat emisi 975 - 1.085 juta ton CO2e **2040**

Supply:
- **Bauran Energi Primer EBT : 51% - 54%**
- Pemanfaatan biofuel: B50-B60 dan E10 – E40

Demand:
- Jargas: 4,2 – 5,4 juta RT
- Kompor induksi: 46,6 juta RT
- Kendaraan Listrik: 25-27,7 jt mobil & 88,5- 95 jt motor, 777 rb Bus, 2,7 jt Truk Kecil, KA 7,6 -8,8 TWh
- BBG: 203-222 ribu kendaraan, 42-48 unit kapal
- Konsumsi energi final: 1,12- 1,27 TOE/kapita
- Konsumsi listrik: 4.489 - 5.653 kWh/kapita

2050: tingkat emisi 598 - 579 juta ton CO2e **2050**

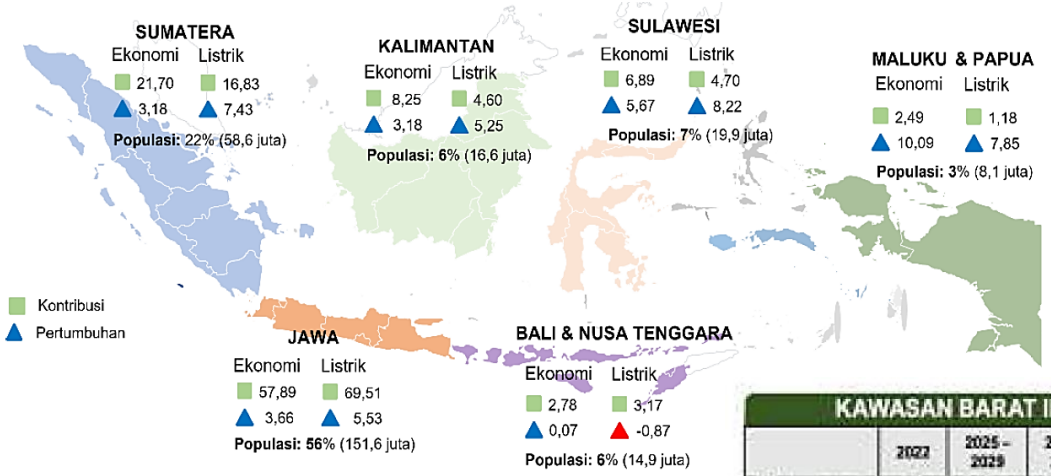
Supply:
- **Bauran Energi Primer EBT : 70% - 72%**
- Pemanfaatan biofuel: B50-B60 dan E10 – E40
- Semua PLT energi fosil menggunakan CCS/CCUS

Demand:
- Jargas : 5,7 – 7,3 juta RT
- Kompor induksi: 52 juta RT
- Kendaraan Listrik: 44-47 jt mobil,128,4-138 jt motor, 1.3 jt Bus, 4.1 jt Truk Kecil, KA 13-14 TWh
- BBG: 203-228 ribu kendaraan, 42-48 unit kapal
- Konsumsi energi final: 1,19 – 1,36 TOE/kapita
- Konsumsi listrik: 5.419 KWh – 6.526 kWh/kapita

2060: tingkat emisi 129 juta ton CO2e **2060**

Sumber: Hasil pemodelan transisi energi per 12 November 2023

Tantangan 3: Kewilayahan



Sumber: Bappenas, 2022 (diolah)

Indikator	Baseline 2022	Target 2045
Indeks Williamson	0,778	0,750
Kontribusi KTI terhadap PDB (persen)*	20,6	28,5
Stok Infrastruktur terhadap PDB (persen)	46,0	62,0

Keterangan:

*KTI mencakup wilayah Bali-Nusa Tenggara, Kalimantan, Sulawesi, Maluku dan Papua.

KAWASAN BARAT INDONESIA

	2022	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2045
Pertumbuhan	5,1	5,4 – 5,8	6,8 – 7,5	6,1 – 7,0	5,1 – 6,0
Kontribusi*	78,5	76,7	74,7	72,9	**71,5**

KAWASAN TIMUR INDONESIA

	2022	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2045
Pertumbuhan	6,1	6,8 – 7,4	8,7 – 9,9	8,0 – 9,5	6,2 – 7,7
Kontribusi*	21,5	23,3	25,3	27,1	**28,5**

KALIMANTAN

	2022	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2045
Pertumbuhan	4,9	5,6 – 6,3	8,5 – 9,9	7,3 – 8,9	5,7 – 7,3
Kontribusi*	9,2	9,6	10,5	11,1	11,3

MALUKU

	2022	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2045
Pertumbuhan	14,2	11,6 – 12,4	12,5 – 13,9	10,8 – 12,7	7,3 – 9,3
Kontribusi*	0,7	1,0	1,4	1,8	2,0

SUMATERA

	2022	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2045
Pertumbuhan	4,7	5,0 – 5,4	6,7 – 7,7	6,0 – 7,1	5,2 – 6,4
Kontribusi*	22,0	22,2	22,9	23,0	23,2

SULAWESI

	2022	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2045
Pertumbuhan	7,1	7,6 – 8,4	9,0 – 10,5	8,6 – 10,3	6,4 – 8,1
Kontribusi*	7,0	7,6	7,8	8,1	8,1

PAPUA

	2022	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2045
Pertumbuhan	7,0	6,8 – 7,2	7,8 – 8,4	7,4 – 8,2	6,0 – 6,9
Kontribusi*	1,8	2,1	2,4	2,7	3,0

JAWA

	2022	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2045
Pertumbuhan	5,3	5,6 – 5,9	6,8 – 7,5	6,2 – 7,0	5,0 – 5,9
Kontribusi*	56,5	54,5	51,8	49,9	48,3

BALI-NUSA TENGGARA

	2022	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2045
Pertumbuhan	5,1	6,8 – 7,0	8,0 – 8,3	7,4 – 8,0	6,6 – 7,3
Kontribusi*	2,7	3,0	3,2	3,4	4,1

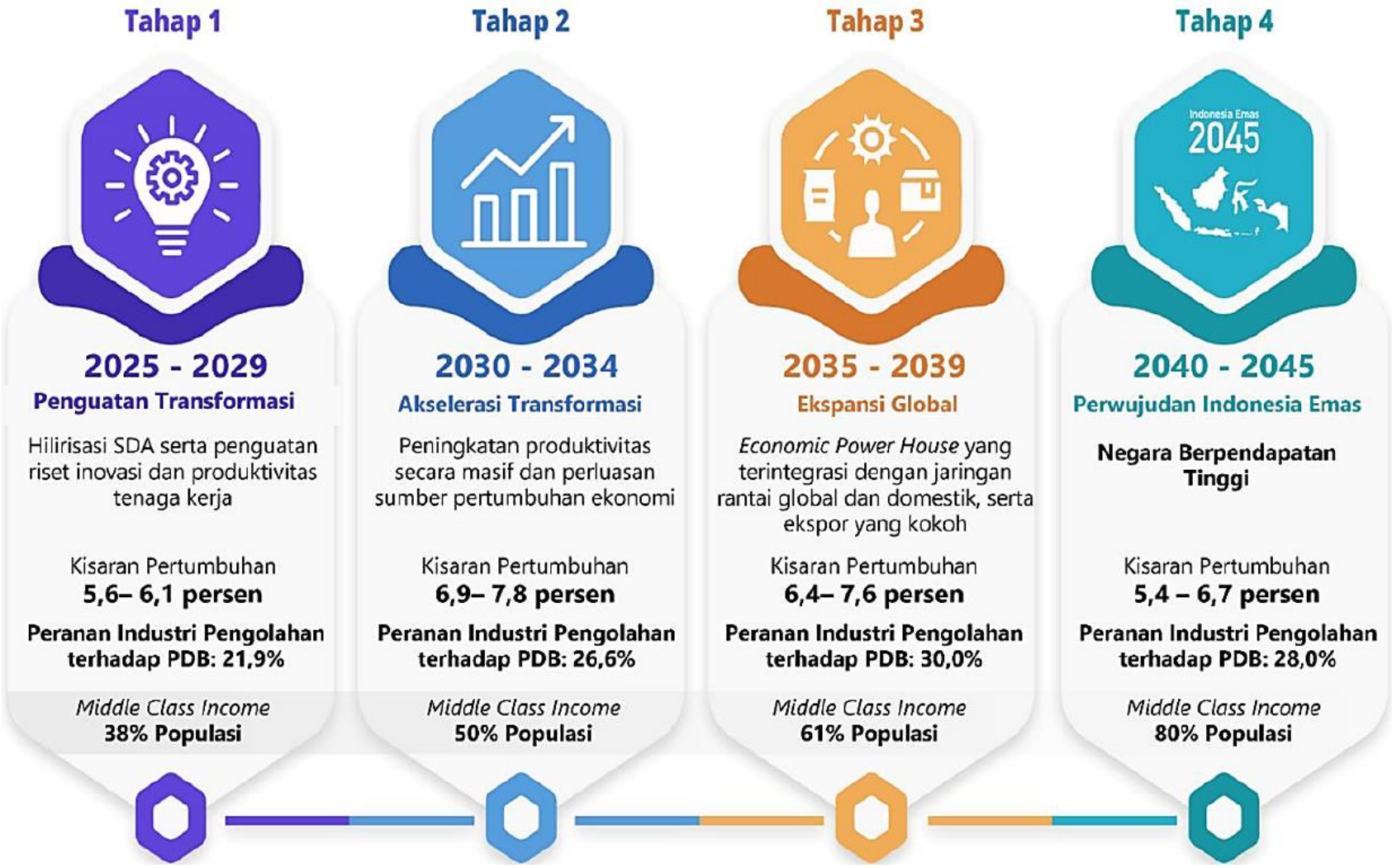
Keterangan:
Kawasan Barat Indonesia (KBI): mencakup Sumatera, Jawa,
Kawasan Timur Indonesia (KTI): mencakup Kalimantan, Bali-Nusra, dan Sulampua
*Kontribusi di akhir periode menggunakan skenario 7%

Sumber: *Exercise* Bappenas (2023) per 22 Juni 2023

Sumber: Kementerian PPN/Bappenas, 2023 (diolah)

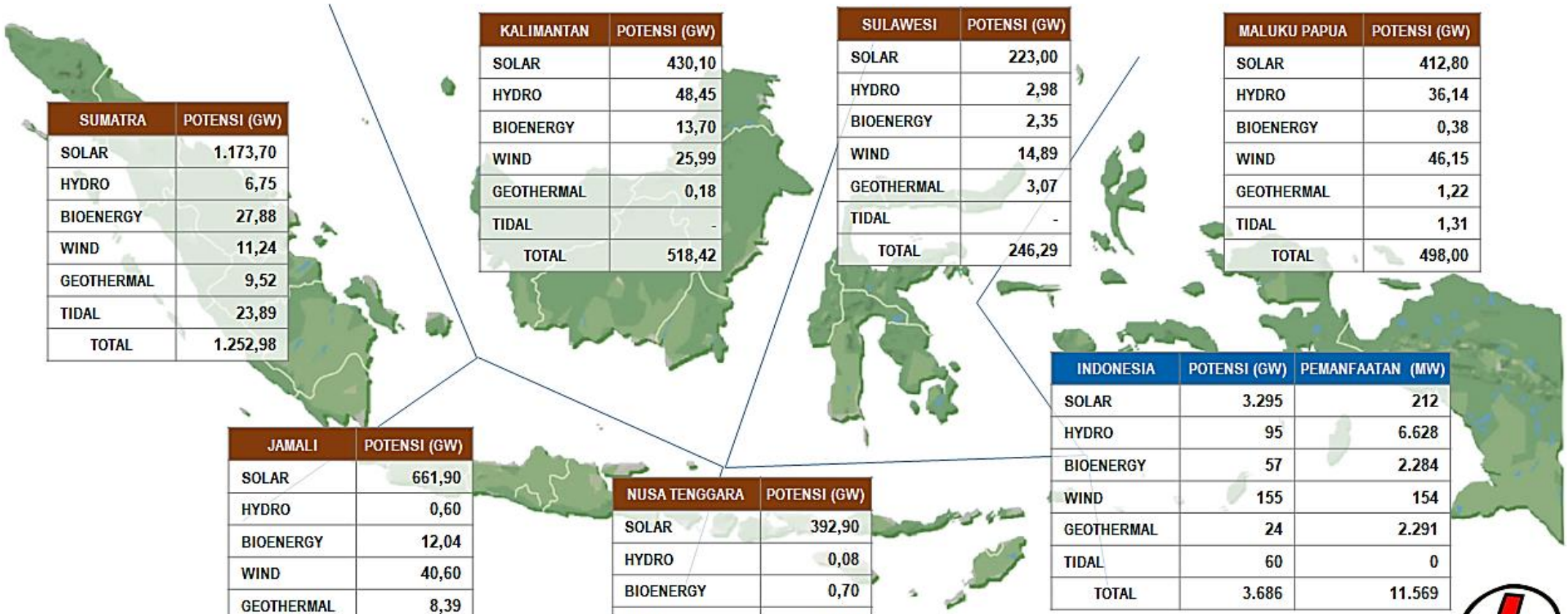
RPJPN 2025 – 2045 (Indonesia Emas 2045)

Tantangan 4: Perubahan Struktur Ekonomi



RPJPN 2025 – 2045 (Indonesia Emas 2045)

