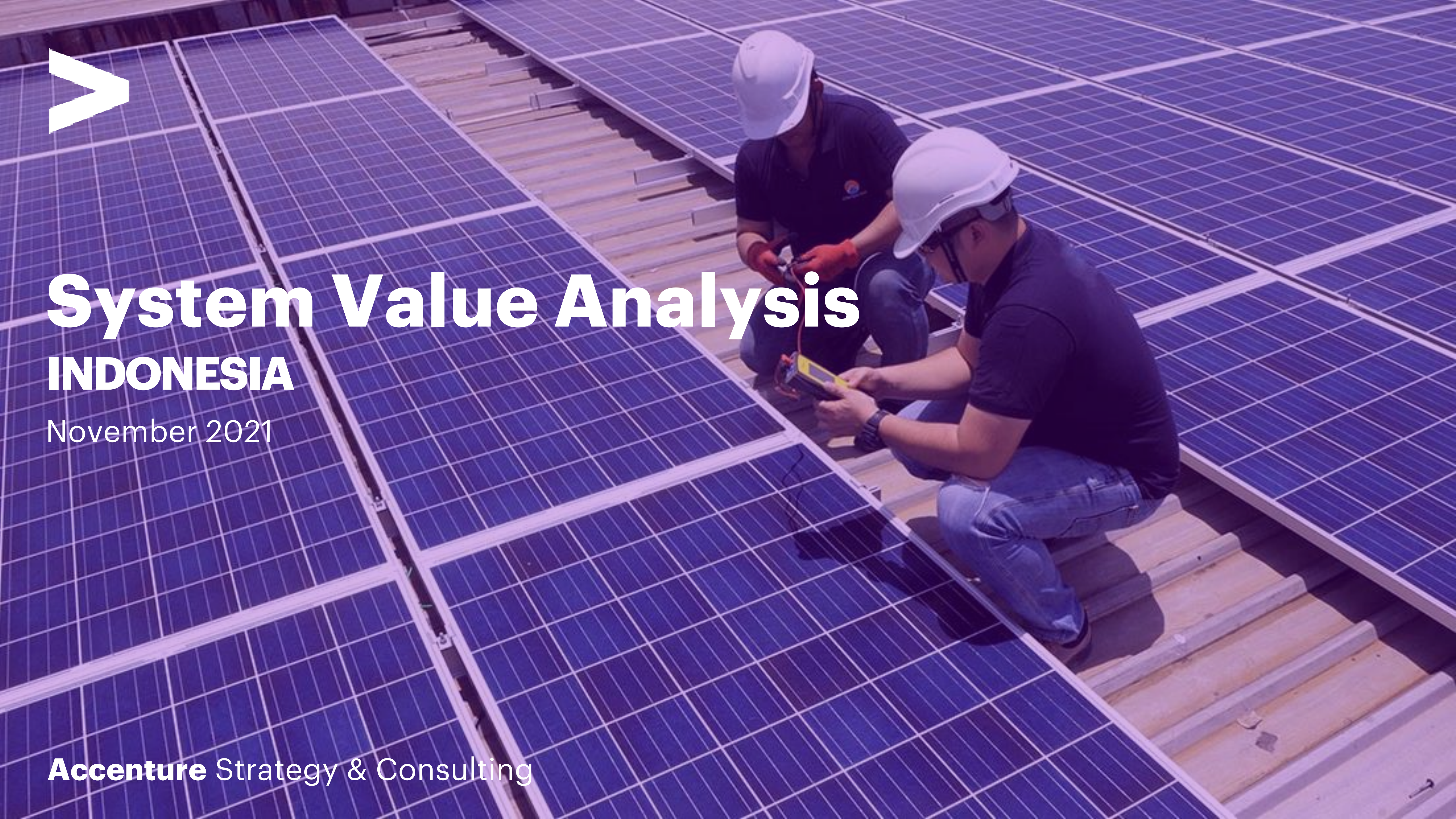


System Value Analysis

INDONESIA

November 2021

Accenture Strategy & Consulting

AGENDA

1 **Executive Summary**

2 **Market Analysis**

3 **Solutions**

4 **Next Steps**

WEF’s System Value Framework applied to Indonesia’s transition

The System Value framework more holistically evaluates economic, environmental, social and technical outcomes of potential energy solutions across markets. The framework aims to shift political and commercial focus beyond cost to include value

Using the System Value framework, the World Economic Forum, supported by Accenture and a group of global electricity companies, conducted analysis across several geographies as part of market evaluations that examined recovery opportunities to accelerate economic growth and the clean energy transition.

The flexible nature of the framework allows inclusion of both quantitative and qualitative analysis. The relevance of System Value dimensions may vary by geography and over time horizons.

Economic, environmental, societal and energy value

CO_2 Emissions
CO_2 emissions based on energy source, generation mix and load changes

Jobs and Economic Impact
Influx of jobs due to energy transition and renewables

Water Footprint
Water footprint based on energy source, generation mix and load changes

Air Quality and Health
Impacts to human health and natural environment from air and water pollutants, land use

Access to Electricity
Physical and economic access to clean electricity to support individual or society development.

Energy Productivity and Systemic Efficiency
Energy efficiency plus systemic efficiency (optimization of interactions among energy value chain elements) to maximize energy productivity

Resiliency and Security
Uninterrupted and diversified energy supply at affordable prices and the ability to bounce back from disruptions

Foreign Direct Investment
Market attractiveness for FDI with reliable energy and skilled resources

Reliability and Service Quality
Life cycle approach to ensuring high system availability; improved customer service

Flexibility
Ability to manage generation, demand and power flows (including power quality) across the grid, enabled by digitalization and storage

System Upgrade
Technology (incl. digital) and capital investments in T&D (incl. interconnections) to upgrade the system for variable renewables and distributed energy resources (DER)

Cost and Investment Competitiveness
Market attractiveness and policy certainty to businesses and policy-makers for investment including R&D and levelized cost of energy

Note: Above hexagons represent desired outcomes

⬢ Priority outcomes for Indonesia

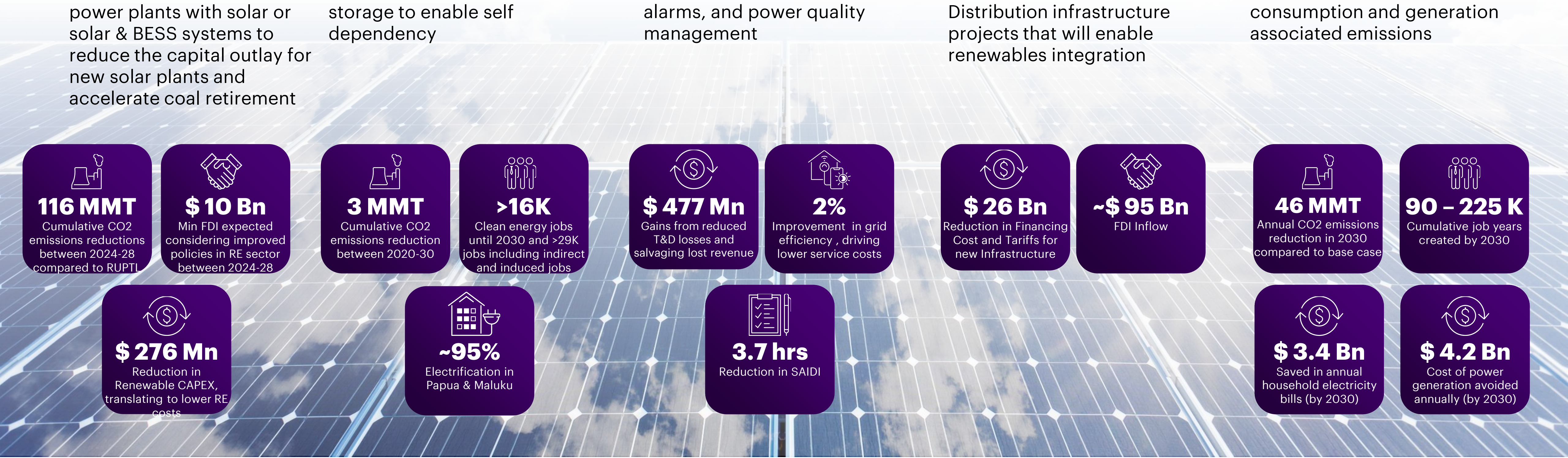
MARKET ANALYSIS | EXECUTIVE SUMMARY

85%	Installed capacity comes from **conventional sources (50% coal, 29% natural gas, 7% oil)**
67%	**Power generation** and 100% transmission and distribution network owned by **PLN**, making Indonesia a vertically integrated market
29-41%	**CO2 emissions target reduction** vs BAU by 2030 as per NDC commitments
3X	Expected absolute **increase in CO2 emission** between 2016 -2030,with reductions lagging global benchmarks , despite being expected to exceed government targets
~14 GW	**New coal capacity** planned by 2030 (RUPTL)

~400 GW	Max. **renewable resource potential** in Indonesia currently, of which only 10% would be exploited by 2030 (<1% solar)*
2x	Renewable potential for each of the **main Indonesian islands** than is currently in plan to be installed by 2030
2027	**Large scale solar LCOE** achieves grid parity with coal, presenting significant opportunity to scale renewables further
0	**Inter-island grid connectivity** today, and limited connections intra-island
$2.3 B	Cost of **network losses** every year (>9% power loss)
$150-200 B	Government Estimates of **Investments needed per year** in clean technologies for a **9-year period** to **meet the Energy Transition targets**

*- The Potential estimates are likely to be revised upwards by an ongoing government study.

5 Solutions for Indonesia’s Energy Transition



Replacing planned and existing Coal with Utility Scale Solar

Accelerate penetration of RE by leveraging:

- Renewable Energy Zones (REZs) focused on Utility Scale Solar to replace 5 GW of planned coal plants
- Repurpose retired coal power plants with solar or solar & BESS systems to reduce the capital outlay for new solar plants and accelerate coal retirement

116 MMT
Cumulative CO2 emissions reductions between 2024-28 compared to RUPTL

$ 10 Bn
Min FDI expected considering improved policies in RE sector between 2024-28

$ 276 Mn
Reduction in Renewable CAPEX, translating to lower RE costs

Distributed Solar and Storage Growth to support Energy Access

Distributed solar deployment will enable Indonesia to grow renewables in islands that present electrification issues. Opportunity to incentivize a self consumption model, complemented with battery storage to enable self dependency

3 MMT
Cumulative CO2 emissions reduction between 2020-30

>16K
Clean energy jobs until 2030 and >29K jobs including indirect and induced jobs

~95%
Electrification in Papua & Maluku

“Zero Net Cost” Digitalization of the Grid for optimal Grid Operations

Reduce T&D losses and uplift service quality by digitalizing the grid through self-financing projects such as dynamic grid configuration optimization, remote network operations and real time field asset alarms, and power quality management

$ 477 Mn
Gains from reduced T&D losses and salvaging lost revenue

2%
Improvement in grid efficiency , driving lower service costs

3.7 hrs
Reduction in SAIDI

Innovative Financing Models for T&D Upgrades

Deploy non-traditional financing models such as Public Private Partnerships, Reverse Auction of Projects and Green Bonds to unlock low cost private and foreign capital for Transmission & Distribution infrastructure projects that will enable renewables integration

$ 26 Bn
Reduction in Financing Cost and Tariffs for new Infrastructure

~$ 95 Bn
FDI Inflow

Energy Efficiency at the Consumer, Industry and Transport level

Scale energy efficiency with a focus on consumers through initiatives such as efficient buildings plan, MEPS for appliances, efficient lighting, and district cooling systems to reduce overall electricity consumption and generation associated emissions