Tantangan 5: Sebaran Potensi EBT



SUMATRA	POTENSI (GW)
SOLAR	1.173,70
HYDRO	6,75
BIOENERGY	27,88
WIND	11,24
GEOTHERMAL	9,52
TIDAL	23,89
TOTAL	1.252,98

KALIMANTAN	POTENSI (GW)
SOLAR	430,10
HYDRO	48,45
BIOENERGY	13,70
WIND	25,99
GEOTHERMAL	0,18
TIDAL	-
TOTAL	518,42

SULAWESI	POTENSI (GW)
SOLAR	223,00
HYDRO	2,98
BIOENERGY	2,35
WIND	14,89
GEOTHERMAL	3,07
TIDAL	-
TOTAL	246,29

MALUKU PAPUA	POTENSI (GW)
SOLAR	412,80
HYDRO	36,14
BIOENERGY	0,38
WIND	46,15
GEOTHERMAL	1,22
TIDAL	1,31
TOTAL	498,00

JAMALI	POTENSI (GW)
SOLAR	661,90
HYDRO	0,60
BIOENERGY	12,04
WIND	40,60
GEOTHERMAL	8,39
TIDAL	4,86
TOTAL	729,39

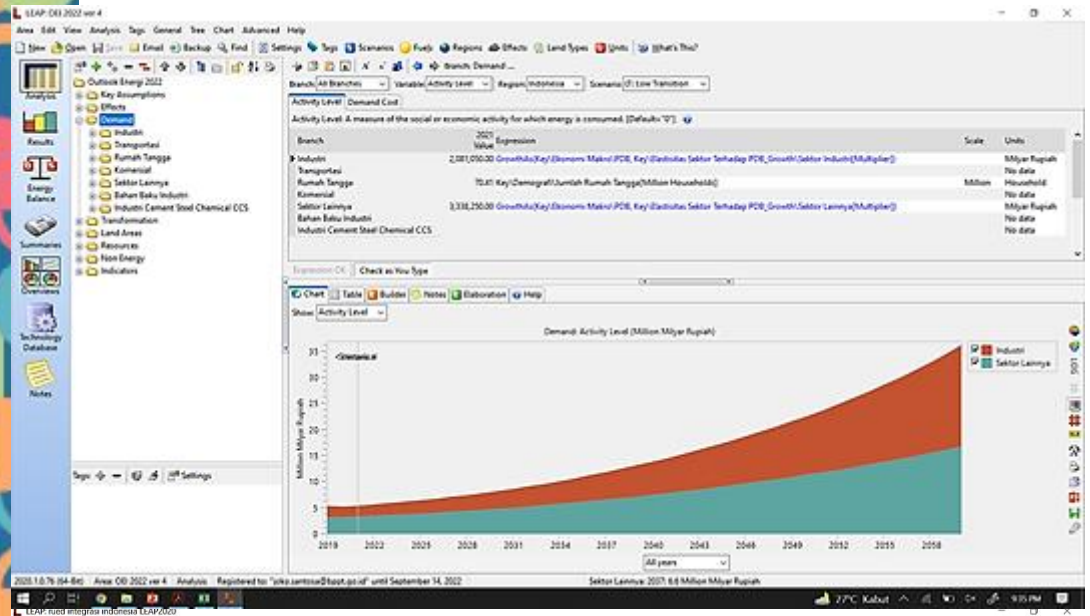
NUSA TENGGARA	POTENSI (GW)
SOLAR	392,90
HYDRO	0,08
BIOENERGY	0,70
WIND	16,02
GEOTHERMAL	1,40
TIDAL	29,94
TOTAL	441,04

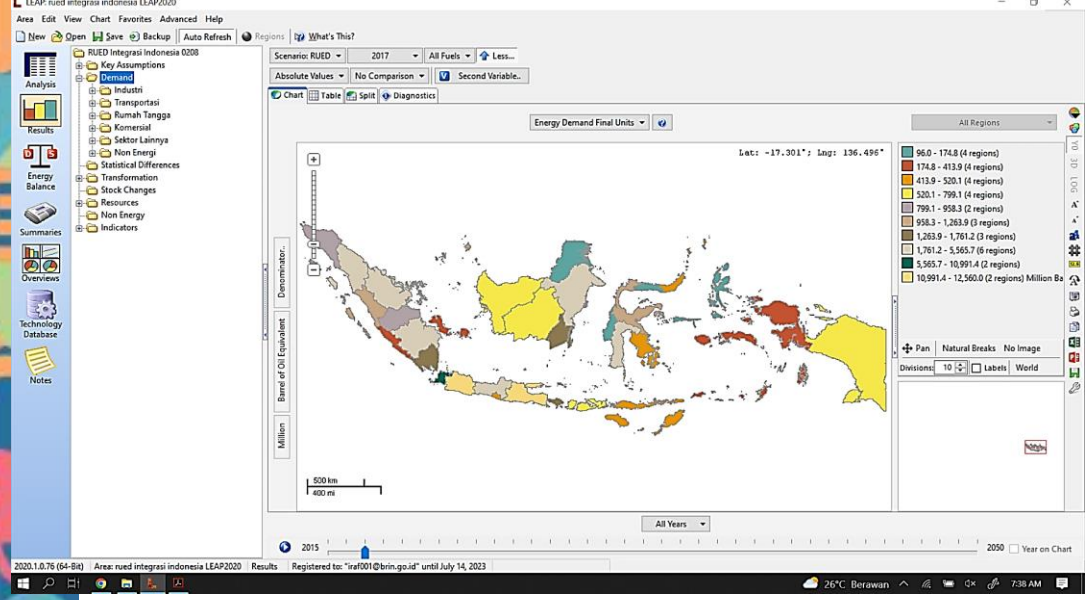
INDONESIA	POTENSI (GW)	PEMANFAATAN (MW)
SOLAR	3.295	212
HYDRO	95	6.628
BIOENERGY	57	2.284
WIND	155	154
GEOTHERMAL	24	2.291
TIDAL	60	0
TOTAL	3.686	11.569

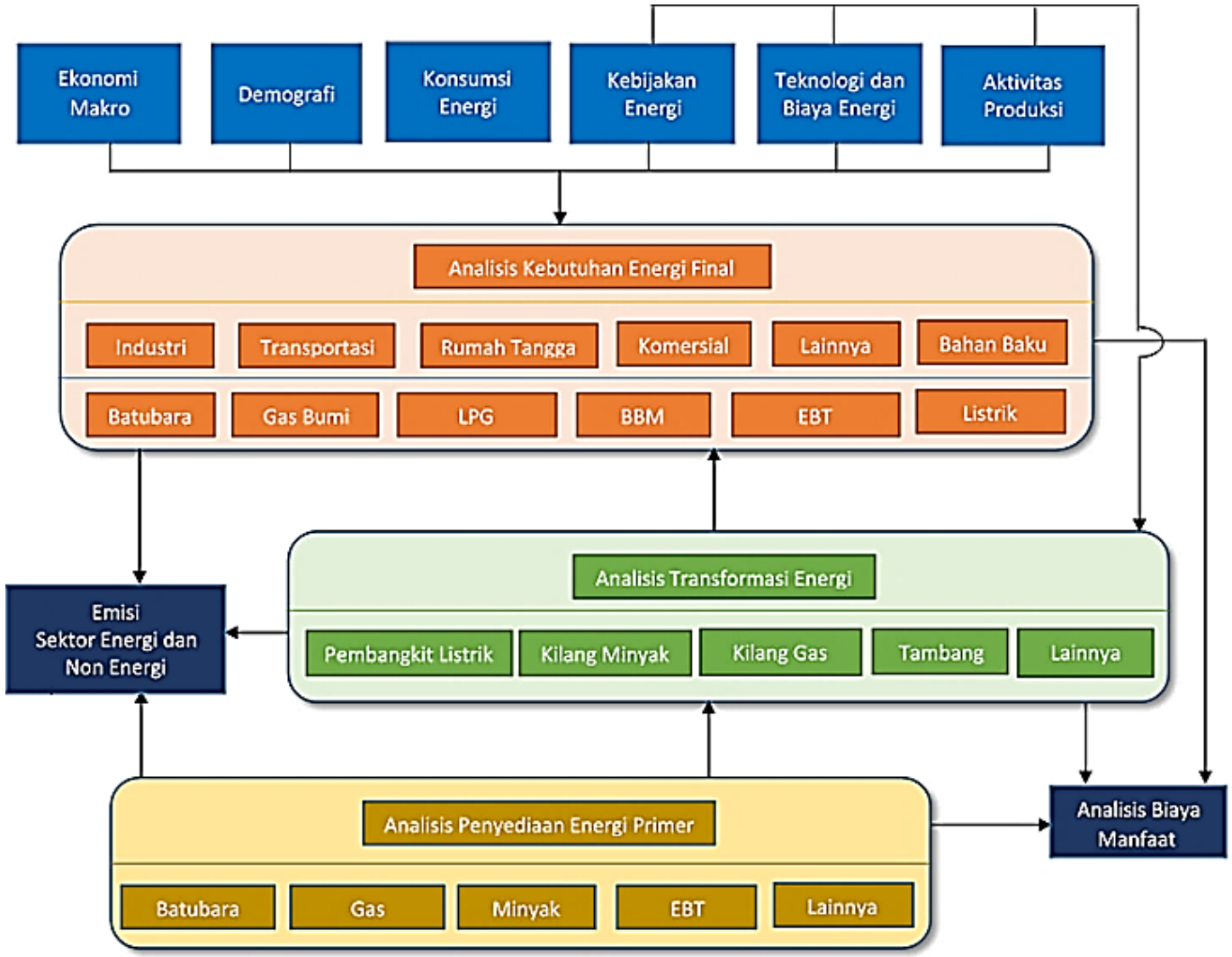
Jamali : 729 GW (20%)
Luar Jamali : 2.957 GW (80%)

Sumber: EBTKE 2022, KESDM

Analytical Framework: Energy Supply and Demand with the *LEAP* Integrated Energy Model



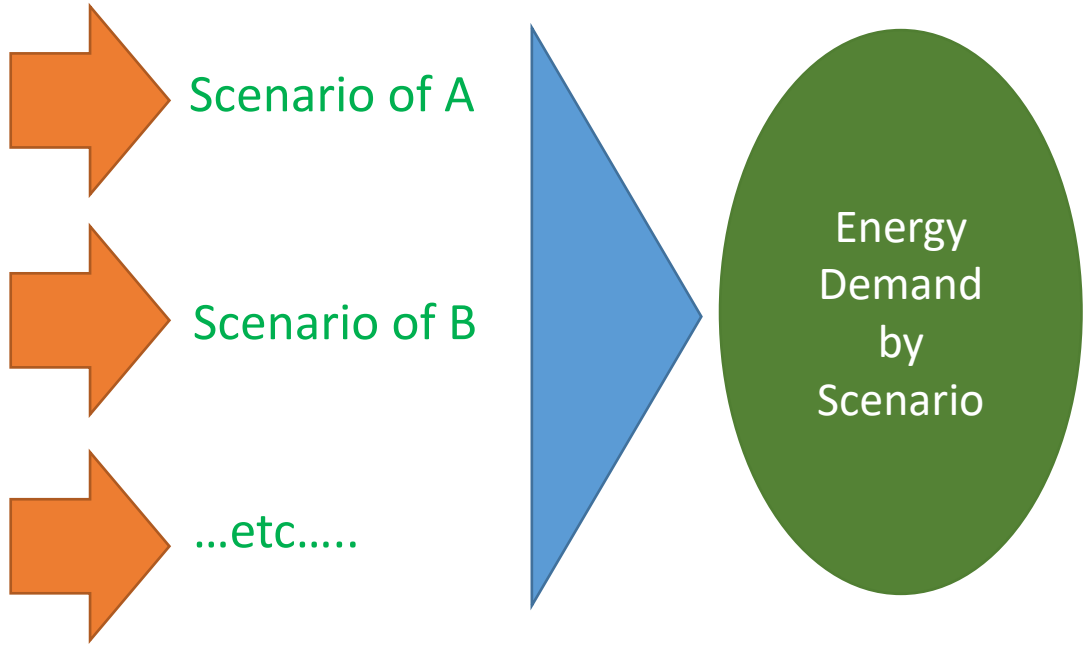




Long Term Energy Demand Key Drivers

Long term energy demand key drivers
(**Uncertanties**)

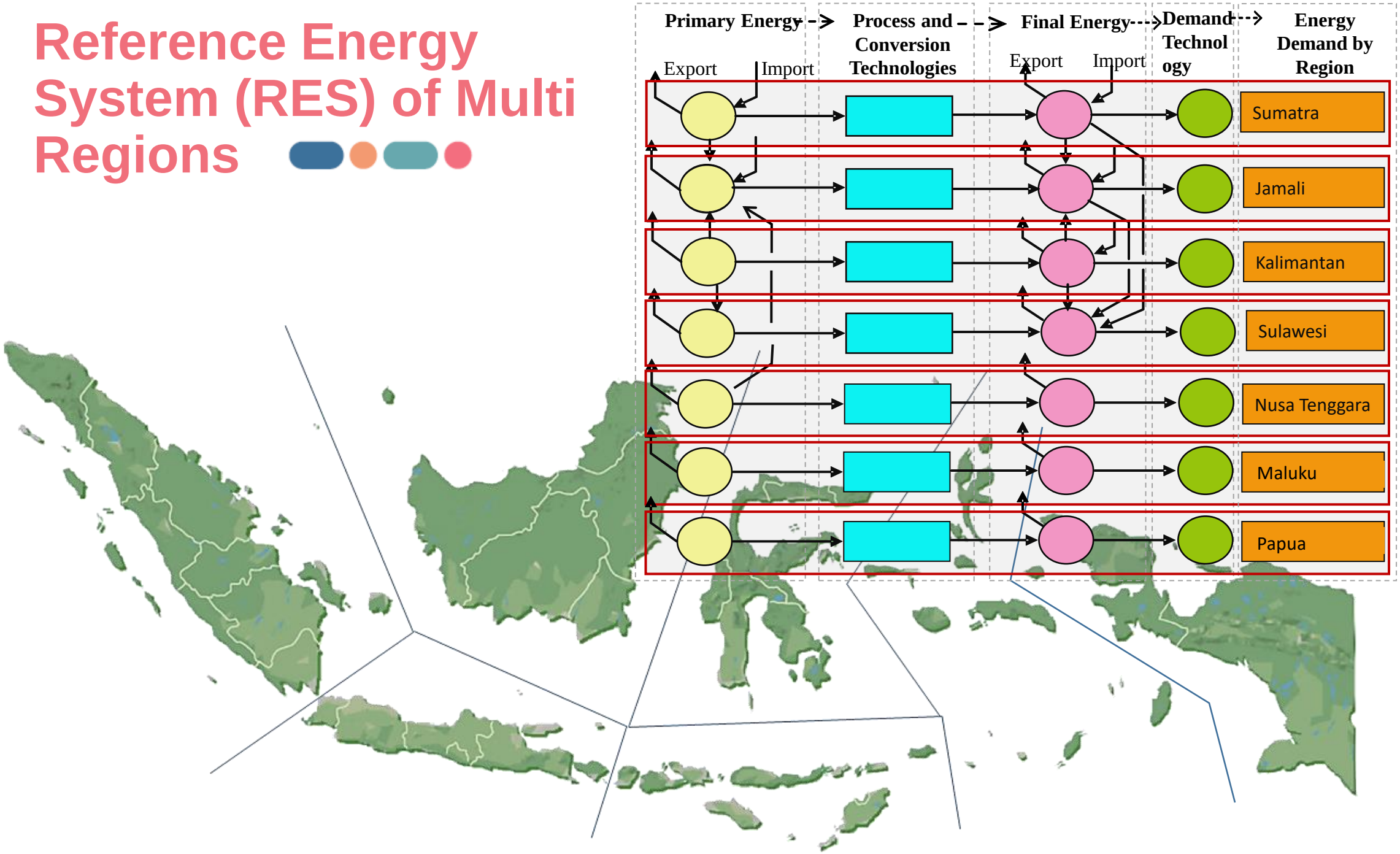
- Economy (GDP/GRDP)
- Population
- Price
- Technology
- Behavioral changes (response to new policies, price changes, technology advancement, education level, environmental awareness, welfare, etc.)