46 MMT
Annual CO2 emissions reduction in 2030 compared to base case

90 – 225 K
Cumulative job years created by 2030

$ 3.4 Bn
Saved in annual household electricity bills (by 2030)

$ 4.2 Bn
Cost of power generation avoided annually (by 2030)

Overview of Indonesia's Electricity Market

84% of Indonesia's generation still comes from conventional sources of power, despite high and diverse renewable potential. Existing targets include 23% of renewables in the primary energy mix by 2025, and a 29-41% CO_2 emissions reductions by 2030

Market Structure Components

- Indonesia's electricity market is dominated by vertically integrated state-owned PLN (**67% of total generation**)
- PLN also sole owner of **distribution and transmission system in Indonesia**
- A small share of the generation market is occupied by IPPs, captive generation and co-operatives (33%)

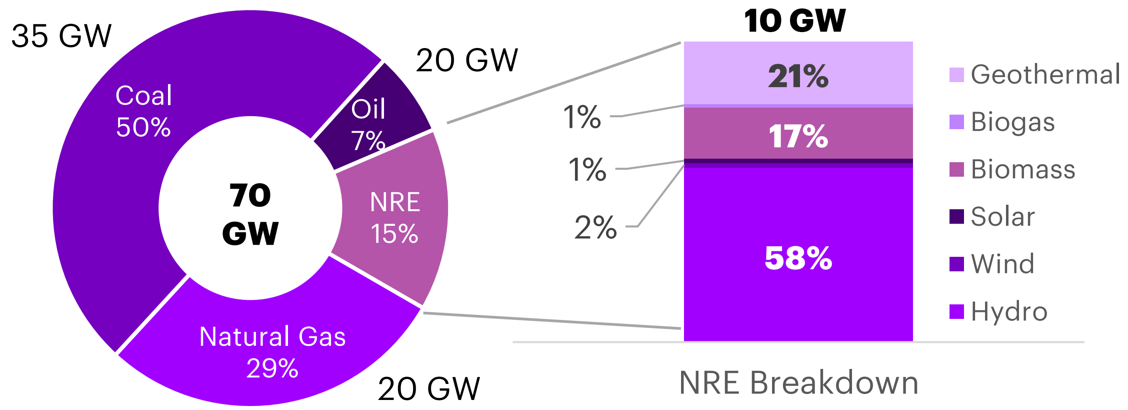
Supply and Demand Dynamics

- None of Indonesia's 17K+ islands are interconnected; some islands also lack intra-island grid connectivity
- 99% electrification rate but high inter-region variability from ~**50 % in Papua** to ~ 100% in Java
- Energy **demand in 2030** will be at 219.7 MTOE which will be **1.7x of 2020 demand** while the installed capacity in 2030 would be **~130 GW** which will be **1.85x of 2020 capacity (~70GW)**
- >400 GW of maximum renewable potential across solar, wind, hydro and geothermal

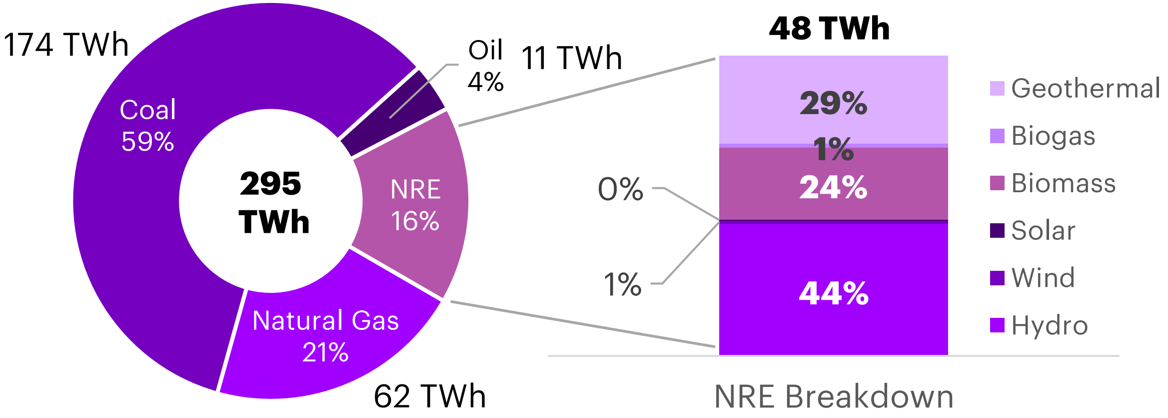
Energy Transition Targets

- **23% Renewables in the primary energy mix by 2025** (National Energy Policy (KEN))
- Reduce **CO_2 emissions from energy by 29-41%** from BAU levels by 2030 to reach 1355-1271 MTon CO_2 eq (NDC)
- Recent announcement of **no more PLN coal plants** built beyond what is already **in plan after 2023**

Indonesia Electricity Capacity Mix (GW, 2019)



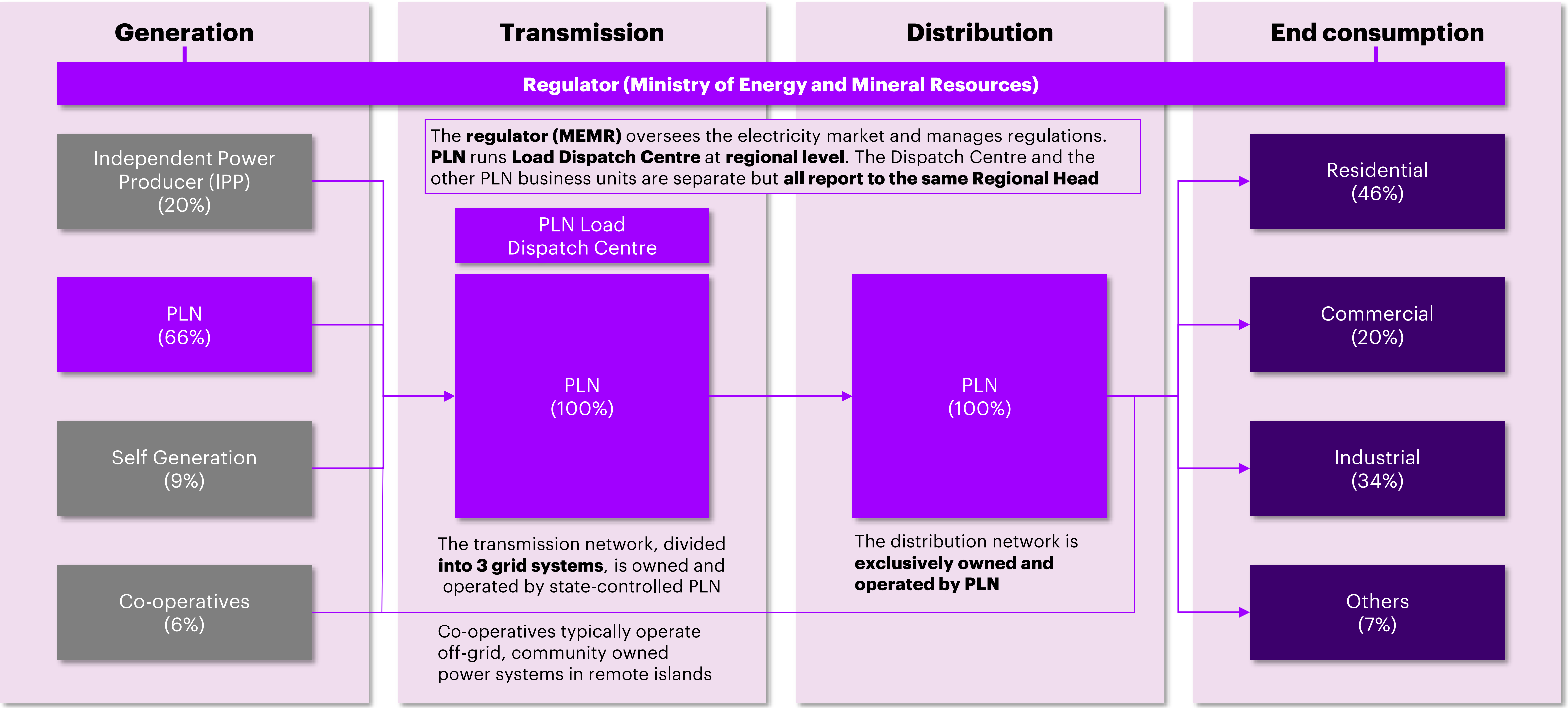
Indonesia Electricity Generation Mix (TWh, 2019)



Source: Handbook Of Energy & Economic Statistics Of Indonesia (HEESI)

Indonesia Electricity Market Structure

Despite several rounds of reform over the past two decades, the vast majority of the power sector value chain in Indonesia is government-owned and operated, with PLN controlling 67% of total generation and the full T&D value chain



Generation | **Transmission** | **Distribution** | **End consumption**

Regulator (Ministry of Energy and Mineral Resources)

The **regulator (MEMR)** oversees the electricity market and manages regulations. **PLN** runs **Load Dispatch Centre** at **regional level**. The Dispatch Centre and the other PLN business units are separate but **all report to the same Regional Head**

Generation:
- Independent Power Producer (IPP) (20%)
- PLN (66%)
- Self Generation (9%)
- Co-operatives (6%)

Transmission:
- PLN Load Dispatch Centre
- PLN (100%)

The transmission network, divided **into 3 grid systems**, is owned and operated by state-controlled PLN

Co-operatives typically operate off-grid, community owned power systems in remote islands

Distribution:
- PLN (100%)

The distribution network is **exclusively owned and operated by PLN**

End consumption:
- Residential (46%)
- Commercial (20%)
- Industrial (34%)
- Others (7%)

Source: PLN

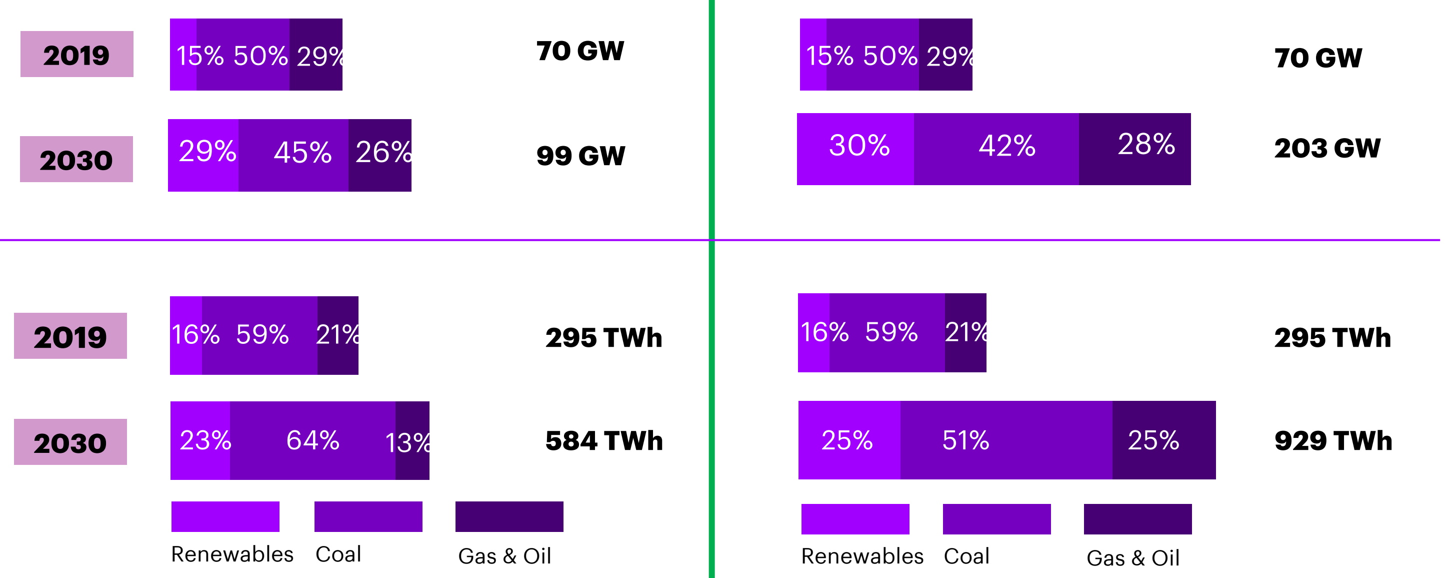
Legend ▨ Private companies ▨ Government companies