The best way to formulate a strategy to meet energy demand in the face of future uncertainties is to develop several projected scenarios. In this study, we consider three scenarios:

- **BaU**
- **RUEN with No Grid Interconnection**
- **RUEN with Grid Interconnection**

Reference Energy System (RES) of Multi Regions



Reference Energy System (RES) of a Region

Primary Energy Supply | **Conversion Technologies** | **End-Use Demand Technologies** | **Energy Demand**

(Primary Energy) (Final Energy) (Useful Energy)

Mining
- Crude Oil
- Natural Gas
- Coal

Renewable
- Solar
- Wind
- Biogas
- Biomass
- Hydro
- Geothermal
- MSW
- Biodiesel
- Ocean

Export Import
- Electricity
- Oil
- Coal
- LNG

Conversion
- Refineries
- Biorefineries
- LNG Plants
- LPG Plants
- LNG Regasification

Pembangkit Listrik
- Coal fired
- Combined Cycle
- Gas Turbine
- Gas Engiine
- Diesel Engine
- Hydro
- Mini Hydro
- Geothermal
- Biomass
- Biogas
- Waste to Energy
- Solar
- Wind
- Ocean
- Nuclear
- Battery Energy Storage

Transport
- Cars
- Buses
- Trucks
- Motor Cycles
- Passenger Trains
- Freight Trains
- Commuting Trains
- Passenger Planes
- Cargo Planes
- Ships

Households
- Cooking
- Lightings
- ACs
- Televisions
- Refrigerators
- Others

Commercial
- Cooking
- Lightings
- ACs
- Transport
- Others

Industry
- Direct Heating Process
- Indirect Heating Process
- Cooling
- Machine drives

Others
- Agriculture
- Fishery
- Construction
- Mining

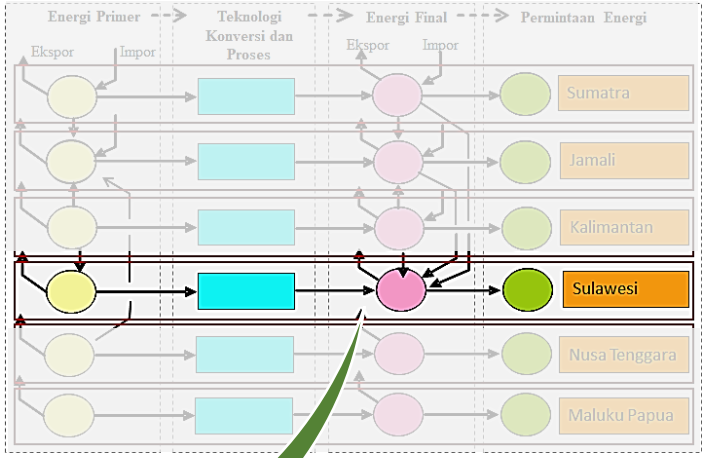
Transport
- Useful energy demand
- Pnp-km
- Ton-Km

Households
- Useful energy demand

Commercial
- Final energy demand

Industry
- Final energy demand

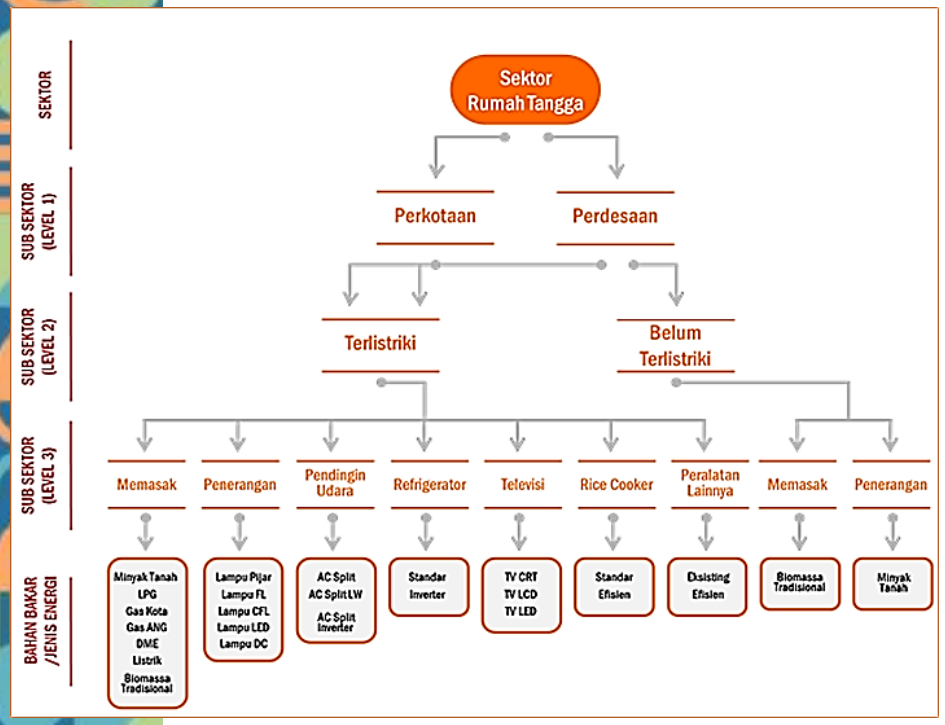
Others
- Final energy Demand

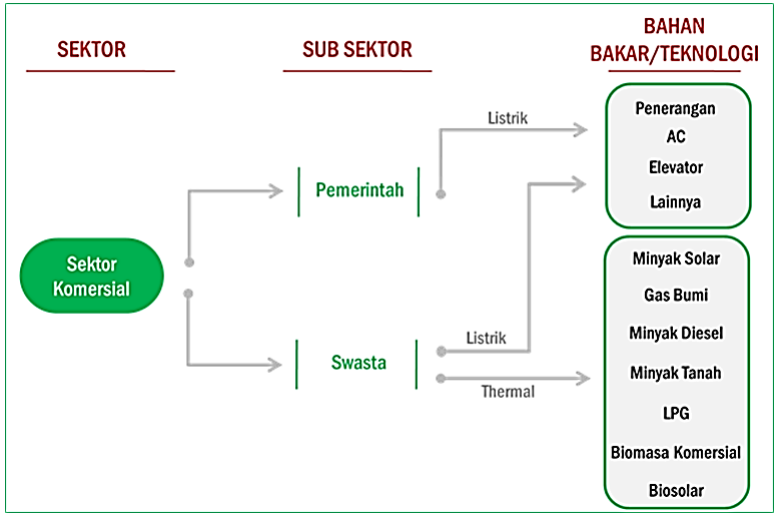


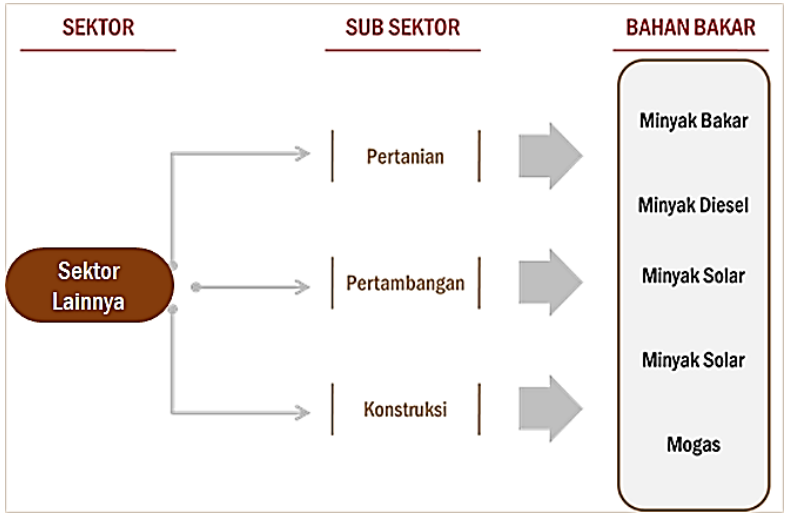
RES of a region (each region may have a different RES)

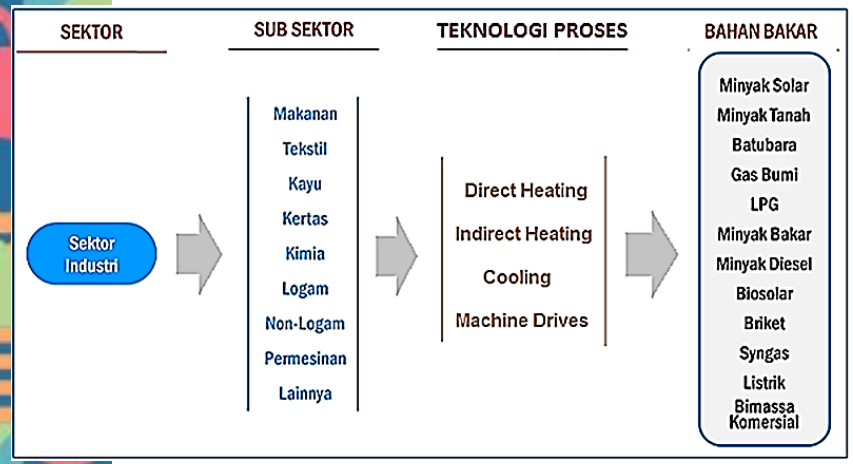
Detailed demand technologies of a region can be found on the next slide

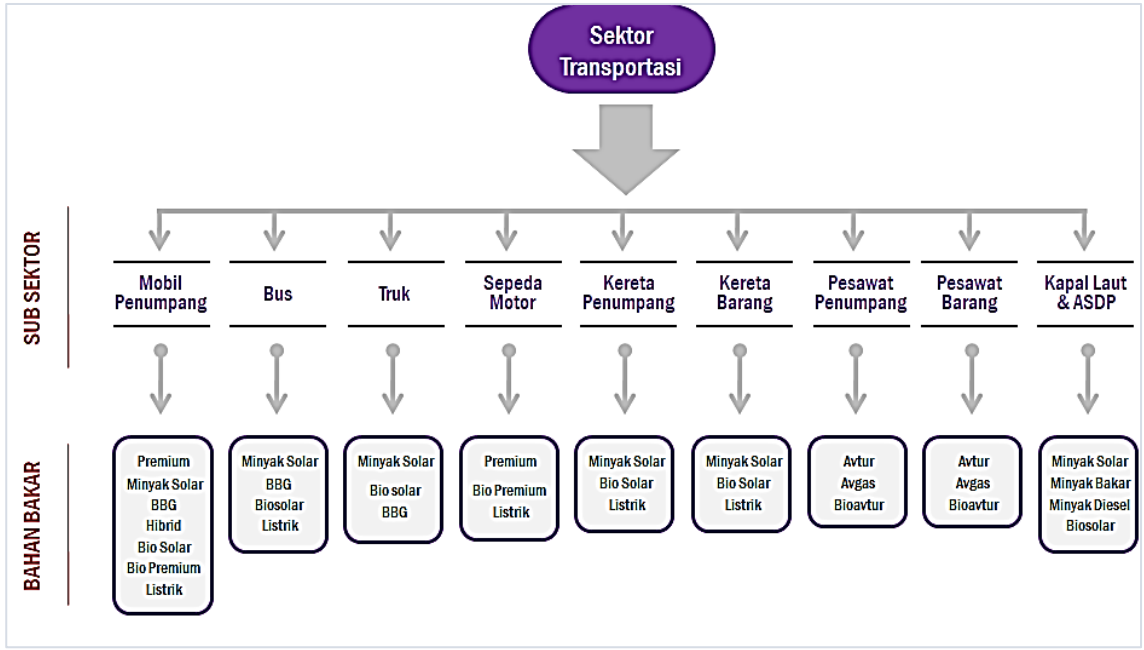
End Use Demand Technologies







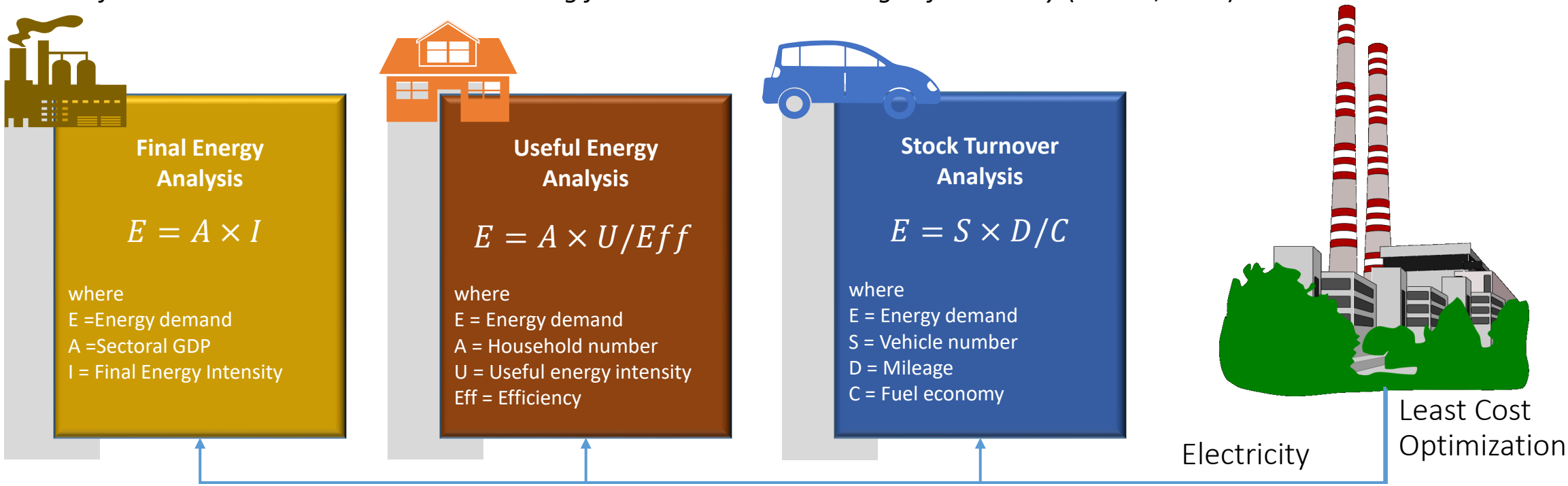




Each region could have a different set of demand technologies

Energy Demand and Supply Analysis

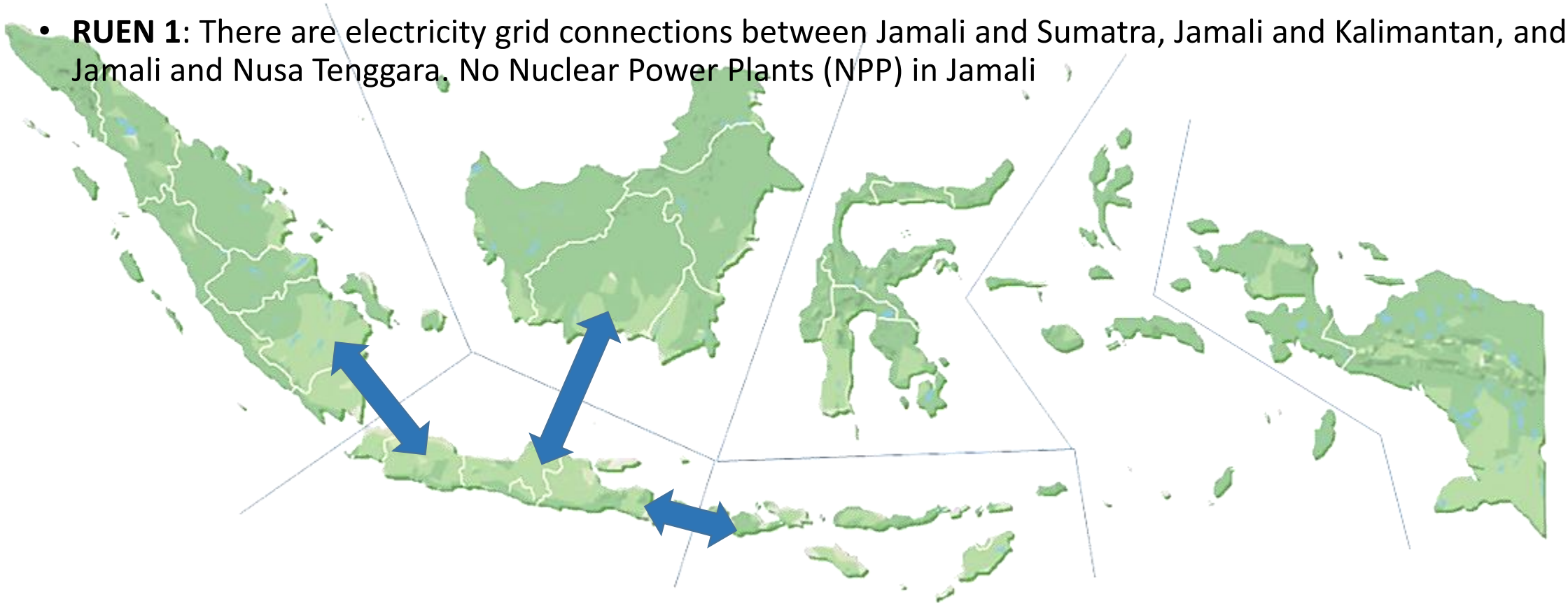
- The LEAP model is able to support a number of different modeling methodologies (top down, bottom up and hybrid) with different projection methodologies such as time series, econometrics, end use and stock turnover.
- In projecting final energy demand, this study employs one of the bottom up approaches like end-use analysis.
  - Industry: Final Energy and Stock Turnover
  - Transportation: Final Energy and Stock Turnover
  - Residential: Useful Energy and Stock Turnover
  - Commercial: Final Energy and Stock Turnover
- Energy activity projections in the industrial, commercial and other sectors use macroeconomic and demographic projection results
- For the baseline scenario, energy intensity projections are based on the correlation between energy intensity and GDP
- Projection of electricity supply applies the least cost optimization approach. Power plant cost data are obtained from *Technology Data for the Indonesian Power Sector: Catalog for Generation and Storage of Electricity* (MEMR, 2021)



Scenarios of Grid Interconnections

Beside BAU, we consider two supply scenarios called RUEN and RUEN 1 in the power sector. These two scenarios use the same electricity demand (RUEN Scenario). The assumptions for each scenario are as follows:

- **BAU** and **RUEN** : There are no electricity grid interconnections among Jamali, Sumatra, Kalimantan, and Nusa Tenggara
- **RUEN 1**: There are electricity grid connections between Jamali and Sumatra, Jamali and Kalimantan, and Jamali and Nusa Tenggara. No Nuclear Power Plants (NPP) in Jamali



Socio Economic Indicator Projection

Indicator	Unit	2020 [1)]	2025	2030	2035	2040	2045	2050	2055	2060
Population	Million People	270.2	284.4	297.4	308.4	317.2	324.1	328.9	332.1	334.1
Popuation Growth	%	1.16	1.01	0.82	0.66	0.51	0.37	0.25	0.15	0.10
Households	Million Households	69.7	73.5	77.0	79.9	82.4	84.3	85.7	86.6	87.3
Urban Share	%	56.4	59.6	62.9	66.1	69.2	72.2	74.0	75.0	75.5

Indicator	Unit	2022 [2)]	2025	2030	2035	2040	2045	2050	2055	2060
GDP	Trillion Rupiah	11,710	13,720	18,282	25,402	34,639	45,079	56,310	68,840	83,754
GDP Growth	%	5.31	5.44	6.50	7.00	6.00	5.00	4.25	4.00	4.00
GDP per capita	Million Rupiah	42.5	48.2	61.5	82.4	109.2	139.1	171.2	207.3	250.7
GDP per Capita	US Dollar	4,724	5,365	6,836	9,162	12,145	15,472	19,040	23,057	27,885

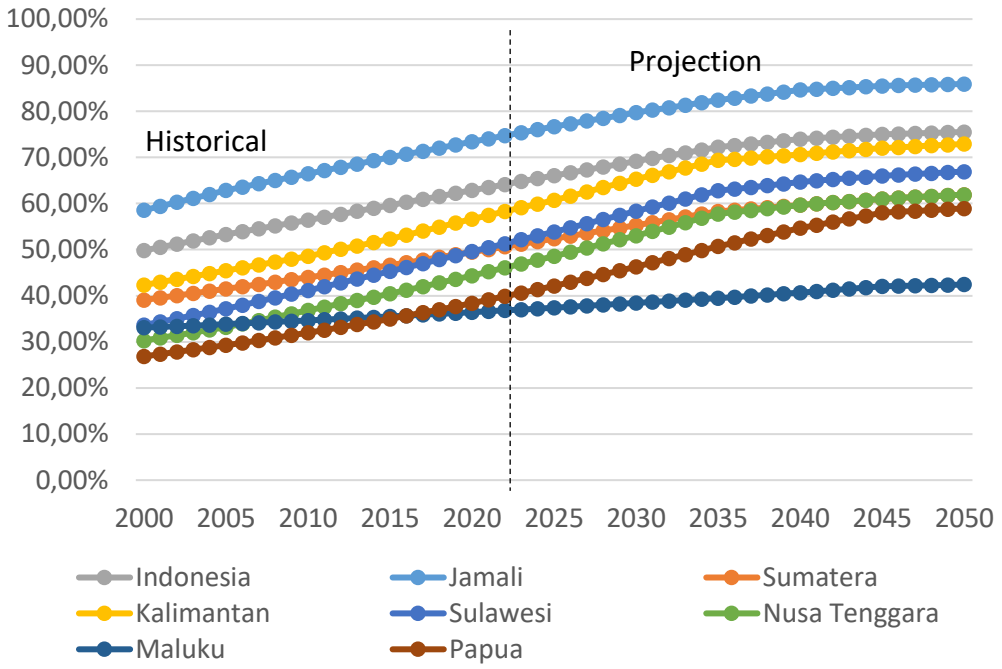
1) 2020 Census by BPS

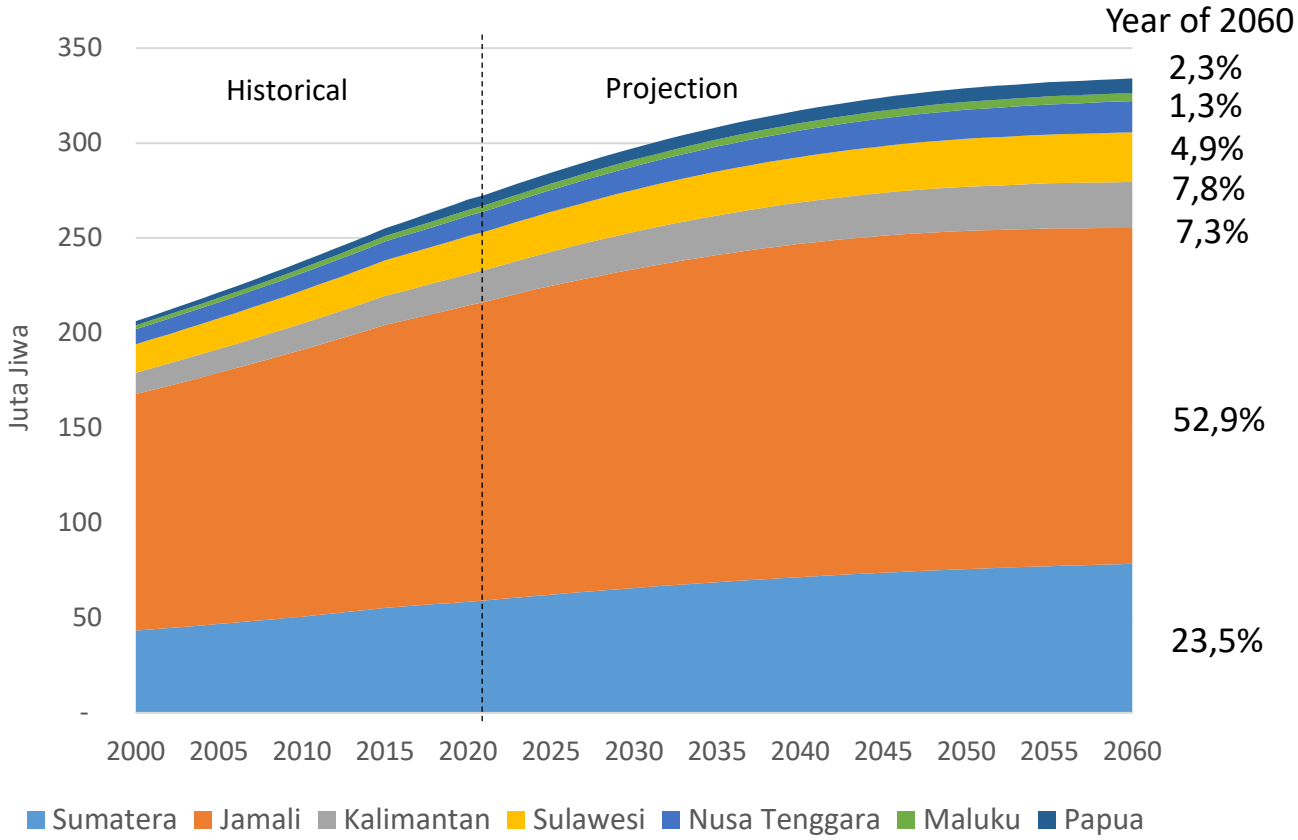
2) Historical data

Source: BPS and BAPPENAS

- Projections of Indonesia's population growth and other indicators refer to the results of the BPS study
- National economic growth (GDP) projections are based on BAPPENAS study results of 6% per year until 2045
- Escaping from Middle Income Trap (about 12,695 US Dollars/Capita) will be realized before 2045 (Government Vision/Target).