Note: The total generation of IPPs and PPUs have been assumed to be split in 2:1 ratio

Indonesia’s Electricity Projections

Indonesia has two different electricity future projections – the RUPTL plan and the Ministry of Energy Outlook. Our analysis is based on the RUPTL plan as the RUPTL supply projections appear more realistic and are in line with the consumption growth projections

Baseline projections used for this study



		RUPTL (2021-2030) **10 years Electricity Development Plan**	**MEMR Energy Outlook (2050)** **Aspirational Long Term Energy Trajectory**
Power Plant Capacity (GW)	**2019**	15% 50% 29% **70 GW**	15% 50% 29% **70 GW**
	2030	29% 45% 26% **99 GW**	30% 42% 28% **203 GW**
Power Generation (TWh)	**2019**	16% 59% 21% **295 TWh**	16% 59% 21% **295 TWh**
	2030	23% 64% 13% **584 TWh**	25% 51% 25% **929 TWh**
CO_2 NDC (29-41% reduction)		Met	Met
Renewables Target (23% by 2025)		Met	Met

RUPTL vs Energy Outlook

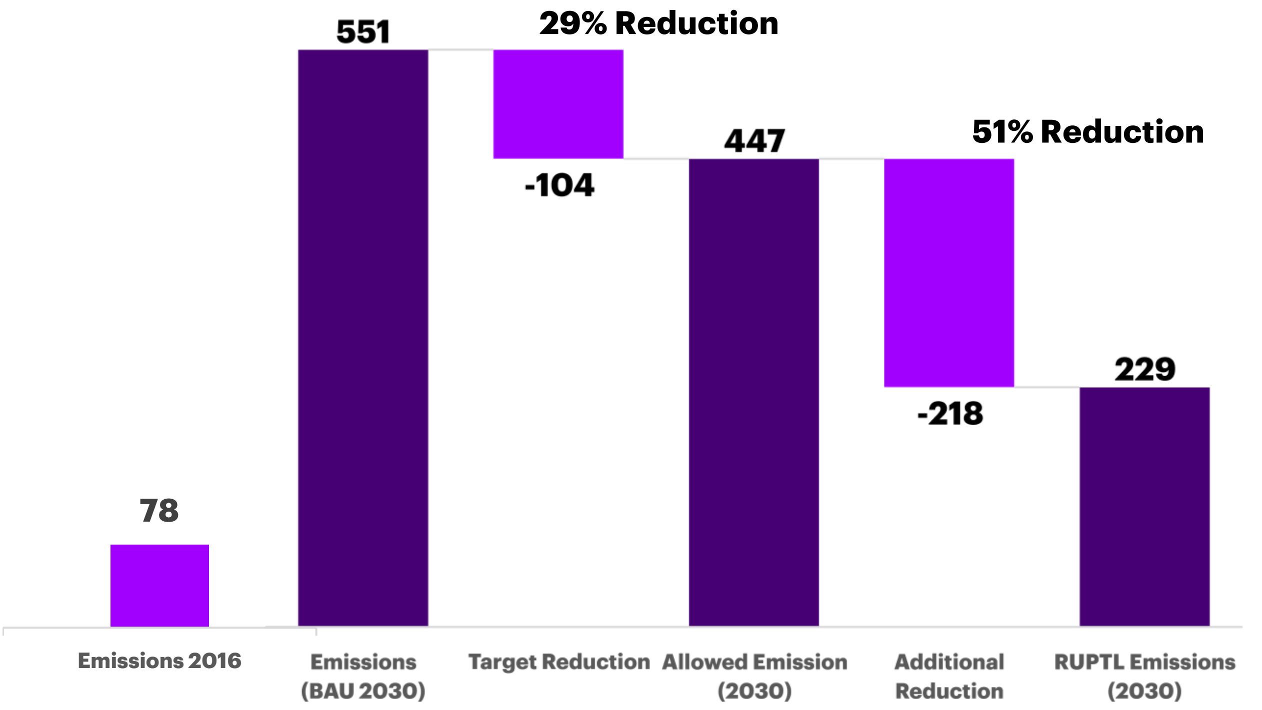
- Energy Outlook (2019) projections assume close to a **3x increase in electricity capacity**
- However, current consumption patterns post COVID do not align with the aspirational plan, leading to a **generation / consumption ratio of ~1.8x**
- **RUPTL plan has been revised in 2021 to include COVID considerations** and is therefore more closely aligns with current consumption projections (~1.1x) and is an execution focused plan which the **government is committed to**
- Hence our analysis **will use the RUPTL as the baseline projections**

Sources: Indonesia Energy Outlook, RUPTL.
Note(s): For the capacity split, Oil Capacity has been ignored, as not included in Energy Outlook; hence removed from RUPTL to ensure like for like comparison. However, the total generation and capacity has been presented at actuals.

Indonesia's 2030 Carbon Emissions Outlook

Forecasts of CO_2 emissions based on RUPTL plan projects a larger decrease in CO_2 emission than the government mandated target, but the reductions still lag global benchmarks, with an absolute increase of 3x between 2016 and 30

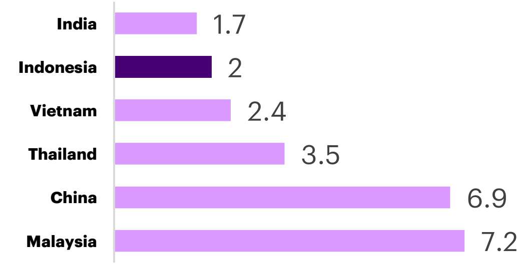
Power Sector Carbon Emissions: 2016 to 2030 (CO2 MMT)



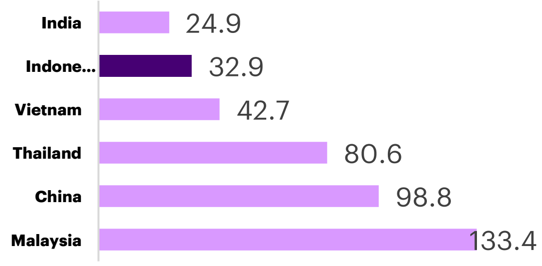
Insights

- RUPTL achieves **~51% reduction from baseline (BAU 2030) numbers for the power sector**
- In **absolute** terms, **the emissions increase from 78 MT of CO_2e to 268 MT** of CO_2e, a CAGR of **9.18%**
- For the same period, the IEA Net Zero 2050 scenario globally projects **an absolute reduction in electricity emission with a CAGR of -6%**

CO_2 Emissions per capita (MT) 2020



Energy Consumption per capita (GJ) 2019



Indonesia's Total Emissions Targets

- **Indonesia 9th world largest CO_2 emitter**
- **29%** unconditional reduction in CO2 emissions (of which **11% from energy sector**); **41%** emissions reduction contingent on international support (of which **14% from energy sector**)

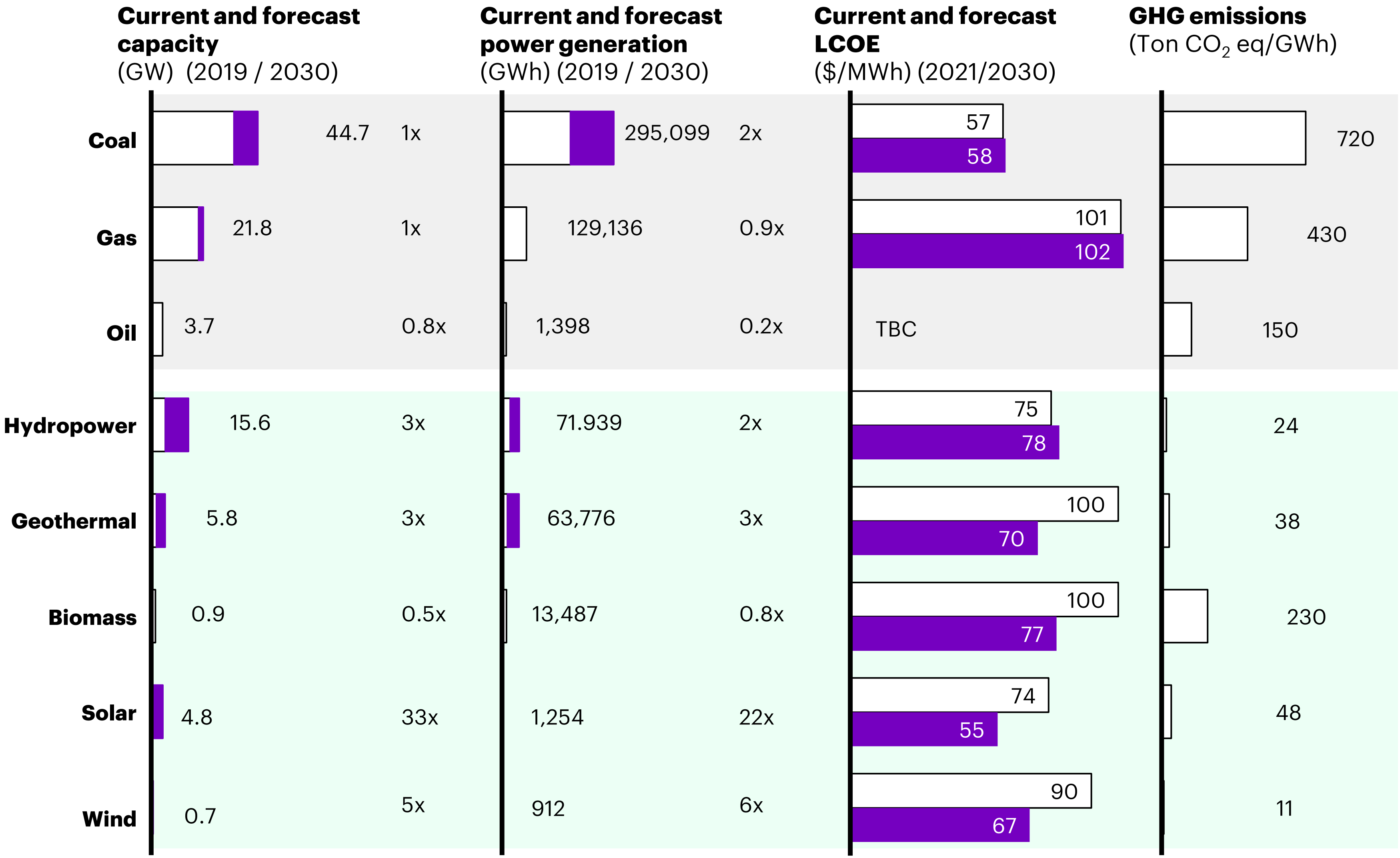
Approach and Methodology

- The **power sector** was attributed the same share in the total energy emissions **in 2016 as that of its share in Final Energy Consumption (~15%).** Attribution of emissions to power sector increases to **~33%** which reflects the increased share of power sector's share in the Final Energy Consumption

Sources: Indonesia Nationally Determined Targets (NDC) , Biennial Update, WEF ETI, Statistical Review of World Energy 2020 ,Accenture Analysis

Outlook of Energy Sources by Technology | Capacity, LCOE, CO_2 Emissions

Despite a ~3x growth in renewables capacity by 2030, the RUPTL plan also still projects the build out of ~14GW of new coal capacity



Source: RUPTL, HEESI

Source: RUPTL, HEESI

Source: Wood Makenzie, EIA , Technical Paper, Accenture Analysis

Source: EIA, World Nuclear Assoc, PLN

Insights

- **Coal is and will remain the leading source of electricity**, in terms of both capacity and generation volume
- **The capacity addition for coal is the largest in absolute terms (~14 GW)** while in percentage terms, solar has the highest growth
- **Large scale solar LCOE achieves grid parity with coal by 2027**. Grid parity may be further accelerated by carbon tax on coal and / or decrease of solar components cost (by local manufacture)
- Other **renewable energy sources** (e.g., hydropower, geothermal) remain more expensive than coal even by 2030, **but cheaper than gas**
- **Gas** is and will remain the technology with **the highest LCOE**

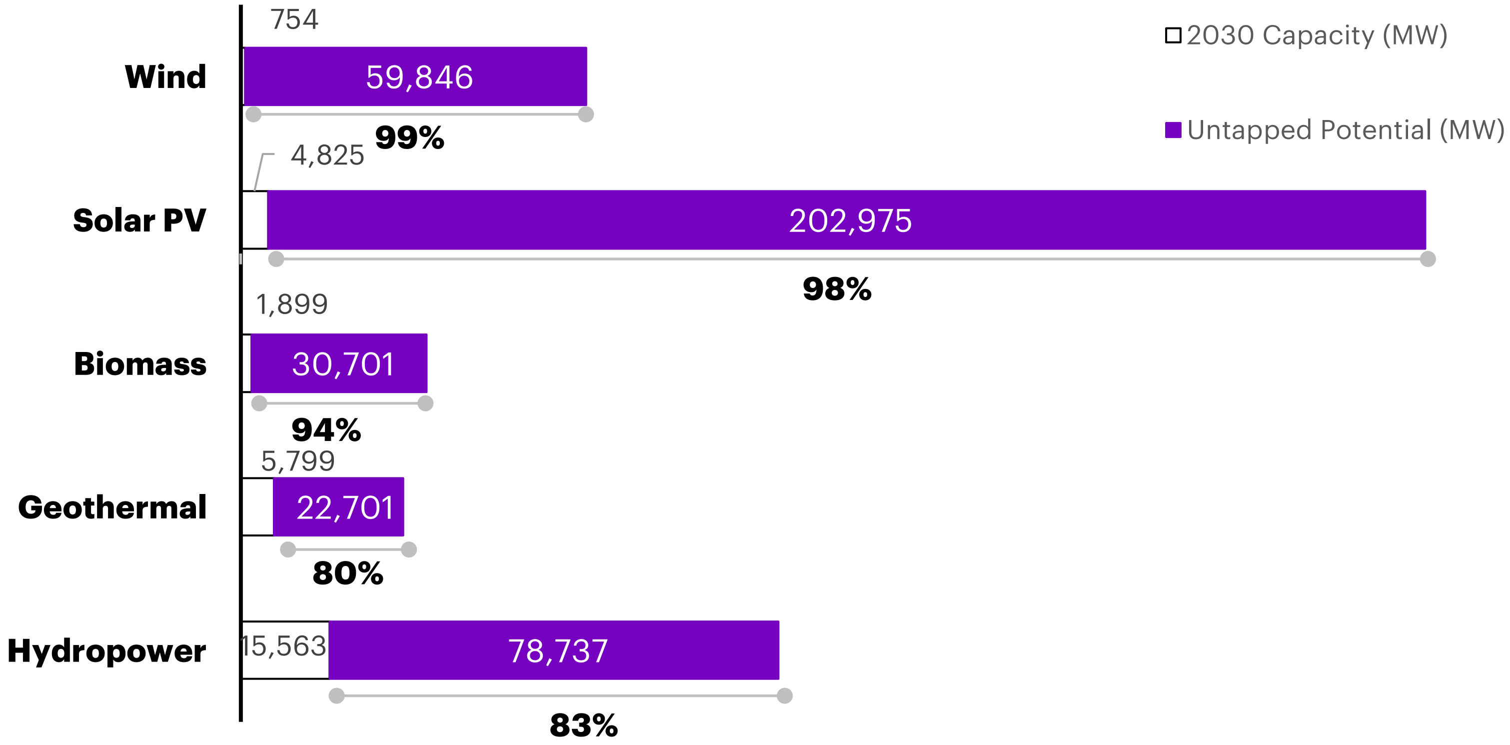
☐ 2019 Data

■ 2030 Projection (additional capacity and generation)

Renewable Resource Potential by Technology

Indonesia has a varied and vast renewable energy potential, with ~90% of its up to 400+ GW potential still untapped even by 2030

Installed Renewable Capacity vs Renewable Resource Potential (MW)



Note:

1.The RE potentials calculated are based on geological and geographical factors only and does not factor in the availability of supporting resources (e.g.: land) or economics.

2. The RE potentials considered are based on the latest released government estimates. Ongoing studies by government agencies are likely to revise the potential upwards, increasing the gap furthermore.

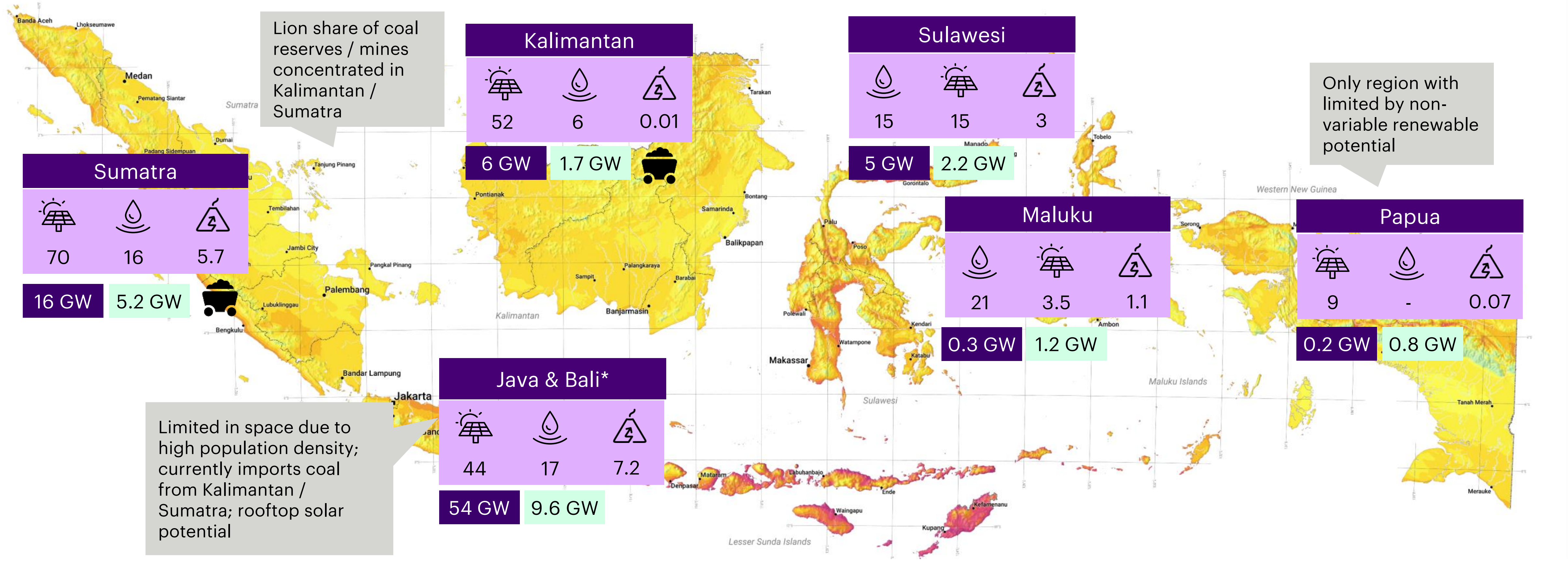
Insights

- Indonesia presents a **400+GW maximum renewable resource potential** vs 10GW currently renewable installed capacity, and 32GW capacity projected for 2030
- Even by 2030, Indonesia will be only exploiting **less than 10% of its total renewable energy potential**
- **Geothermal energy** is the most harnessed of technologies, despite high risk exploration process and higher LCOE than other renewable energy sources e.g. solar
- Sources, with lower LCOE and higher potential **(e.g. solar and wind)**, remain largely untapped
- The **penetration of Variable Renewable Energy remains very low (<5%) across all island grid**
- The draft of the new RUPTL (2021-2030) proposes a **9GW reduction** in **coal capacity** addition vis-à-vis RUPTL (2019-2028) and significant increase in Wind & Solar penetration. But, **even with the increased adoption**, Indonesia will **utilize only ~1%** of its total **solar** and **wind potential** by 2030.

Sources: Indonesia Energy Outlook, Accenture Analysis

Installed Capacity and Resource Potential by Island

Each of the main Indonesian islands, which all have independent grid systems (not interconnected), have at least a 2X renewable potential than what is currently in plan to be installed by 2030



Lion share of coal reserves / mines concentrated in Kalimantan / Sumatra

Only region with limited by non-variable renewable potential

Limited in space due to high population density; currently imports coal from Kalimantan / Sumatra; rooftop solar potential

Sumatra

☀	💧	⛰
70	16	5.7

🟪 16 GW 🟩 5.2 GW ⛏

Kalimantan

☀	💧	⛰
52	6	0.01

🟪 6 GW 🟩 1.7 GW ⛏

Sulawesi

💧	☀	⛰
15	15	3

🟪 5 GW 🟩 2.2 GW

Maluku

💧	☀	⛰
21	3.5	1.1

🟪 0.3 GW 🟩 1.2 GW

Papua

☀	💧	⛰
9	-	0.07

🟪 0.2 GW 🟩 0.8 GW

Java & Bali*

☀	💧	⛰
44	17	7.2

🟪 54 GW 🟩 9.6 GW

☀ Solar PV Potential (GW)

⛰ Geothermal Potential (GW)

💧 Hydro Potential (GW)

🟪 Total Installed Capacity 2030 (GW)

🟩 Planned Renewable Capacity 2030 (GW)