Indonesian Population by Region



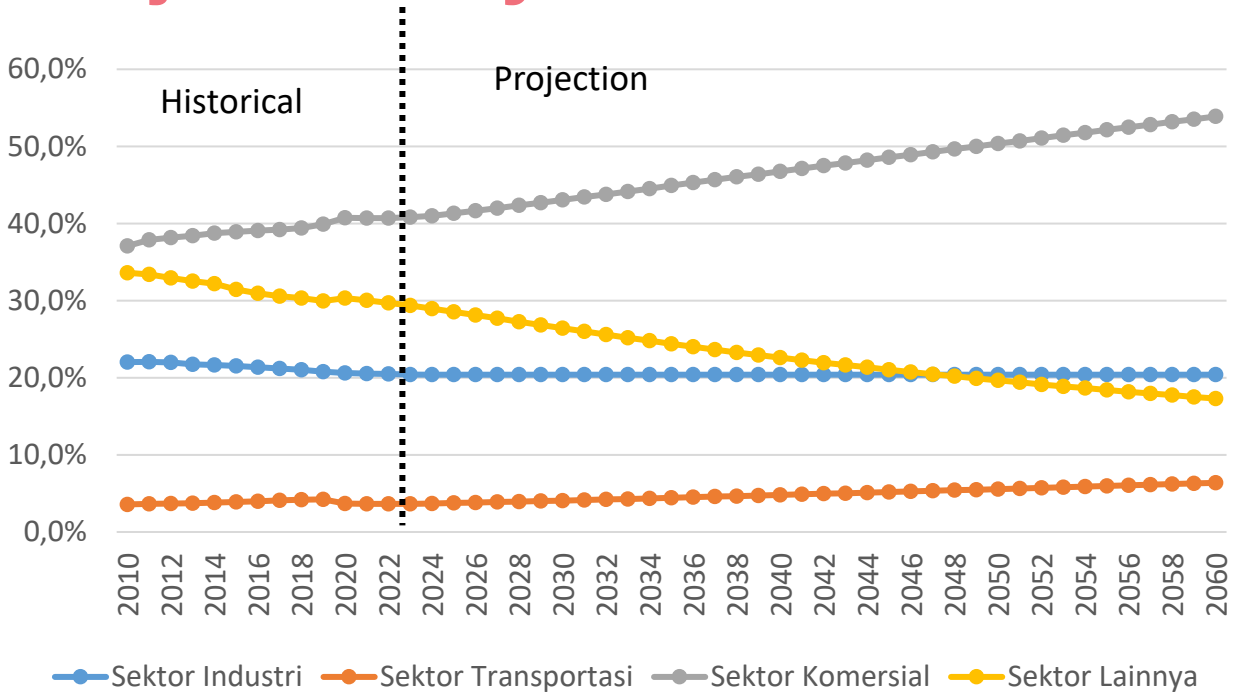


- Indonesia's population growth and other indicators both nationally and by region refer to the results of the BPS study until 2050 *)
- For the period after 2050, the population is projected using the extrapolation method

*) Source: Proyeksi Penduduk Indonesia 2015-2050 Hasil SUPAS 2015, BPS 2018

**) 2020 BPS Census

Indonesia GDP Share Projection by Sector



- GDP data in BPS statistic are broken down into 17 sectors. These sectors are aggregated into four sectors, which are Industry (Manufacturing), Transportation, Commercial and Others for the purpose of simplifying the final energy demand modeling.
- Sectoral GDP share projections are calculated based on historical GDP elasticity by sector
- GDP share is very important in making sectoral energy demand projections considering that each sector has different energy consumption patterns which are also indicated by different energy intensities.

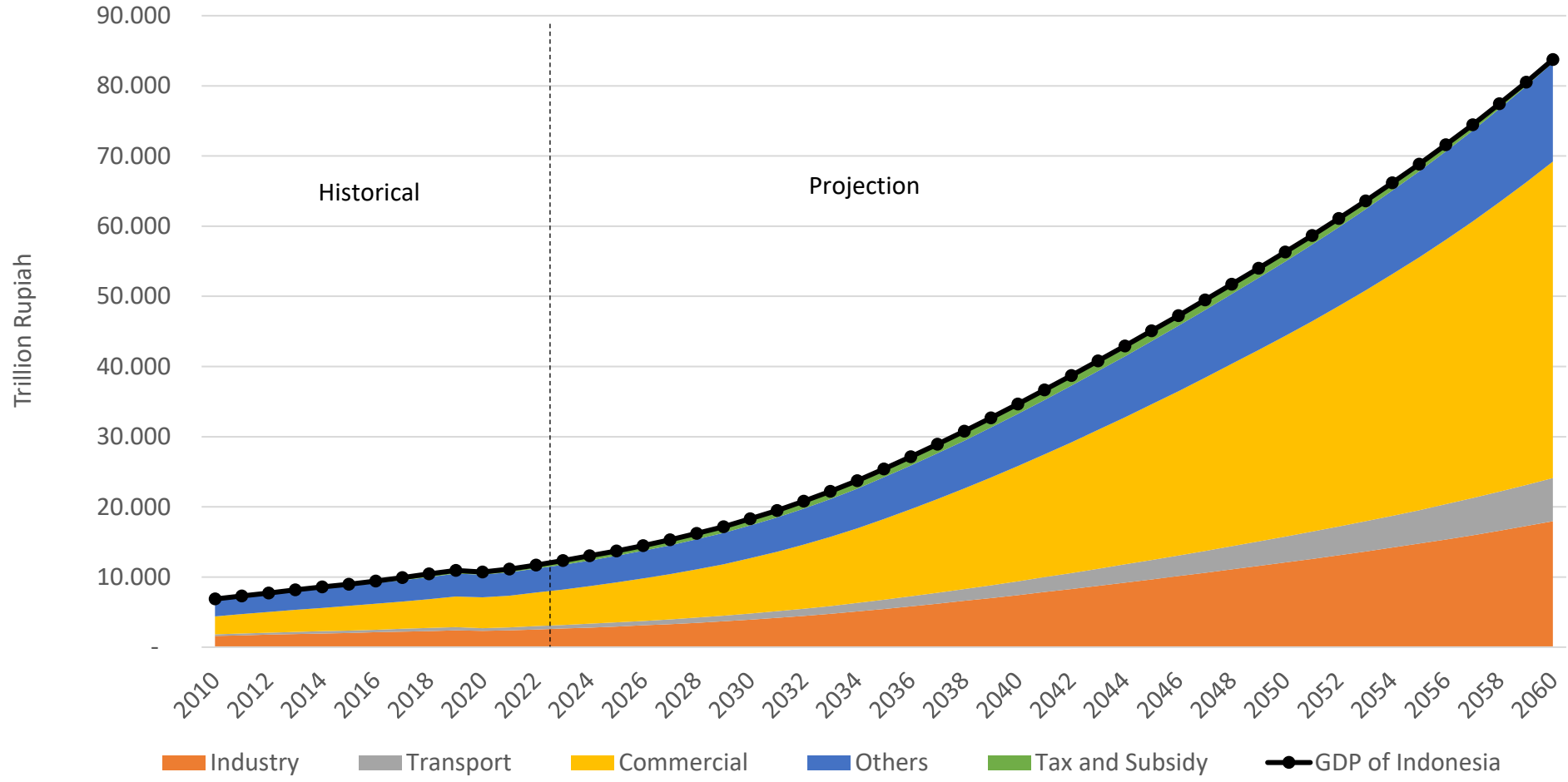
Source: CIA "The World Factbook – GDP", 2019

GDP by Sector	
Industry:	C. Manufacturing Industries
Transport:	H. Transport and Warehousing
Commercial:	E. Water Supply, Waste Management, and Recycling
	G. Wholesales and Retails, Car and Motor Cycle Repairs
	I. Accomodation, Food and Beverages
	J. Information and Communication
	K. Financial Services and Insurance
	L. Real Estate
	M,N. Corporate Services
	O. Government Administration, Defence, and Social Security
	P. Educational Services
	Q. Health Services and Social Activities
	R,S,T,U. Other Services
Others:	A. Agriculture, Forestry, and Fishery
	B. Mining and Quarrying
	F. Construction

Real GDP by Sector Negara G20

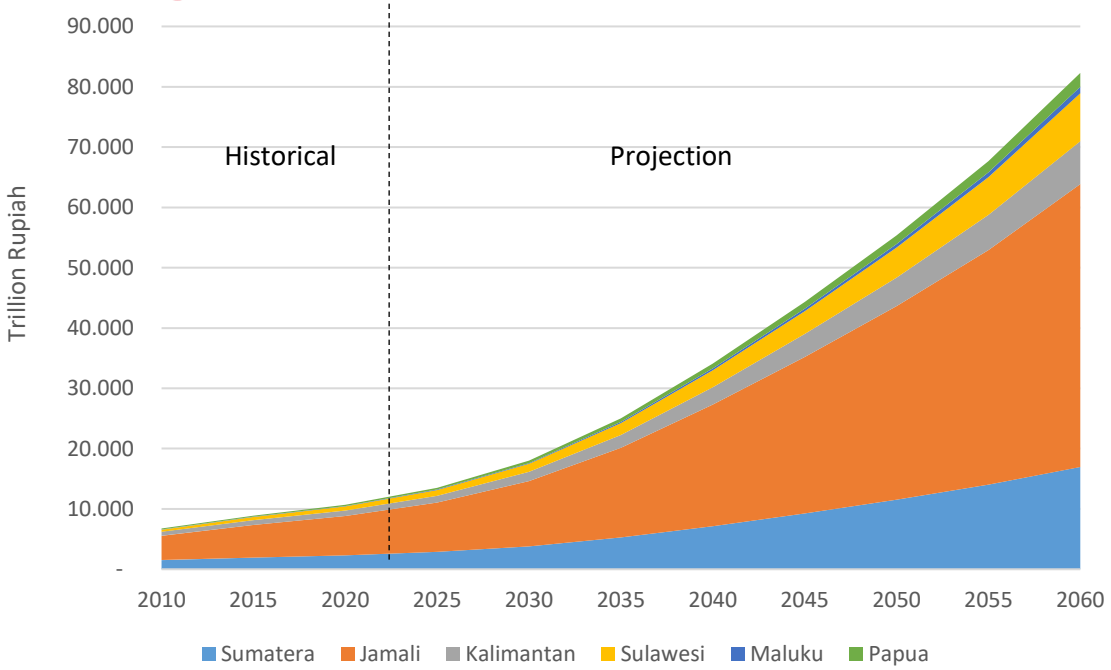
Country/Economy	Real GDP (US$MM)	Agricultural (%)	Industrial (%)	Service (%)
China	23,210,000	8%	41%	52%
USA	19,490,000	1%	19%	80%
India	9,474,000	15%	23%	62%
Japan	5,443,000	1%	30%	69%
Germany	4,199,000	1%	31%	69%
Russian Federation	4,016,000	5%	32%	62%
Indonesia	3,250,000	14%	41%	45%
Brazil	3,248,000	7%	21%	73%
France	2,956,000	2%	20%	79%
United Kingdom	2,925,000	1%	20%	79%
Mexico	2,463,000	4%	32%	65%
Italy	2,317,000	2%	24%	74%
Turkey	2,186,000	7%	32%	61%
Korea, Republic of	2,035,000	2%	39%	58%
Spain	1,778,000	3%	23%	74%
Saudi Arabia	1,775,000	3%	44%	53%
Canada	1,774,000	2%	28%	70%
Australia	1,248,000	4%	25%	71%
Argentina	922,100	11%	28%	61%
South Africa	767,200	3%	30%	68%

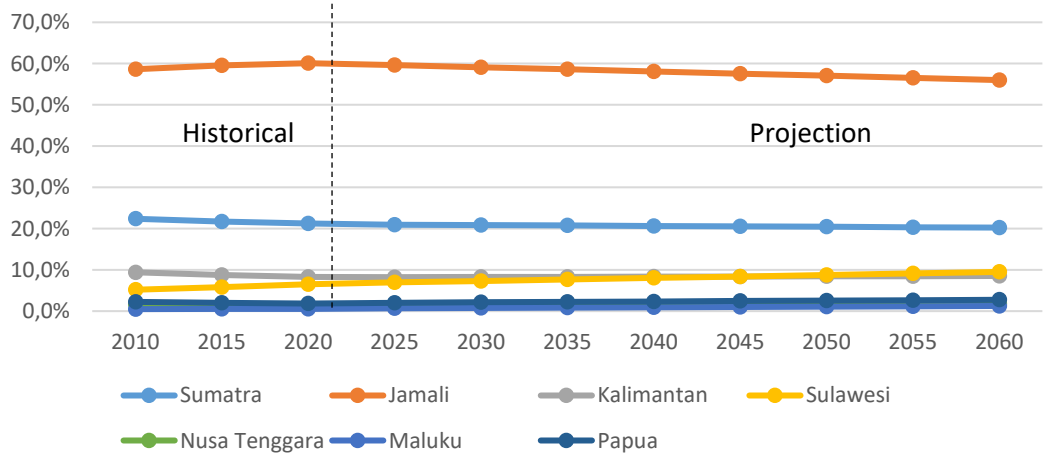
Indonesia GDP Projection Based on Vision 2045 by Sector



Source: Indonesia Statistic, BPS (2023)