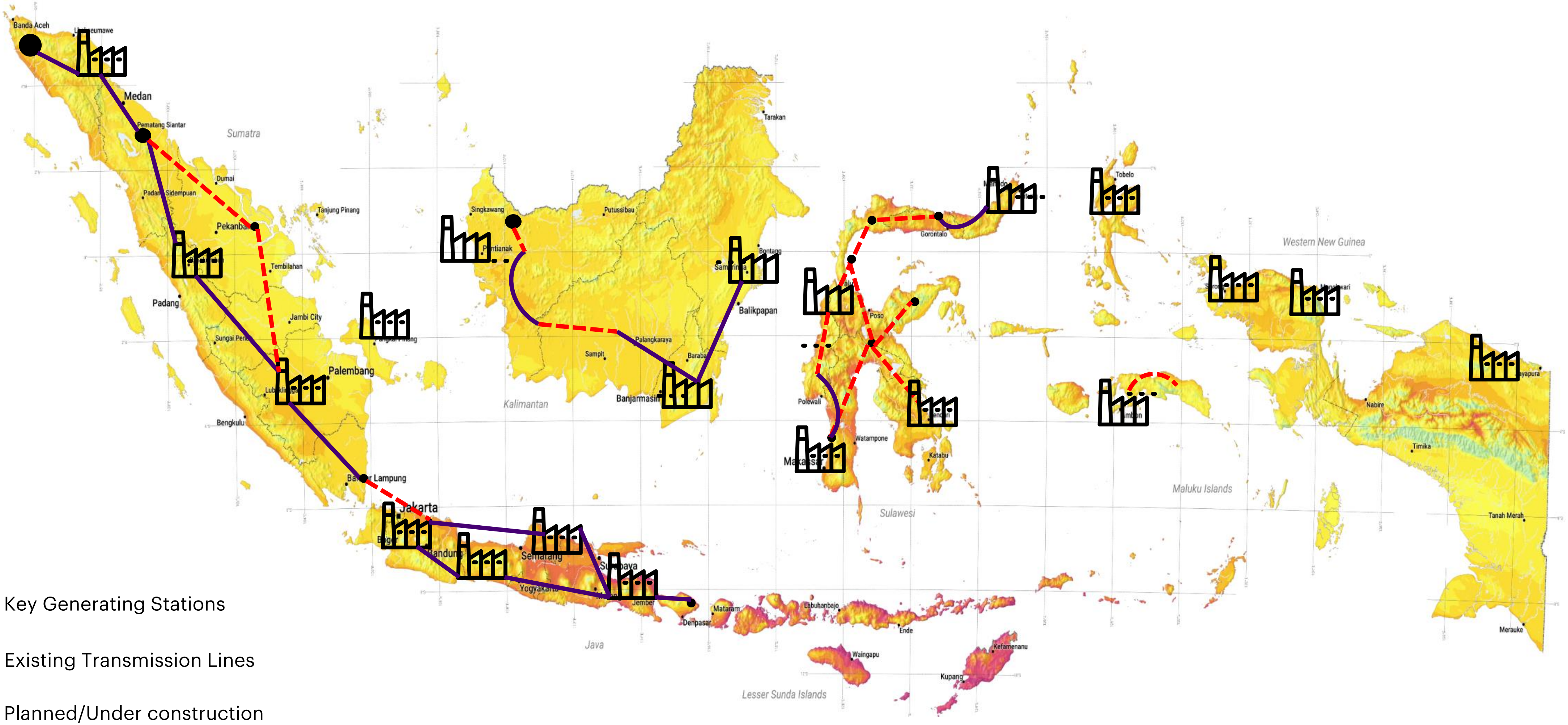
⛏ Coal Reserves

Sources: Solargis, skkmigas *- Includes Lesser Sunda

Note: 1. The new RE capacities have been divided between Maluku and Papua in proportion to their installed capacities in 2030.

The Indonesian Grid

The Indonesian grid is largely isolated, with no inter-island connections insufficient and limited intra-island connections. This means that the power dispatch is limited to each island, creating geographic constraints for future electricity capacity expansion



🏭 Key Generating Stations

━ Existing Transmission Lines

- - - Planned/Under construction Transmission Lines

Sources: MEMA, Annual Reports of PLN, Media Reports

Grid Challenges

The Indonesian Grid is a major roadblock in adopting a greater share of variable renewable energy sustainably as it currently grapples with reliability issues, higher T&D losses than its neighbouring countries and a low level of digitalization and low investments

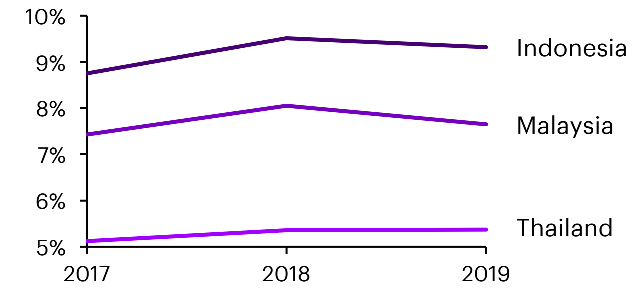
Current | Reliability and Efficiency

Low Reliability & High T&D Losses directly impacting service quality & utility bottom line

41M USD/Yr Revenue loss due to interruptions

Indonesia's System Average Interruption Duration Index (SAIDI) in 2020 was 763.13 minutes/customer/year). This is **12 times Thailand's** and **22 times Malaysia's SAIDI** in the past 3 years[1], bringing disruption for end consumers, and leading to financial losses for PLN.

2.3BN USD/Yr Cost of T&D Losses



T&D Losses

Indonesia's **Network losses (>9%)** are the **higher** than **Malaysia and Thailand** by several percentage points. By bringing down its losses to Malaysia's level (~7.5%), Indonesia could potentially save **483M USD annually**. [2]

Looking Ahead | Capacity and Flexibility

Poor Flexibility and lack of digitalization to impact the effective integration of new power capacity, especially that of variable renewable energy

0 Interconnections Between islands

No existing interconnections between islands and limited connections intra-island. Key interconnection project linking Java and Sumatra (~500km) has been paused and has not reached completion.

34BN USD PLN Debt

PLN's debt and its **Net Debt/EBITDA Ratio (5.40) presents a financial constraint on financing grid upgrades and extensions**. This has also been a factor in the rise of its cost of capital[3]. International institutions have been supporting PLN and the Indonesian government with funding and loans for grid maintenance and updates – more than USD 1.2bn was funded by ADB's ASEAN Infrastructure Fund (AIIF) to date

LOW DIGITALIZATION LEVELS | Poor level of automation at the substation levels, and obsolete Network Management Systems

Sources: 1.Annual Reports of PEA, TNB & PLN; 2. S&P Capital IQ; 3. PLN Annual Report 2020 (pg. 42)

Key Question

How might Indonesia realign its energy mix to achieve its energy transition targets?

5 Solutions for Indonesia’s Energy Transition

We recommend 5 solutions across the value chain to drive a sustainable, financially viable and just Energy Transition in Indonesia

Power Generation

1. Replacing planned and existing Coal with Utility Scale Solar

2. Distributed Solar and Storage Growth to support Energy Access

Transmission & Distribution

3. “Zero Net Cost” Digitalization of the Grid for optimal Grid Operations

4. Innovative Financing Models for T&D Infrastructure Upgrades

End Consumer

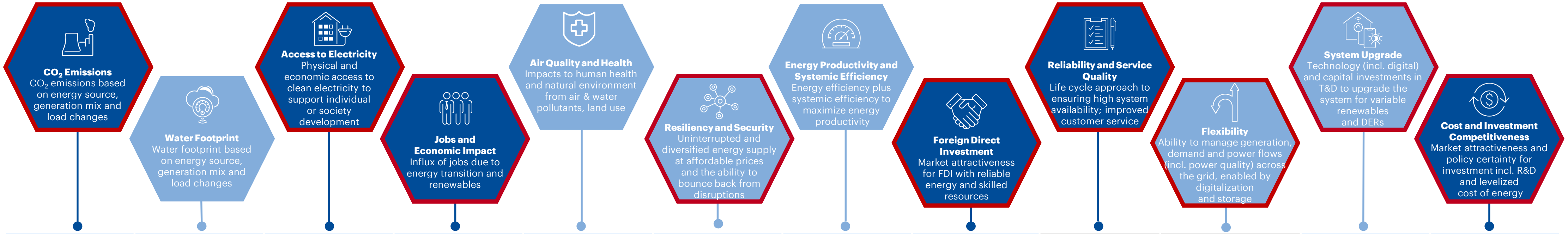
5. Energy efficiency at the Consumer, Industry and Transport level

System Value of Indonesia’s clean energy transition

⬢ System Value dimension with quantitative analysis

⬢ System Value dimension with qualitative analysis

⬡ Priority System Value dimension



	CO_2 Emissions CO_2 emissions based on energy source, generation mix and load changes	**Water Footprint** Water footprint based on energy source, generation mix and load changes	**Access to Electricity** Physical and economic access to clean electricity to support individual or society development	**Jobs and Economic Impact** Influx of jobs due to energy transition and renewables	**Air Quality and Health** Impacts to human health and natural environment from air & water pollutants, land use	**Resiliency and Security** Uninterrupted and diversified energy supply at affordable prices and the ability to bounce back from disruptions	**Energy Productivity and Systemic Efficiency** Energy efficiency plus systemic efficiency to maximize energy productivity	**Foreign Direct Investment** Market attractiveness for FDI with reliable energy and skilled resources	**Reliability and Service Quality** Life cycle approach to ensuring high system availability; improved customer service	**Flexibility** Ability to manage generation, demand and power flows (incl. power quality) across the grid, enabled by digitalization and storage	**System Upgrade** Technology (incl. digital) and capital investments in T&D to upgrade the system for variable renewables and DERs	**Cost and Investment Competitiveness** Market attractiveness and policy certainty for investment incl. R&D and levelized cost of energy
1. Replacing planned and existing Coal with Utility Scale Solar	**116 MMT** Cumulative CO2 emissions reductions between 2024-28 compared to RUPTL	●	◐	◐	**$ 2 B** Human Health Benefits through 2030 from decreased air pollution	○	○	**$10 Bn +** Min FDI expected considering improved policies in RE sector between 2024-28	▨	▨	○	**$276 Mn** Reduction in Renewable CAPEX, translating to lower RE costs
2. Distributed Solar and Storage Growth to support Energy Access	**3 MMT** Cumulative CO2 emissions reduction between 2020-30	◐	**~95%** Electrification rate in Papua & Maluku	**>16K** Clean energy jobs until 2030 and >29K indirect and induced jobs	●	◐	◐	●	▨	◐	◐	▨
3. “Zero Net Cost” Digitalization of the Grid for optimal Grid Operations	◐	○	◐	▨	○	●	●	▨	**227 Mins** Reduction in SAIDI	◐	●	**$ 477 Mn** Gains from reduced T&D losses and salvaging lost revenue
4. Innovative Financing Models for T&D Infrastructure Upgrades	●	○	●	▨	○	●	◐	**$ 64-127 Bn** Incremental FDI Inflow	●	●	●	**$ 26 Bn** Reduction in Financing Cost and Tariffs for new Infrastructure
5. Energy efficiency at the Consumer, Industry and Transport level	**54 MMT** Annual CO2 emissions reduction in 2030 compared to base case	◐	○	**85-212K** Cumulative job years created by 2030	**$ 113 Bn** Human Health Benefits through 2030 from decreased air pollution	○	●	◐	◐	◐	▨	**$ 7.5 Bn** Electricity savings and power generation cost avoided

🟦 *Analysis performed for given System Value dimension and recovery solution. For more detail, please see specific solution and/or relevant System Value dimension slide(s).*

▨ *System Value dimension not as relevant to geographic market or not considered with given recovery solution.*

Relative System Value dimension benefit for given recovery solution within market

● High benefit ◐ Medium benefit ○ Minimal-to-no benefit

Opportunities to Address Coal Decarbonization in Indonesia

#	Decarbonisation Opportunity	Opportunity Description	Feasibility	Impact	Comments	
1	**Replace existing plans to build new coal plants with new renewable capacity**	• Stop existing plans to build new coal plants beyond what is being constructed already • **Replace planned coal capacity** to be built between 2023 and 2028 (**up to 5 GW**) with **renewables** • Prioritise new renewable capacity according to LCOE, renewable resource availability and variable renewable penetration	◕	●	• **Impact** opportunity to avoid 720 Tonnes / GWh new CO2 emissions and to transition jobs away from coal towards renewables • **Feasibility** issues may include existing commitment to e.g. EPC contractors to build new coal plants that lead to high cancellation penalties; jobs replacement (coal with renewables) requires retraining / reskilling	Prioritised
2	**Decarbonise existing coal plants**	• **Upgrade existing coal plants** with **power filtration** technology to reduce SOx and NOx emissions leading to cleaner air, following example of coal plant regulations in China where SOx and NOx filers are mandated	◕	◔	• **Impact** is not on CO2 emissions but on SOx and NOx emissions (air pollutors) • **Feasibility** technology is proven; however, concerns about cost / benefit trade off	
		• Build **infrastructure to gasify coal** following examples of gasification projects initiated in South Africa and India.	◔	◔	• **Impact** reduction of CO2 emissions, but only partially vs building renewable capacity and decommissioning / avoiding build out of new coal • **Feasibility** requires high infrastructure capital investment and lead time; despite technology is proven, not reached scale in any key coal market	
		• Invest in **Green Ammonia Co-firing** to power existing coal power plants with ammonia, building on early stage development in Japan (lead by JERA) and leveraging Indonesia's planned prominent role as the manufacturing hub of Green Ammonia Supply Chain for Japanese plants[1,2]	◔	◕	• **Impact** reduction of partial reduction of CO2 emissions, and the opportunity to set up a Green H2/Ammonia value chain within Indonesia. • **Feasibility** requires significant investment in the technology R&D from developed Nations (e.g. Japan) for technology to be cost effective and proven at scale.	

3	**Fast track existing coal plants decommissioning and repurposing of plants with renewable energy**	• **Accelerate decommissioning of existing coal** power plants (**up to 7.1 GW**), prioritising decommissioning according to plant efficiency, CO2 emission, baseload needs
		• Adapt regulation and provide incentives on coal:
		  ◦ **Grant priority permits for solar / wind plants** for coal producers that agree to early decommissioning, following example of China's regulation
		  ◦ Update regulations to have **more stringent environmental requirements** on coal plants **emissions,** similarly to what the Indian government did
			◑	●	• **Impact** opportunity to leverage existing land permits and interconnection and repurpose coal plants with cleaner energy, leading to reduction in CO2 emissions and lowering cost of new installed capacity; opportunity to maintain local jobs linked to coal mine and retrain / reskill workforce
					• **Feasibility** combination of best practice already achieved in India and China (two of the largest coal producers in the world)
						Prioritised

Sources: 1.Corporate Press Release ; 2. Corporate Media Release (Mitsubishi)

1a. Replacement of Planned Coal Plants with Renewable Energy in REZ (1/2)

Indonesia can avoid building 5GW of new coal plants, and can leapfrog to replacing this capacity with renewable power directly

Current State

- As per **2021-2030 RUPTL plans**, Indonesia has plans to install **~14 GW of new coal by 2030**; **5 GW** of this new coal capacity is expected be **built between 2024 and 2030**
- As per latest announcement in June 2021, **PLN has committed to not build new coal plants beyond 2023**; this is estimated to result **in ~0.3 GW** not getting built (<10% to new total installed capacity)
- However, there is a wider opportunity to **stop building the entire 5 GW of coal plants that have not started construction yet** – these are both PLN and IPPs' coal plants plans, and to instead, build out solar capacity in dedicated **Renewable Energy Zones (REZ)**, given the significant renewable resource potential Indonesia has to offer

Opportunity

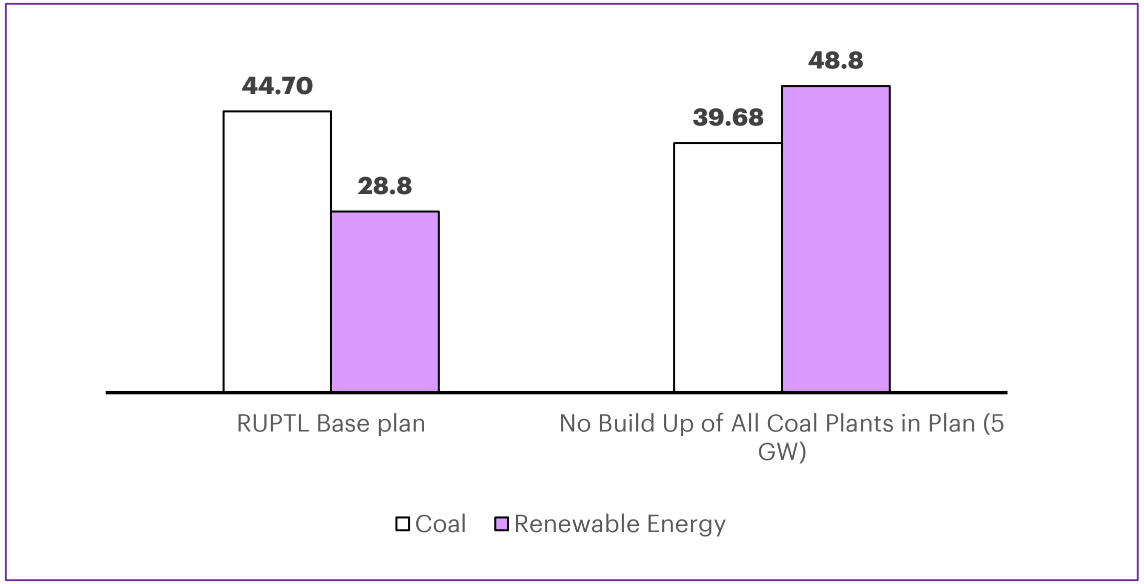
Prioritise renewable sources to ensure transition is financially and technically sustainable by facilitating Renewable Energy Zones. A REZ is a geographic area characterised by features that support cost-effective renewable energy development, including high-quality renewable energy resources, suitable topography, and strong developer interest

The impacts of REZ on the Indonesia's Energy Transition journey are:

1. **Streamlined Land acquisition**: The Government plays an active role in land acquisition, which has been one of the key impediments of RE penetration in Indonesia, and hands over the acquired land to RE developers through transparent bidding.
2. **Proactive T&D Network and Storage Planning:** Integrated planning of transmission connections and storage facilities along with solar panels to ensure that the power generated is evacuated without congesting the grid, the variations in solar generation are restricted within the limits which the grid can handle, and curtailment is minimal.
3. **Reduced project risk and catalysis of private and foreign investment** due to participation of developers during planning and execution process, as well as alleviating risks of other investment impediments such as land acquisition

Further analysis was carried to identify the most optimal renewable technology to leverage by island / region within a Renewable Energy Zone (see further analysis on the next slide)

Planned Coal Replacement Scenarios by 2030 (GW)



System Value Impacts

Benefits

↓ 101 MMT
Cumulative CO2 emissions reductions between 2024-28 compared to RUPTL

↑ Min $10 Bn
Min FDI expected considering improved policies in RE sector between 2024-28

↑ Reskilling
Opportunity to retrain the coal workforce and reskill employees for renewable energy projects

Source: RUPTL Plan 2019-2028, Argus Media

1a. Replacement of Planned Coal Plants with Renewable Energy in REZs (2/2)

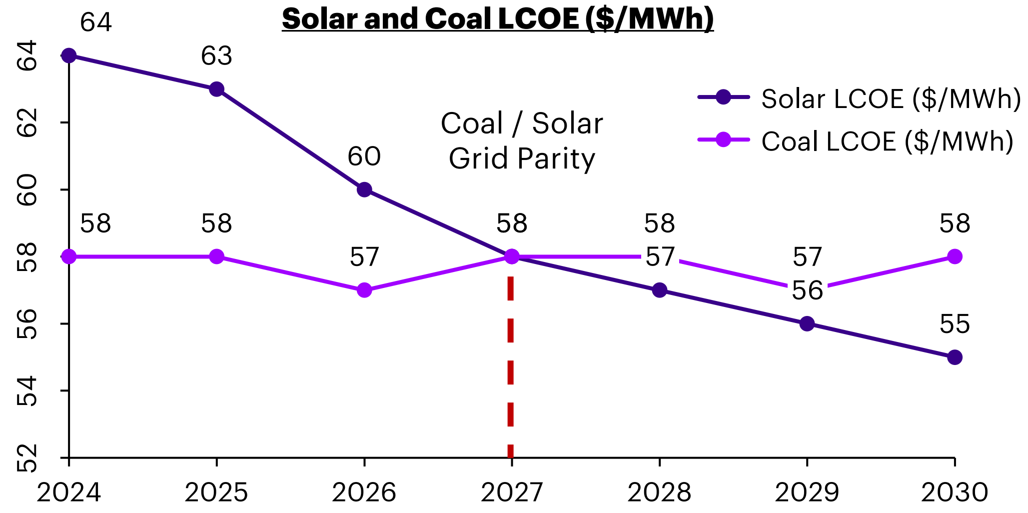
As the solar LCOE is the lowest among other sources of renewable power (in Indonesia) and is projected to become cheaper than coal by 2028, the coal planned capacity can be replaced by solar power in a financially sustainable way

Solar and Coal LCOE ($/MWh)

Preferred RE technology for REZs was selected based on:

- **Technology LCOE** – ranked renewable technologies by average LCOE between 2021 and 2023.
- **Renewable Resource Availability** – Checked for renewable potential by region to ascertain whether all additional renewable capacity could be met by cheapest renewable resource.
- **Maximum variable penetration** – included a maximum threshold of variable renewable penetration (solar & wind) of 20%; beyond 20%, non-variable renewable resource (geothermal or hydro) were given preference, wherever available

Across islands, Utility Scale Solar emerged as the primary choice for REZs



Source: RUPTL Plan 2019-2028, Wood Mackenzie

Insights

- Utility scale solar decreases progressively and achieves **grid parity with coal latest by 2027.** Several studies estimate that the grid parity can be achieved significantly earlier.
- In the period **between 2024 and 2028**, replacing all the planned coal plants with renewable energy will lead to an **additional cost of USD 134mn in total**
- However, this only includes the financial cost of the replacement and does not take into account the value of reduction in CO2 emissions and advantages driven by reskilling of the workforce
- Further, the increase in generation cost can be offset by:
  - **Optimizing Solar CAPEX further** – the cost of solar has decreased at a much faster pace in the last decade that anyone would have expected and innovation will continue to accelerate LCOE decrease
  - **Modulating the demand curve** to delay the commissioning of power plants

1b. Decommission Existing Coal Plants early by Repurposing them with Solar

Indonesia can repurpose up to 7 GW of coal capacity which will be decommissioned into solar plants

Current State

- Indonesia has announced plans to retire **1.1 GW** out of its 35 GW of existing coal capacity **by 2030** (assumed as the Base Case) and a further **6 GW by 2035**
- Coal plants in Indonesia present a relatively low-capacity factor (~50%) which indicates operational inefficiencies, especially in small sized and older coal plants
- Retirement of coal plants results in **high closure costs** (USD 65m / GW), hence IPPs with long term take-or-pay offtake contracts are **not keen** to decommission plants.
- One of the **key challenges** in achieving Indonesia's RE goals is **acquisition of land**, which is a **constrained resource on the archipelago**, for the RE installations.