GDP Projection by Region





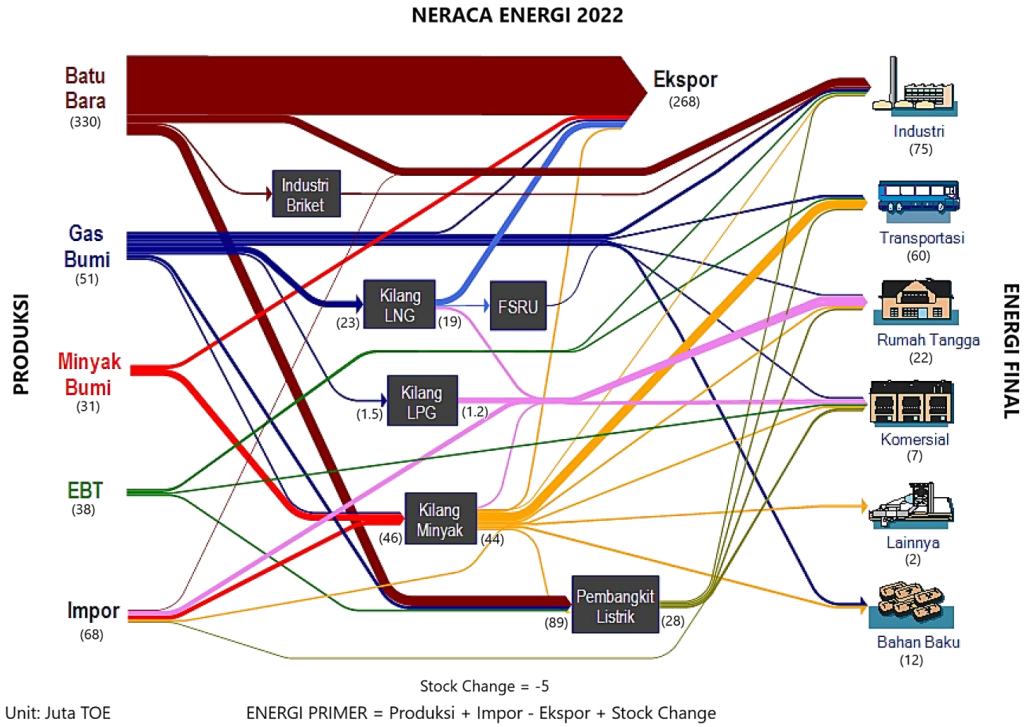
*) 2010 Constant Price

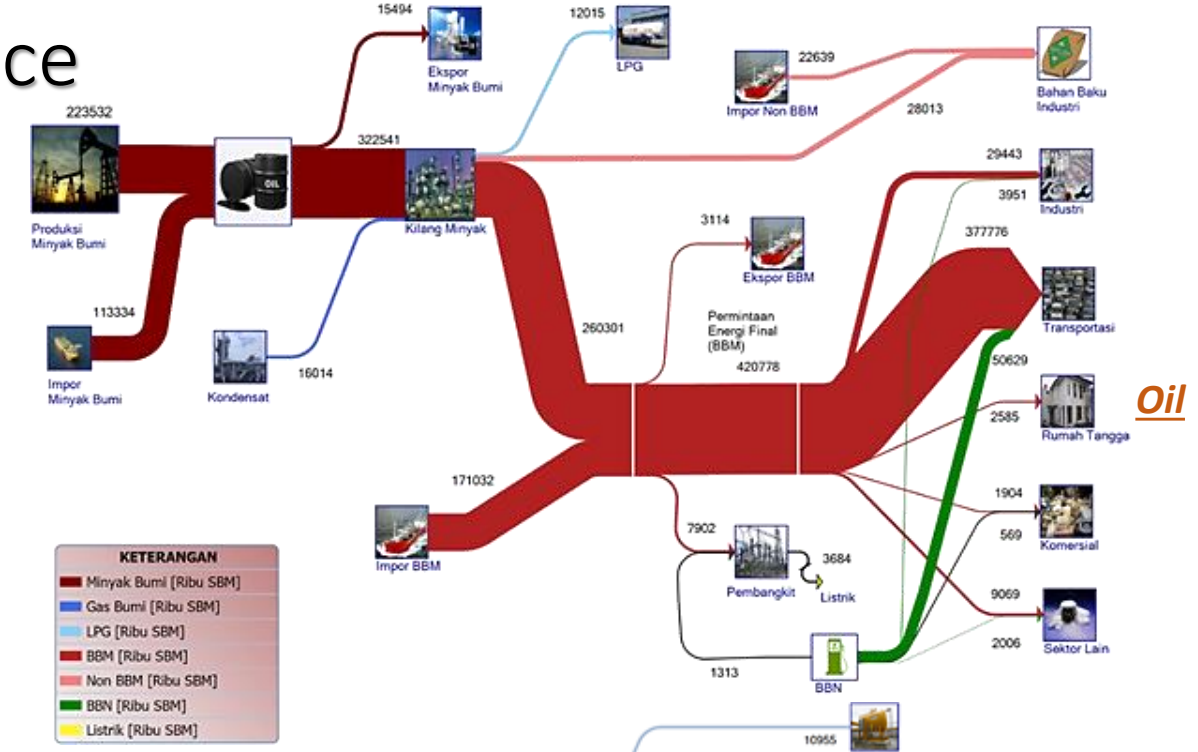
Region	GRDP Growth							
	2022-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2051-2055	2056-2060
Sumatra	4.93%	5.81%	6.70%	6.30%	5.31%	4.45%	4.00%	3.90%
Jamali	4.85%	5.72%	6.61%	6.21%	5.22%	4.36%	3.91%	3.81%
Kalimantan	5.13%	6.01%	6.90%	6.50%	5.50%	4.64%	4.19%	4.09%
Sulawesi	6.16%	7.00%	7.84%	7.39%	6.35%	5.44%	4.95%	4.82%
Nusa Tenggara	5.54%	6.41%	7.30%	6.88%	5.88%	5.00%	4.54%	4.43%
Maluku	7.76%	8.40%	9.05%	8.43%	7.24%	6.22%	5.64%	5.43%
Papua	6.08%	6.93%	7.78%	7.33%	6.29%	5.39%	4.91%	4.77%

	Share 2010	Share 2022	Share 2060
Jamali	59%	60%	56%
Luar Jamali	41%	40%	44%
	Share 2010	Share 2022	Share 2060
KBI	81%	81%	76%
KTI	19%	19%	24%

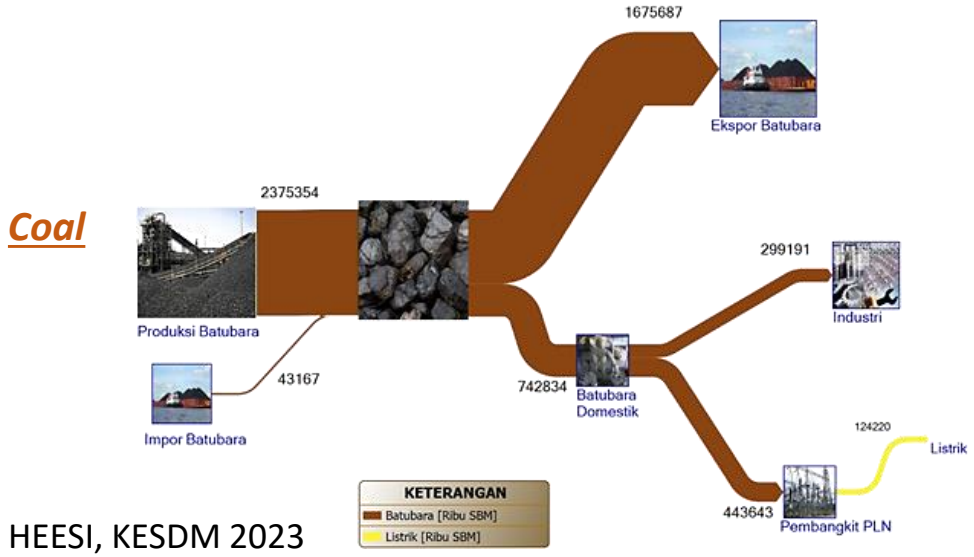
Source: BPS, 2023 dan Bappenas, 2023

2022 Indonesia Energy Balance

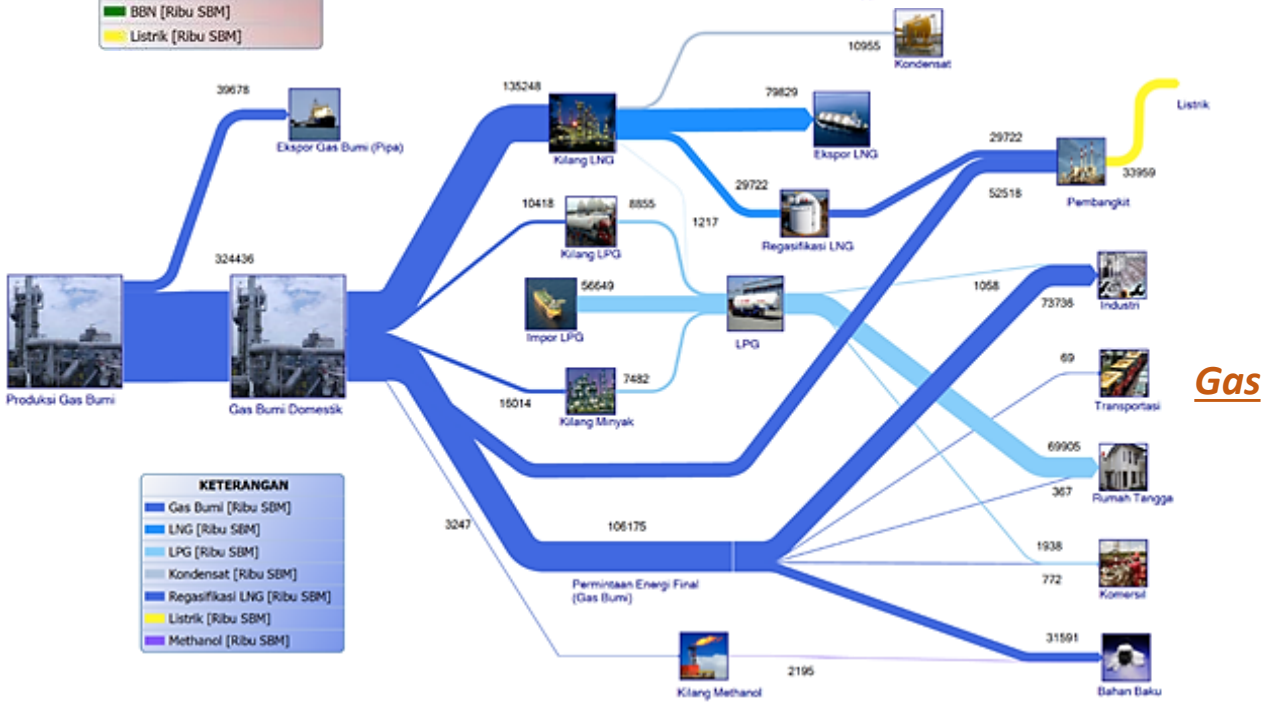




Oil



Coal



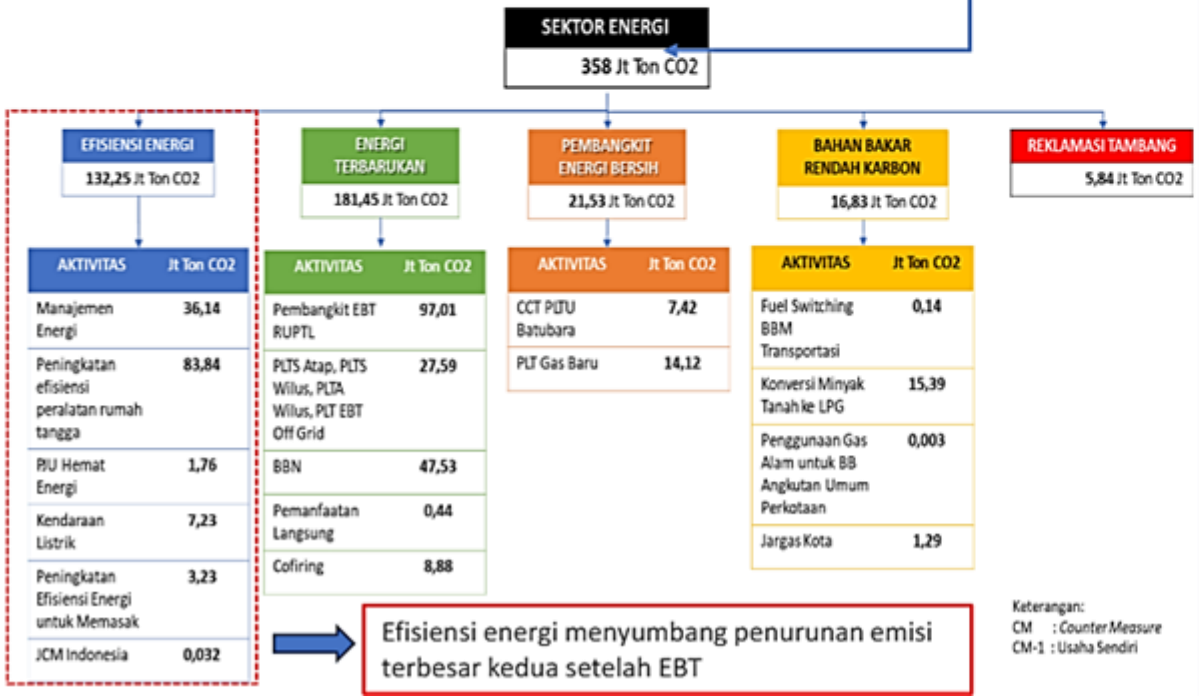
Gas

Source: HEESI, KESDM 2023

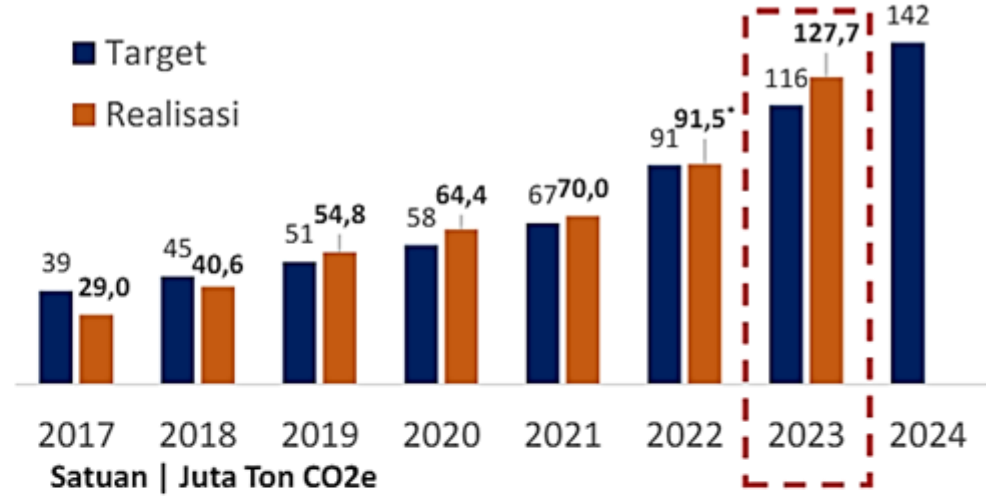
Enhanced NDC Indonesia 2030

Enhanced NDC 2030

No	Sektor	Emisi GRK 2010 (Juta Ton CO_2e)	Emisi GRK pada 2030			Penurunan Emisi	
			BaU	CM1	CM2	CM1	CM2
1.	**Energi**	**453,2**	**1.669**	**1.311**	**1.223**	**358**	**446**
2.	Limbah	88	296	256	253	40	45,3
3.	IPPU	36	70	63	61	7	9
4.	Pertanian	111	120	110	108	10	12
5.	Kehutanan	647	714	217	-15	500	729
	TOTAL	**1.334**	**2.869**	**1.953**	**1.632**	**915**	**1.240**



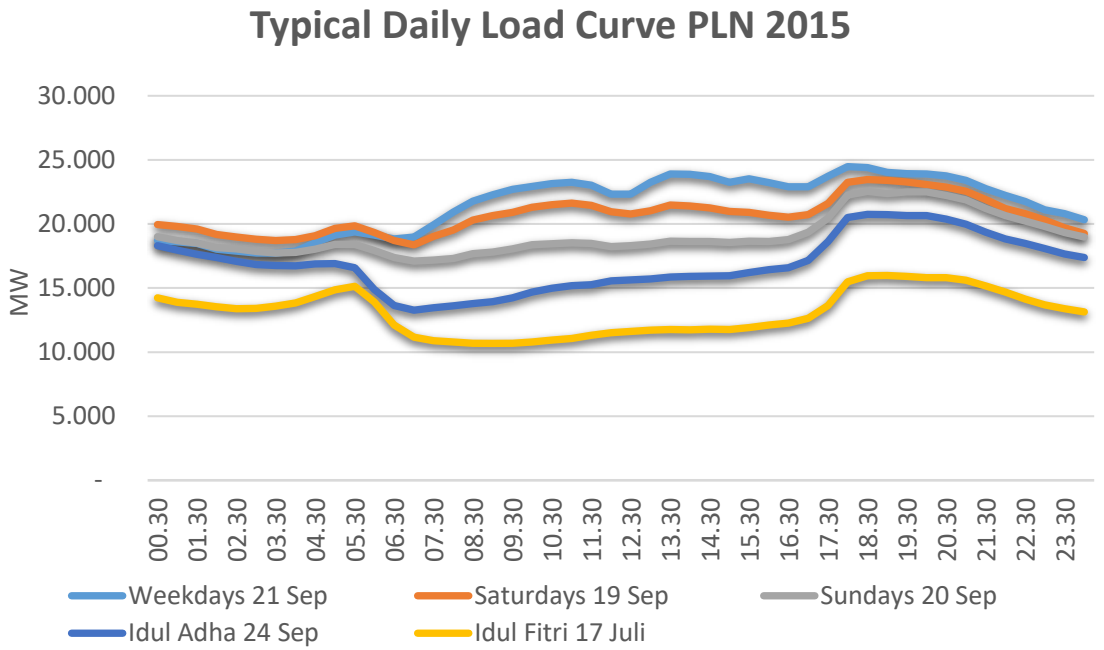
Realisasi Capaian Penurunan Emisi GRK Sektor Energi

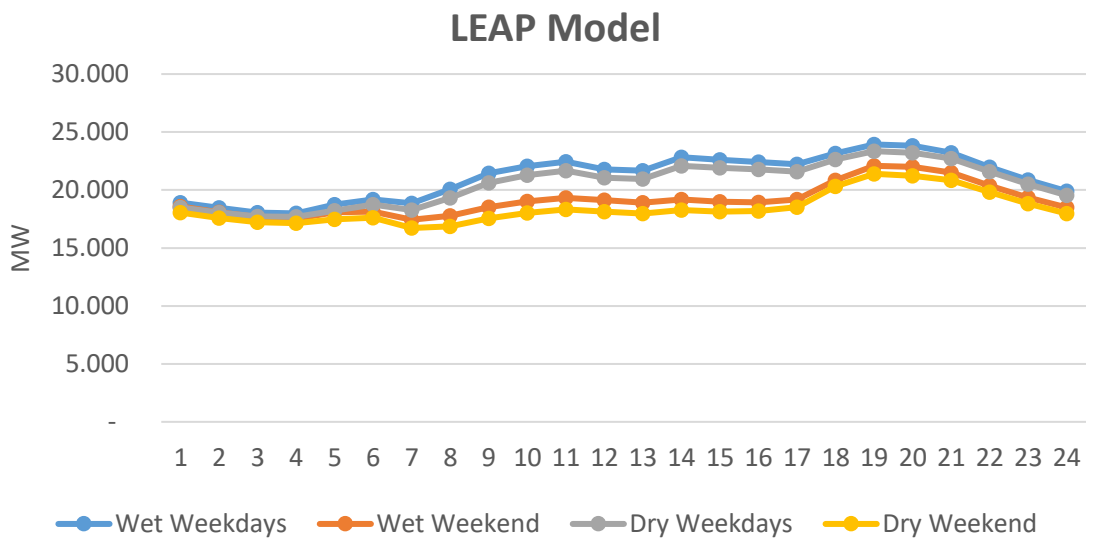


No	Aksi Mitigasi	2023		Target 2030	% Capaian dari Target 2030
		Target	Capaians		
1	Efisiensi Energi	29,14	31,87	132,25	24,1%
2	EBT	51,00	51,29	181,45	28,3%
3	Bahan Bakar Rendah Karbon	15,92	15,55	16,83	92,4%
4	Teknologi Pembangkit Bersih	16,54	13,33	21,53	61,9%
5	Kegiatan Lainnya	3,95	15,63	5,84	267,6%
	TOTAL	**116,45**	**127,67**	**358,00**	**35,6%**

Load Curve

- Not all power plants are operating for 24 hours a day. Based on its operating hours, power plants can be categorized as base load, load follower, and peaker.
- PLN load curve data are provided in ½ hour interval for 24 hours and for 365 days. So, there would be 2 x 24 x 365 = 17,280 time slices
- Running an energy model with 17,280 time slices → it is possible but it will take a very long time to complete
- So, the load curve of PLN is groupped into a smaller number of time slices, which are 96 time slices (2 x 2 x 24 = 96). This would give a faster runtime in the LEAP model
  - 2 : Wet and Dry Seasons (6 months each)
  - 2 : Weekdays and Weekend (every week)
  - 24 : hours a day (every day)





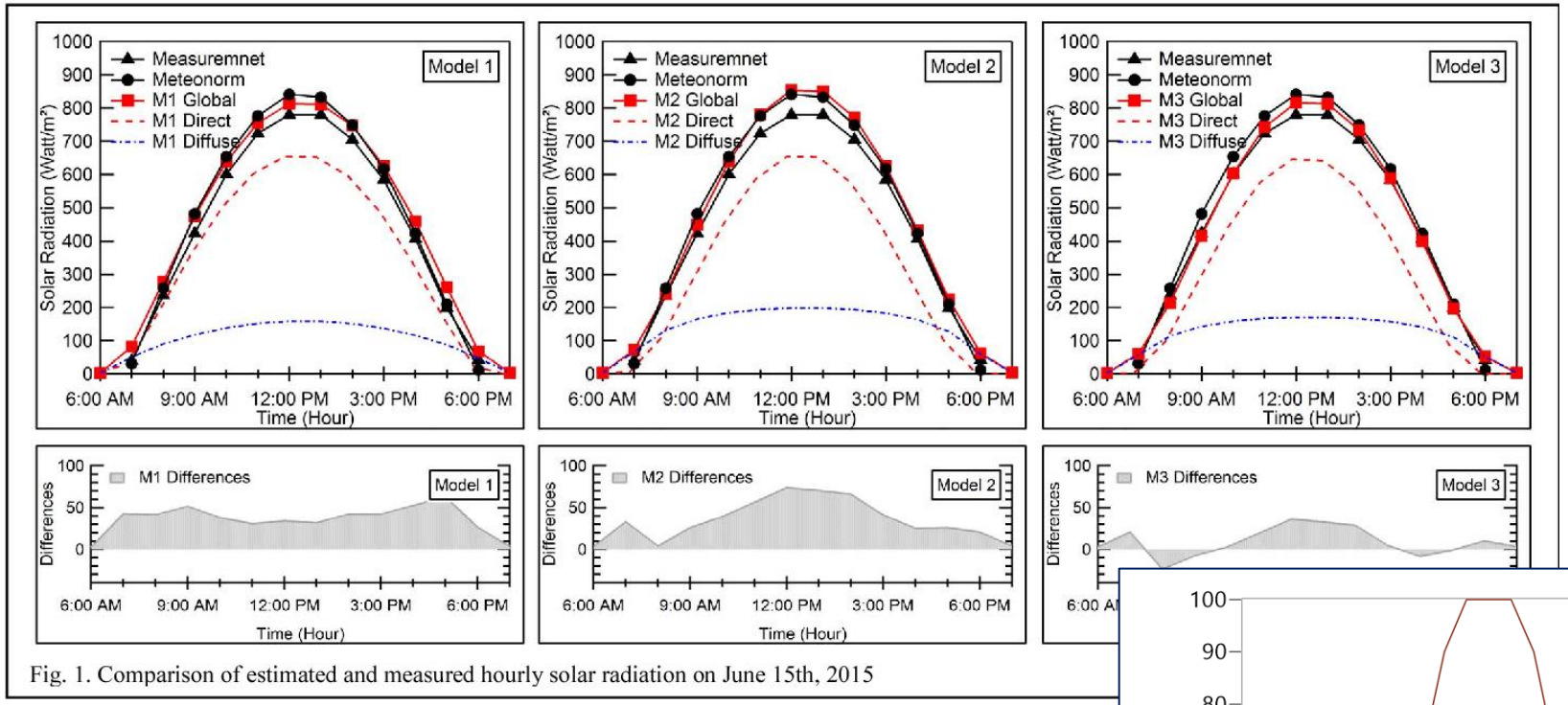
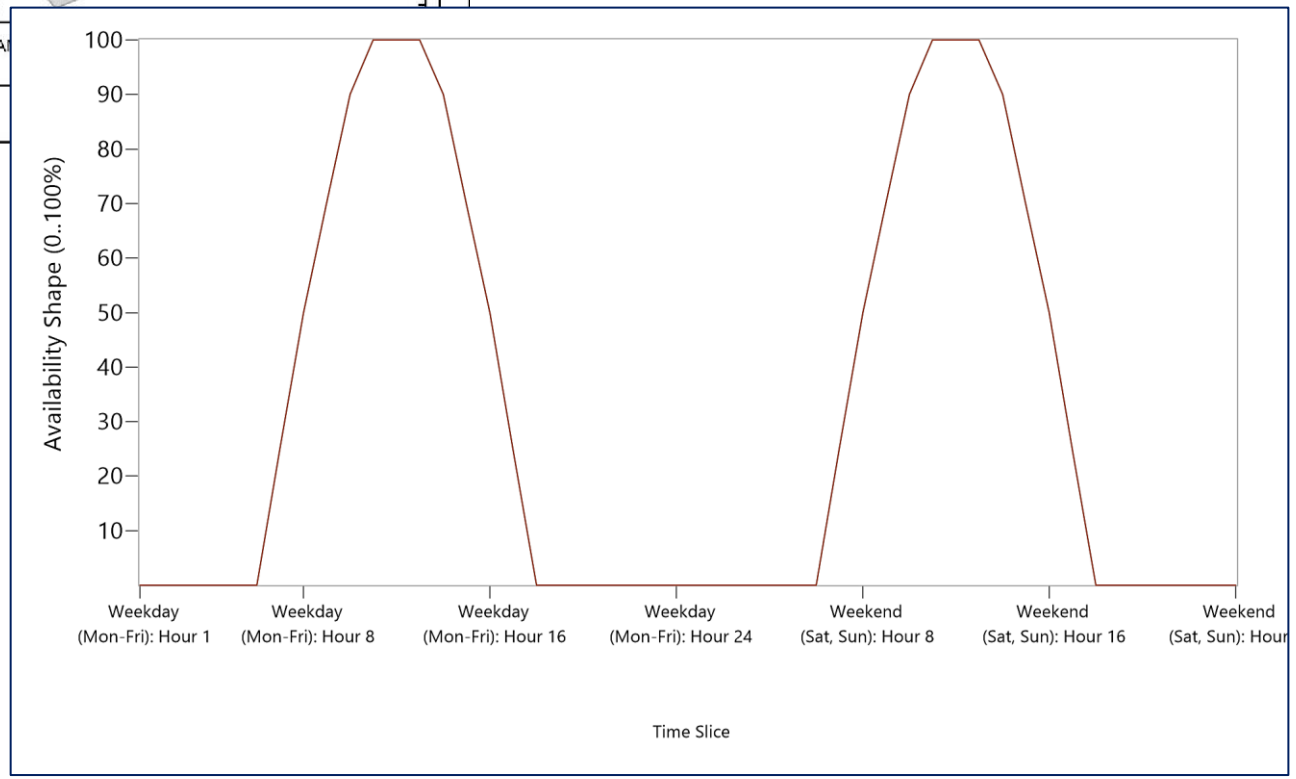