Opportunity

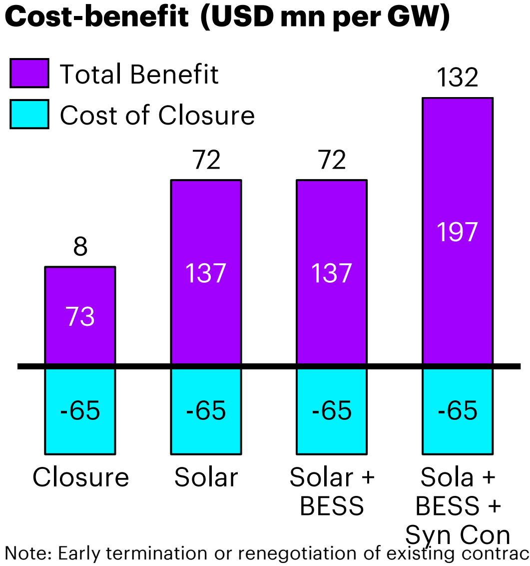
When a coal plant is decommissioned, the default option is to close the plant and decontaminate the land to avoid health hazards. However, there is an opportunity for PLN/IPPs to **repurpose the plants to house Renewable Energy installations already in plan**, setting up a total 1.8 GW on solar capacity on the land housing 7.1 GW of coal capacity, in order to **leverage existing land rights** and **existing interconnection**:

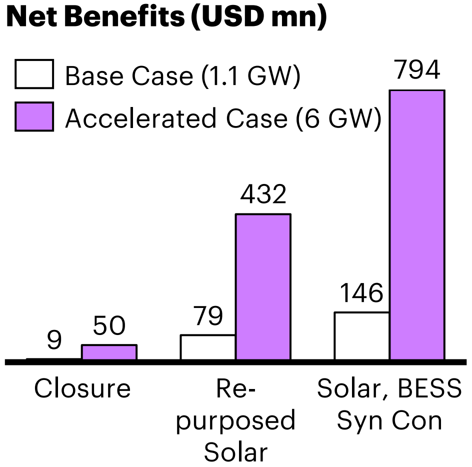
1. **Repurpose coal plants with solar or solar-Battery Energy Storage Systems (BESS):** the land is used to set up a solar plant which leverages existing grid connections & civil structure of the coal plant. The overall benefits equal to USD 72m / GW
2. **Re-purposed Solar, BESS with Synchronous Condenser:** in addition to leveraging the land and grid connections, the existing generators can be run as Synchronous Condensers to supply reactive power, enabling grid stabilization

Coal decommissioning and re-purposing can be accelerated by:

- **Introducing stringent emission norms** such as mandatory Flue Gas Desulphurization requirements equivalent to what is recommended in India
- **Granting priority access to renewable permits / licenses** to mining companies committing to early decommissioning of coal plants (incentive adopted in China)

Cost-Benefit Analysis and Net Benefits of Repurposing Coal \


Cost-benefit (USD mn per GW)


Net Benefits (USD mn)

Note: Early termination or renegotiation of existing contracts may possible However, this has not been analyzed in detail due to limited technical/contractual data and requirement of simulation to gauge the effect of renegotiated contracts on the grid, which is outside the scope of this SVA.

System Value impacts

Benefits

⬇15 MMT	**⬇~$276 M**	**⬆Reskilling**
Of CO2e reductions per year from accelerated repurposing	Reduction in Renewable CAPEX, translating to lower RE costs	Existing coal plants employees can be re-trained & retained

Sources: RUPTL, Cost benefit Analysis of coal plant repurposing in developing countries , PLN, OECD, Business Green
Note(s): (1) Coal plant closures will result in some job losses which are not reflected due to data unavailability
(2) On an average, 1 GW Coal plant can be repurposed to support a 250 MW of solar plant.

Coal to Renewables Transition | Cost vs Benefits for Society

The value created and the adverse impact of coal usage extends beyond the LCOE of the electricity it generates. The true benefits of shifting away from coal can be captured from the net economic value generated and accelerated through focused policy

Net Socio-Economic Benefits from switching to Solar **significantly outweigh** the **Switching Costs**

Re-employment of Coal Workers

Majority
Of Coal Workers can be absorbed Solar sector at higher Median Wages

Easy Re-employment

>55%
Coal Workers can be employed in the solar sector with no re-training

Additional Job Creation

7.41
jobs created per MW of Solar vs **1.01 jobs/MW for Coal**

Healthcare Benefits

702 MT
PM 2.5 Emission reduction per year by installing one GW of solar

Re-skilling Costs

USD 10K
Average Training Costs /worker for those needing re-skilling

- The **Lifetime Value created** by solar over coal, for the same installed capacity, through additional job creation, re-employment at higher wages, and Dollars saved in Healthcare Bills **far outweighs its costs.**
- While the benefits over 20 years offset the costs, the transition will initially require **additional financing** to ensure a ‘just transition’ (e.g., costs incurred due to job reskilling)

Success Stories across the Globe

Among mid Income jobs not needing a college degree, Solar sector jobs are 3rd fastest growing segment
US Labour Bureau Statistics

The Economic Times

Over 300,000 workers to be employed in solar, wind energy sectors in India

India is set to add 300,000+ jobs in Renewables by 2022
The Economic Times

Storage, Wind, Solar Companies Are Recruiting Coal Miners for Their Work Ethics and High-Tech Skills

US RE & New Energy Companies hire Coal Workers in large numbers
Newsreports

Sources: HBR, Journal of Energy Economics

Synergies with WEF's Mobilizing Clean Energy Investments in Emerging Markets initiative

Coal phasing out in Indonesia could benefit from the Energy Transition Mechanism financing idea, as well as from a holistic approach to prioritize which coal plants should be phased out first, as outlined by think thank CEEW for India's coal plants

Energy Transition Mechanism (ETM)

- The Energy Transition Mechanism (ETM) is a financing mechanism to accelerate the retirement of coal, and its replacement with renewable energy
- An ETM would be formed for a specific country in order to be effective and based on that country's energy needs and nationally determined contributions
- The ETM is composed of a Carbon Reduction Facility (CRF) and a Clean Energy Facility (CEF). Current owners agree to transfer their carbon-intensive power assets to the CRF in exchange for cash and possibly equity interest in the ETM. They would be expected to invest the cash they received into renewable power, grid upgrades and a just transition for workers and local communities
- The coal-fired power assets would continue to operate for an agreed period that is shorter than the current expected lifetime, but long enough to pay back the ETM investors/lenders
- In parallel, the CEF collaborates with national authorities and the power sector to build up renewable energy capacity and storage. As renewable power expands, the ETM retires CRF assets

How it could be applied to Indonesia

- The Energy Transition Mechanism could be applied in Indonesia to fast track and fund the closure of its most polluting coal plants by creating a Carbon Reduction Facility; it could also be leveraged to finance the growth of clean power by leveraging the Clean Power

CEEW's Coal Decommissioning Planning

- CEEW completed a mapping of 130 coal plants in India, representing 208 GW and 45% of total installed capacity
- The mapping was completed with the purpose of understanding the cost of early decommissioning of the plants
- The mapping categorizes plants based on, amongst others, variable cost, and efficiency to help understand their impact on the eventual costs for retirement
- India's coal-powered assets with a large share of inefficient plants are underutilised due to lower than anticipated growth in energy demand, minimal retirement of assets despite steep targets under NEP,2018 and late increasing RE contribution in the system. This also leads to stress for the financiers with 11% nonperforming assets (NPA) of loans towards in September 2020
- Key findings include that while decommissioning may not be a viable option for most of the new plants, it make sense financially on itself for a number of the older plants above 20 years

CEEW's Coal Decommissioning Planning

- CEEW's mapping of coal plants in Indian could be replicated for Indonesia, with the purpose of understanding the cost and feasibility of early decommissioning for a number of coal plants. This would provide a holistic methodology to prioritizing the phasing out following standard parameters

Sources: World Economic Forum, CEEW

2. Distributed Solar and Storage Growth to support Energy Access

Indonesia has the opportunity to tackle energy access issues and fast track its energy transition by scaling distributed solar

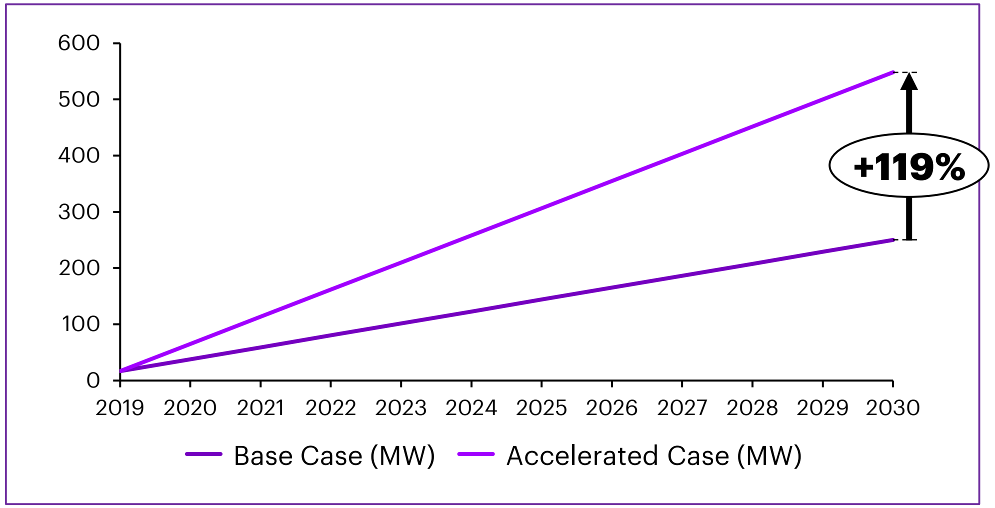
Current State

- Indonesia has high solar radiation (1450- 2200 kWh/m2) across all its islands, which means it presents high solar potential (up to 200 GW of potential)
- However, by 2019 only 16.6 MW of distributed solar capacity installed which is lower compared to that in neighboring countries, viz. Malaysia (1.63 GW), Thailand (0.4 GW), Vietnam (10 GW)
- Further, while the overall electrification rate has reached 99%, there are still areas such as Papua and Maluku, where the electrification rate is ~50% and 80% only respectively. In the same, grid implementation is a challenge, given financial constraints and sparsely populated areas

Opportunity

- Indonesia's current target of 0.25 GW of cumulative distributed solar capacity by 2030 (Base Case) is a modest target compared to its neighboring countries' distributed solar power installed capacity and targets. There is an opportunity to double its target (0.54 GW) by focusing on solar based microgrids to ensure 95% electricity access across both Papua and Maluku through distributed solar (Accelerated Case)
- **Incentivizing Self Consumption + Behind the Meter Battery** in community owned solar microgrids can significantly increase the electrification in low demand islands such as Maluku and Papua, without the government having to invest in the lumped capacity in form of large power plants or in extensive T&D infrastructure. The battery storage will help to ensure that access to electricity is also enabled during hours with low irradiation, and it will minimize use of diesel generators
- **Deploying Solar-as-Service Models** will minimize key barrier of initial investment by fronting the installation cost and charging consumers monthly fees. Moreover, this model takes care of the maintenance costs, taking away the performance risk associated with solar ownership

Distributed Solar Installed Capacity by 2030 (MW)



System Value Impacts

⬇ **3 MMT**
Cumulative CO2 emissions reduction between 2020-30

⬆ **>16K**
Clean energy jobs until 2030 and >58K jobs including indirect and induced jobs

⬆ **~95%**
Electrification in Easter Islands (Papua & Maluku)

Sources: IRENA, Accenture Analysis; ECN.TNO

3. "Zero Net Cost" Digitization of the Grid for optimal Grid Operations

Indonesia has an opportunity to reduce its T&D losses by digitalizing the grid through self-financing projects

Current State

- Indonesia T&D system is loss ridden (3-Year Average Losses- 9.33%) and lacks reliability (3 Year Average SAIDI - 952.73 mins/customer/year, 3 Year Average SAIFI- 10.22 interruptions/customer/year)
- Indonesia has multiple grids across its islands, with no interconnection between islands and limited interconnection intra-island (e.g., in Kalimantan and Sulawesi); limited infrastructure, paired with limited digitization and automation, leads to suboptimal grid configuration and load dispatch
- In addition, plans to install renewable capacity growth, paired with growing mobility electrification, will require grid integration, leading to further digitization requirements, to enable stability in the face of generation and demand variability

Opportunity

The digitization of the Grid offers several avenues of improving cost of service, service quality and the capacity factor for generation plants:

1. **Dynamic Grid Configuration Optimization** considering generation scheduling and transmission network configuration to minimize technical losses in the T&D network and minimize the total cost of service
2. **Remote Network Operations & Real Time Field Asset Alarms** to accelerate the restoration of power in event of network failures and improving the service quality by reducing the SAIDI. Moreover, a faster restoration also allows the T&D operator of salvage a significant part of the revenue lost to outages
3. **RE Integration and Power Quality management** which can be driven by digital grid control systems to maximize the utilization of RE resources, manage the variability and sustain power quality at the customer end

The investments in Digitizing the Grid are less CAPEX intensive investments than physical infrastructure investments; they have the ability to reduce loses, leading to higher revenues and cost savings for the T&D operator. Based on global use cases, the investment garners an RoI of 10-25%.