Fig. 1. Comparison of estimated and measured hourly solar radiation on June 15th, 2015

Solar Radiation

Lokasi Pengukuran : Jakarta

Input terkait pola yearly shape dari radiasi matahari selama 24 jam sangat diperlukan dalam pemodelan yang mengikut sertakan teknologi pembangkit seperti PLTS dan Battery Energy Storage System



Biaya Produksi Listrik Rata-Rata (Levelized Cost of Energy/LCOE)

- Capital cost
- Fixed O&M cost
- Variable O&M cost
- Fuel Cost
- Produksi Listrik

LCOE

$$\text{LCOE} = \frac{\text{sum of costs over lifetime}}{\text{sum of electrical energy produced over lifetime}} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

I_t : investment expenditures in the year t

M_t : operations and maintenance expenditures in the year t

F_t : fuel expenditures in the year t

E_t : electrical energy generated in the year t

r : discount rate

n : expected lifetime of system or power station

MACC: Rational and Measurable Mitigation Planning Tool

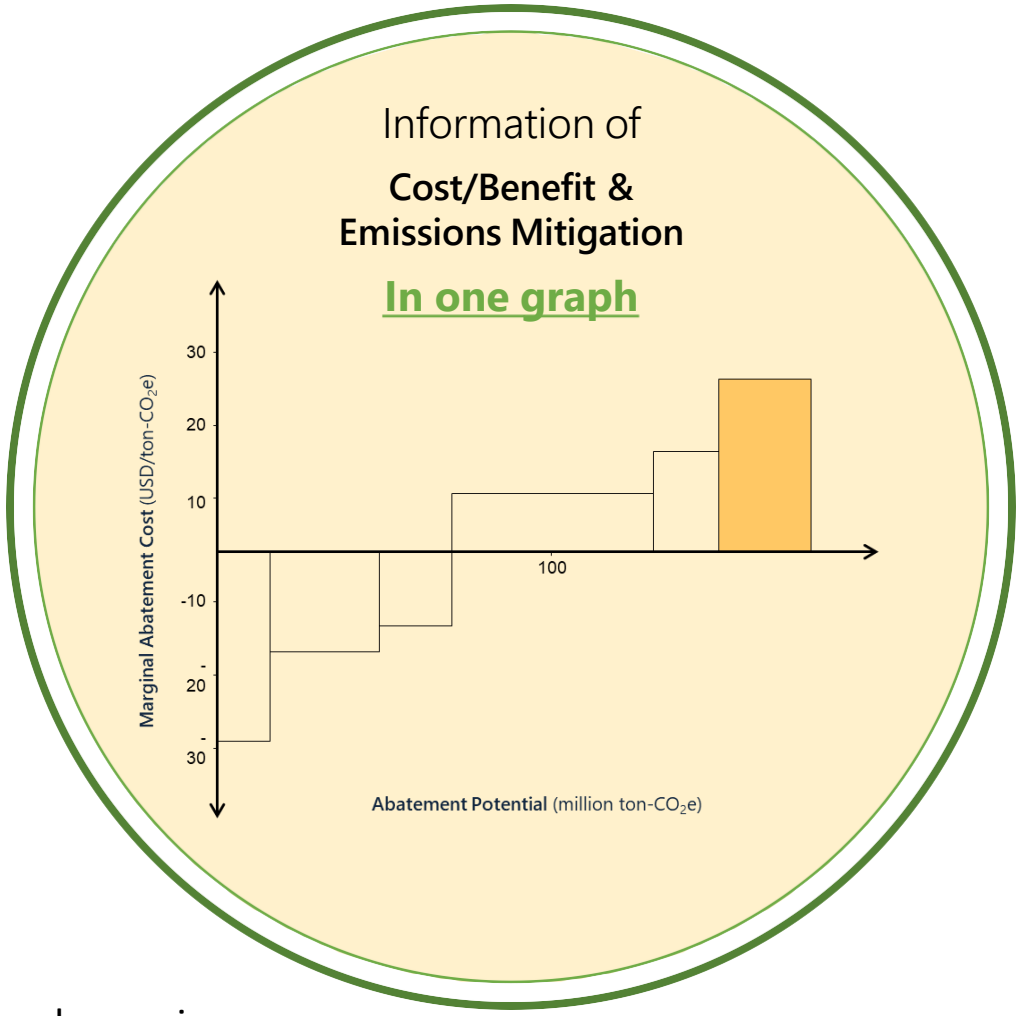
Emissions Reduction Target → **Enhanced Nationally Determined Contribution (E-NDC)**

Unconditional
31.9% of the BaU Scenario by 2030
Energy sector: 358 MT CO_2e (11%)

Conditional
43.2% of the BaU Scenario by 2030
Energy sector: 446 MT CO_2e (14%)

The Advantage of MACC

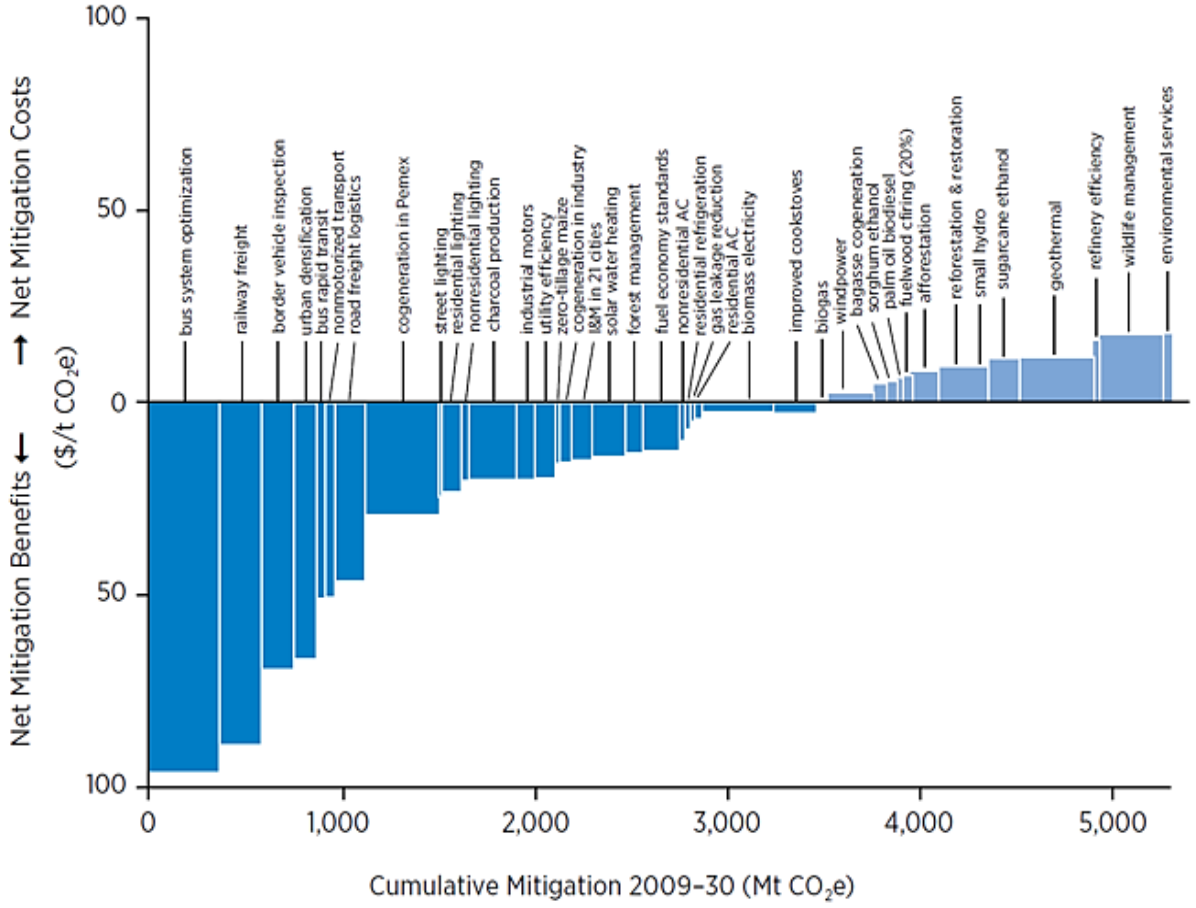
1. Provide insight on the technologies/measures that need to be prioritized.
2. Provide key information to the government, i.e.:
   - Mitigation options that provide benefits;
   - Mitigation options that require government incentives;
   - Mitigation options requiring RD&D support.
3. Quantify mitigation measures according to actual conditions, especially the Model-derived MACC, because it integrates energy system inputs.
4. Simple interface – easy to see how much costs to be born or benefits gained.



leap.sei.org

Marginal Abatement Cost Curve (MACC)

- Marginal Abatement Cost Curves (MACCs) help assess the cost and abatement potential of mitigation options and can be used in prioritizing implementation of measures.
- MACCs plot cumulative emissions reductions from successive options (e.g. Tonnes of GHGs avoided) against the incremental cost per unit of emission reduction (e.g. $/T CO2e).
- For any given set of options the area enclosed by a MACC equals the cumulative avoided cost of those options.
- MACCs makes it easy to see which options are low or negative cost (below the X axis) and which have the largest mitigation potential (widest bars).



A typical example of a Marginal Abatement Cost Curve (MACC). Source: Mexico Low Carbon Country Case Study, World Bank ESMAP

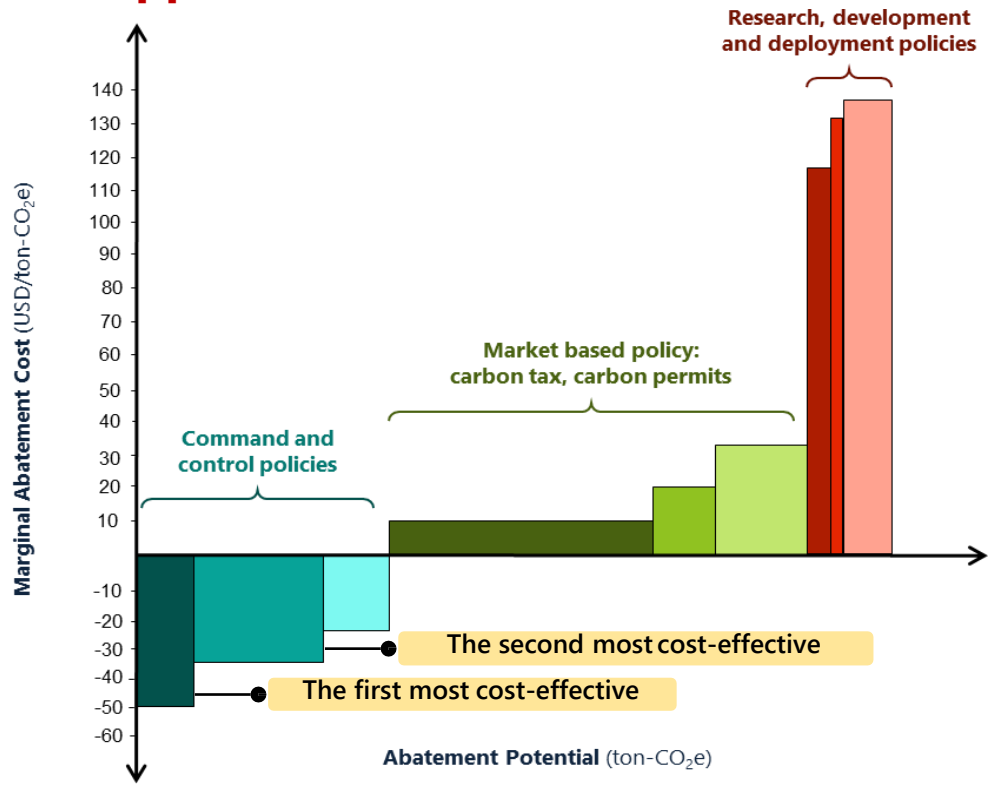
SEI Stockholm Environment Institute

leap.sei.org

LEAP

MACC Development using LEAP

MACC Approach in LEAP



Key Information

Command-and-control:

- Energy efficiency policies, such as building & industrial efficiency standards;
- Management of collection and supply of biomass raw materials;
- Control of land provision/ acquisition, etc.

Market/Incentive-based:

- Carbon tax to achieve certain GHG emission reductions;
- Cap-and-trade to provide GHG emission constraints and promote carbon trading;
- Feed-in tariff;
- Highest benchmark price policy;
- Government drilling for geothermal plant; etc.

Research, development, & deployment:

RD&D assistance with high MAC mitigation efforts, such as research on biodiesel catalysts, green diesel, fuel cell, etc.

Scenario Development

1 BASELINE SCENARIO (BAU)

- User-defined reference scenario;
- Usually without mitigation measures implemented in the projection years.

2 MITIGATION SCENARIO (NZE)

- Consists of existing mitigation measure plans listed in the policies;
- Scenario to be developed to obtain the MACC results.

Penutup

- Substansi yang paling penting dalam dokumen Rencana Umum Energi Nasional ini utamanya mencakup:
  - Penjabaran dari apa yang diamanatkan oleh KEN mencakup aspek penyediaan dan pemanfaatan energi per tahun selama 10 tahun (2025 – 2035) dengan tetap mengacu pada sasaran yang telah ditetapkan dalam KEN.
  - Menyusun kebijakan/program/proyek yang cukup kongkrit untuk memastikan pasokan energi dalam memenuhi kebutuhan energi hingga 10 tahun kedepan (2035).
- Perlu juga penyelarasan dengan RUKN, RUPTL, RPJMN, RIPIN, dan rencana umum lainnya yang terkait dengan energi serta ekonomi dan lingkungan
- Karena RUEN bersifat lintas sektor maka diperlukan kerjasama dan koordinasi yang baik antar semua pemangku kepentingan baik public maupun swasta