Net Benefits of Digitization

Range of Improvement (%)

Loss Reduction	SAIDI Improvement
0.5% - 2%	10% - 20%
117 - 469 M	4 - 8 M

Financial Benefits (USD/Year)

Total Benefits/Yr USD 121 M- 477 M

System Value impacts

Benefits

↑ ~$477 M
Gains from reduced T&D losses and salvaging lost revenue

↓ 227 Mins
Reduction in power interruption duration for every customer/yr

↑ ~2%
Increase in grid efficiency, driving lower service costs

Source: PLN Annual Report 2020, Accenture Research

4. Innovative Financing Models for T&D Infrastructure Upgrades

Non-Traditional Financing models can unlock low cost private & foreign capital for large scale infrastructure projects

Current State

- To inter-connect the generating stations, islands and achieve the flexibility to support large volume of renewables, new transmission interconnections are needed across Indonesia
- The distribution network, which is failure-prone and ageing, also needs upgradation and capacity augmentation to support the electricity usage growth prompted by energy transition which Indonesia is targeting
- The necessary infrastructure upgrades require capital investments; however, PLN's existing debt, paired with high cost of capital, calls for alternative ways of financing the projects – which involves the private sector

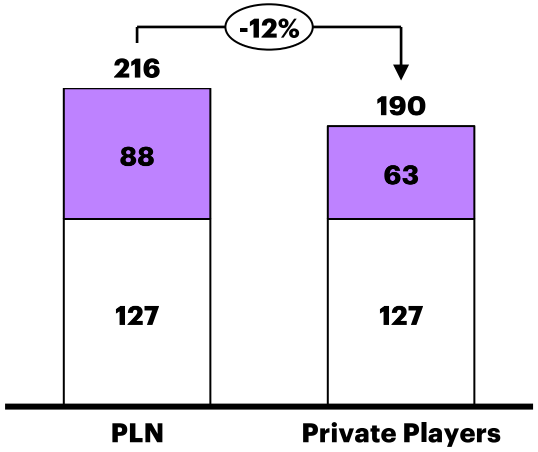
Opportunity

Opening the market to private players and using non-conventional financing mechanisms can enable Indonesia to execute the infrastructure projects, minimizing any additional debt for PLN, or burdening the end customer with higher tariffs:

1. **Public Private Partnerships** structured as Build-Own-Operate-Transfer (BOOT) or Design-Construct-Maintain-Finance (DBFO), in which the **returns are tied to the cost of capital**, can enable PLN to offset its capital investments and **lower the cost of service** by leveraging the private partners' lower cost of capital
2. **Reverse Auction of Transmission Projects based on PLN's wheeling charges** (Transmission Charges/MWh of energy flowing through the lines) - private players bid against PLN's forecast wheeling charges for new infrastructure capacity; this assumes the bidding process will lead to lower wheeling charges, as a result of a more competitive cost of capital by private actors, and a more efficient running of the built infrastructure, minimizing the additional cost for consumers
3. **Green Bonds** – issued by PLN, guaranteed by the government and **linked to meeting Renewable Energy commitments.** Green bonds can be leveraged to build additional T&D infrastructure to accommodate for higher Renewable Energy penetration, at a **lower cost of capital**, by attracting foreign capital from **ESG focused investors**

Impact of Low-Cost Financing on Total Project Cost & Tariffs

Total T&D Project Costs till 2030



- Investment requirement for a stable grid (USD 127 B) is calculated by benchmarking T&D spends against India.
- PLN's Cost of Capital is based on the weighted average of the coupon rates of bonds issued in 2020 and period is taken as 15 yrs.
- Private players' cost of capital is benchmarked against Green Bonds in Asia.

System Value impacts

Benefits

⬇ **~26 Bn USD**	⬆ **64-127 Bn**	⬆ **Grid Flexibility**
Reduction in Financing Cost and Tariffs for new Infrastructure	Increase FDI inflow to support T&D infrastructure	To support increased RE sources in the grid

Source: PLN Annual Report 2020, ADB

5. Energy efficiency at the Consumer, Industry and Transport level (1/2)

Indonesia has the opportunity to further fast track its energy transition by scaling energy efficiency solutions at the consumer level

Current State

- **Electricity use dominated by residential sector and lighting and cooling uses:**
  - **Residential demand:** 44% of total electricity demand, projected to grow beyond 50% with increasing appliance ownership (ACs, refrigerators) by 2030[3]
  - **Industrial and commercial demand:** 32% and 24% of total electricity demand today. Lighting and ACs largest part of peak demand in commercial sectors
- **Current Policy landscape**
  - **National Master Plan for Energy Conservation (RIKEN):** targets 17% overall savings vs BAU[1] by 2025. No implementation details
  - **Minimum Energy Performance Standards (MEPS):** coverage limited to ~18% of total energy use (limited to AC and lamps)

Opportunity

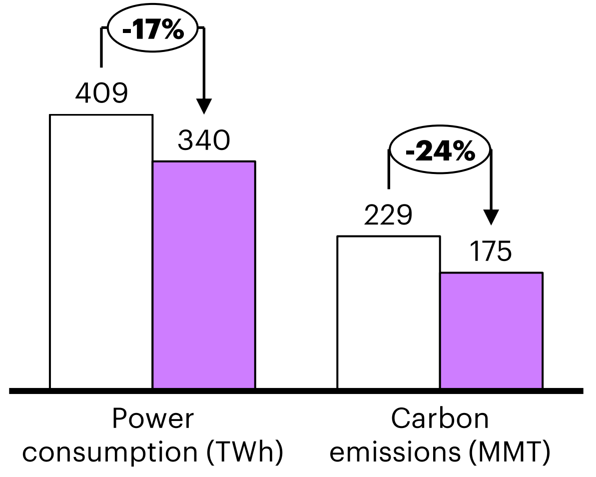
1) Consumer:

- **Efficient Buildings plan**: holistic plan including new builds and retrofits with wider sector coverage (e.g., to residential) and segment specific initiatives
- **MEPS for appliances:** extend coverage beyond 18% to other appliances
- **Efficient Lighting plan:** deploy national program to upgrade existing lighting to LED lighting; adopt best practice such as eased access to LED lightbulbs in local retail stores (following example in India); boost existing ADLIGHT program
- **District Cooling system / National Cooling action plan:** reduce cooling energy requirement and cost of cooling

2) Industry | Define mandatory industry targets and audits : incentivize adoption by combining with tradeable certificates (e.g., India's PAT – Perform, Achieve, Trade)

3) Transport | Fuel and vehicle efficiency standards / EV Adoption: Introduce fuel standard, upgrade vehicle efficiency standards and promote modal shift to mass transport and electric public transport

Reduction in Generation Capacity (TWh) and CO2 Emissions



Indonesia's full potential (BAT) savings could mean generation and subsequently emissions can be reduced by 25% by 2025 and 30% by 2030

(Primarily based on the consumer lens)

System Value impacts

Benefits

⬇ **54 MMT**
Annual CO2 emissions reduction in 2030 compared to base case

⬆ **85–212 K**
Cumulative job years created by 2030

⬇ **$3.4 Bn**
Saved in annual household electricity bills (by 2030)

+ **$4.0 Bn**
Cost of power generation avoided annually (by 2030)

Sources: IEA Energy Efficiency 2020, IESR Indonesia Clean Energy Outlook 2020, Forecasting Indonesia's peak demand reductions from appliance and lighting efficiency, Study of district cooling implementation opportunity in Jakarta, IEA India 2020 Energy Policy Review, APEC Energy Efficiency Finance in Indonesia

5. Energy efficiency at the Consumer, Industry and Transport level (2/2)

There are multiple successful examples of energy efficiency programs that Indonesia can replicate across consumer, industry and transport sectors

	Solution	Current situation	Solution Description	Case reference	Potential impact
Consumers	**Efficient Buildings plan**	▪ Governed by Energy efficiency Policy 70/2009 and green building code ▪ Only 3 cities with local green building code today ▪ Mandatory energy eff. Plan covers only large commercial consumers consuming > 4000 toe. ▪ Reporting on Energy Management programs only ~40%	▪ **Expand coverage** to residential buildings and including new builds and retrofits ▪ Enable **national or island wide** building green codes ▪ Close the loop with **audit, measurement, and mandatory reporting** and tighten enforcement	▪ Singapore	◕
	District cooling	▪ No district cooling in place currently. Local AC systems	▪ Build **public-private partnerships** for a district cooling system for high density building clusters and multi-function buildings	▪ UAE	◑
	MEPS for appliances	▪ MEPS and labelling only for ACs and compact fluorescent lamp (CFL). Standards exist but lower than international best practices and SEA peers	▪ **Expand scope** to other appliances such as refrigerators, washing machines, and television ▪ Raise MEPS to **international best practice standards**	▪ Taiwan	◕
	Efficient lighting	▪ ADLIGHT program conceived in Sep 2020 to build local manuf. capacity for efficient LED lighting and strengthen awareness. No implementation plan	▪ Build **strong implementation plan** including, audit, measure, improve initiatives	▪ India – UJALA initiative ▪ San Diego	◕
Industry	**Industrial and commercial efficiency plan**	▪ Mandatory energy eff. Plan covers commercial/ industrial entities consuming > 4000 toe. Reporting on EM programs ~40%	▪ Institute **mandatory targets and audits** combined with **market-based incentives** such as tradeable certificates for large energy intensive industries and large commercial entities	▪ India – PAT (Perform, achieve, trade) program	◔
Transport	**Fuel and vehicle efficiency standards**	▪ No fuel standards in place ▪ Limited vehicle efficiency standards	▪ Introduce **fuel standards** ▪ Upgrade **vehicle efficiency standards**	▪ Singapore ▪ Thailand ▪ Vietnam	◑
	Electric public transport	Presidential regulation to drive EV adoption and build a local EV and EV component industry. ▪ Initial notable adoption by taxis and public buses esp. in dense cities like Bali, Jakarta ▪ Target share of EV output to reach 20% of total car production by 2025. ▪ PLN target to have >7000 EV charging stations by 2030, actual requirement projected >30,000 by 2026 ▪ No national roadmap and no progress measurement plan to link EV adoption with system value outcomes.	▪ Build **strong national implementation plan** for EVs including public and private transport with mechanisms to measure progress , improve and collaborate regionally ▪ Roll –out and integrate national electric bus networks with electric light rails (potentially) ▪ Promote modal **shift to mass public transport**	▪ Norway ▪ China	◑