# SEA Stakeholder Meeting of Master Plan for Energy Transition Management Project in Indonesia

9th Apr, 2026

Japan International Cooperation Agency (JICA)

and

JERA Co., Inc. (JERA)

TEPCO Power Grid, Inc. (TEPCO PG)

Tokyo Electric Power Services Co., Ltd (TEPSCO)

Mitsubishi Research Institute (MRI)

# Overview of Master Plan for Energy Transition Management Project in Indonesia

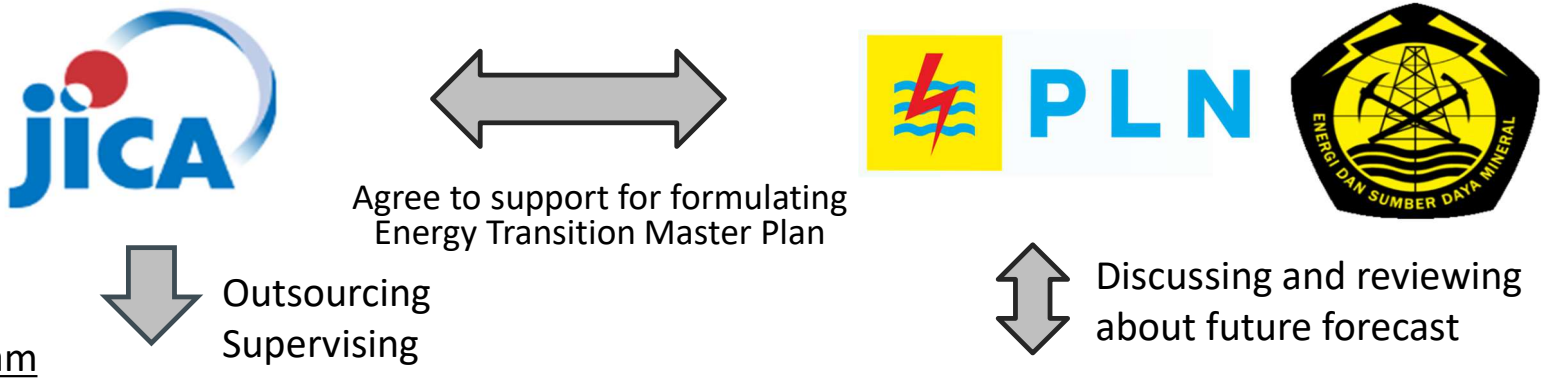
Soichiro Niwa, Project Leader

JERA Co., Inc.

# Project Structure



| | |
|---|---|
| **CNRM Strategy** | Suggest the appropriate solution toward decarbonization of power sector considering countries' situation, and explore opportunities of energy transition project through development of the CNRM/MP with local partners. |
| **Project Mission** | To contribute to the realization of **a stable, affordable and sustainable** power supply for achieving carbon neutrality by 2060 in Indonesia by supporting the formulation of the master plan for energy transition and capacity building of the Indonesian officials. |



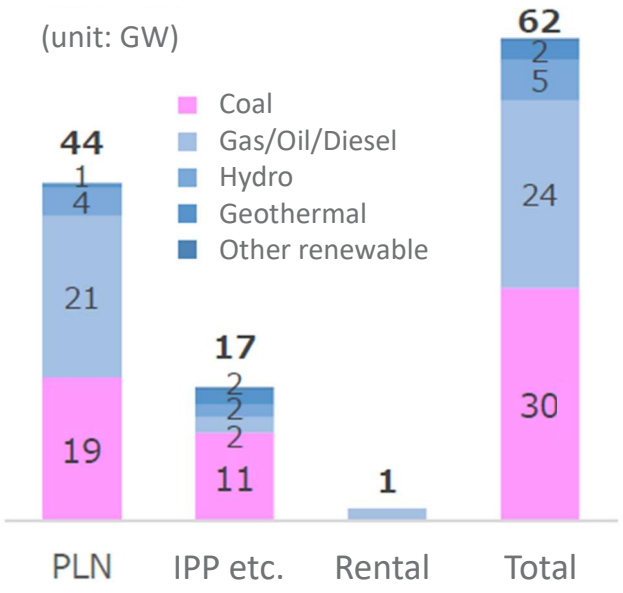

JICA Project Team

- JERA Co., Inc. (Lead): Decarbonization Thermal (Ammonia, Hydrogen, CCS) etc.
- TEPCO Power Grid, Inc. : Grid System Plan, Grid Operation etc.
- Tokyo Electric Power Service Co., Ltd : Grid Analysis, Renewable etc.
- Mitsubishi Research Institute : Demand forecast, Donor cooperation etc.

# Challenges of Power System Decarbonization in Indonesia



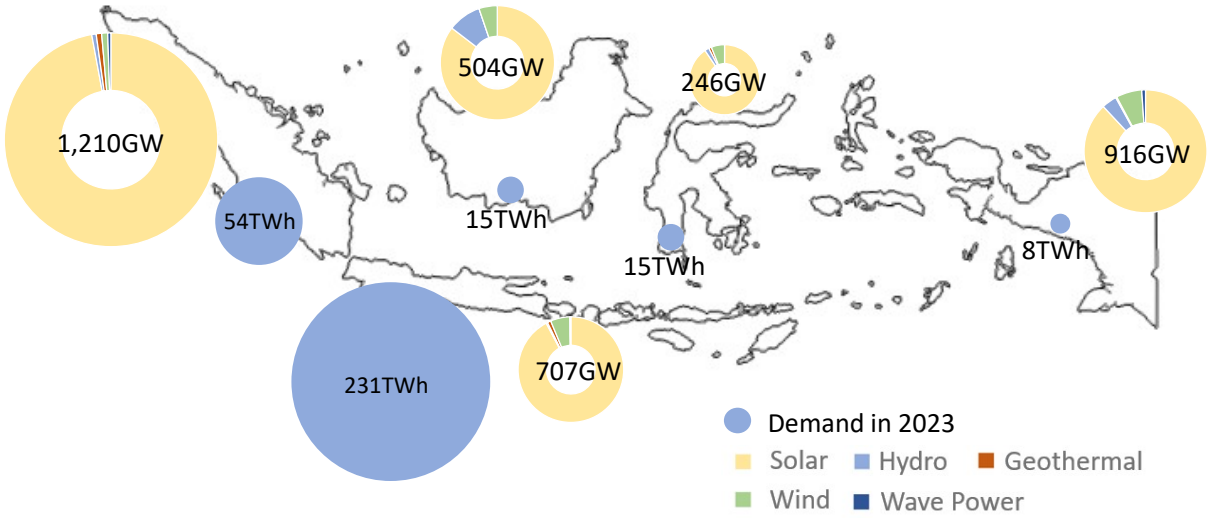
- ✓ Fossil fuels account for the majority of current power supply types
- ✓ Output of Variable Renewable Energy (solar and wind) fluctuates greatly depending on weather conditions
- ✓ About 70% of electricity demand is concentrated in the Java system, which accounts for only about 7% of the total land area. On the other hand, solar power, which is considered to be the most promising renewable energy resource, is more abundant in the larger islands of Sumatra and Kalimantan.




Composition of existing power supply facilities (2020)

Reference: RUPTL 2021-2030

Renewable energy potential and uneven demand

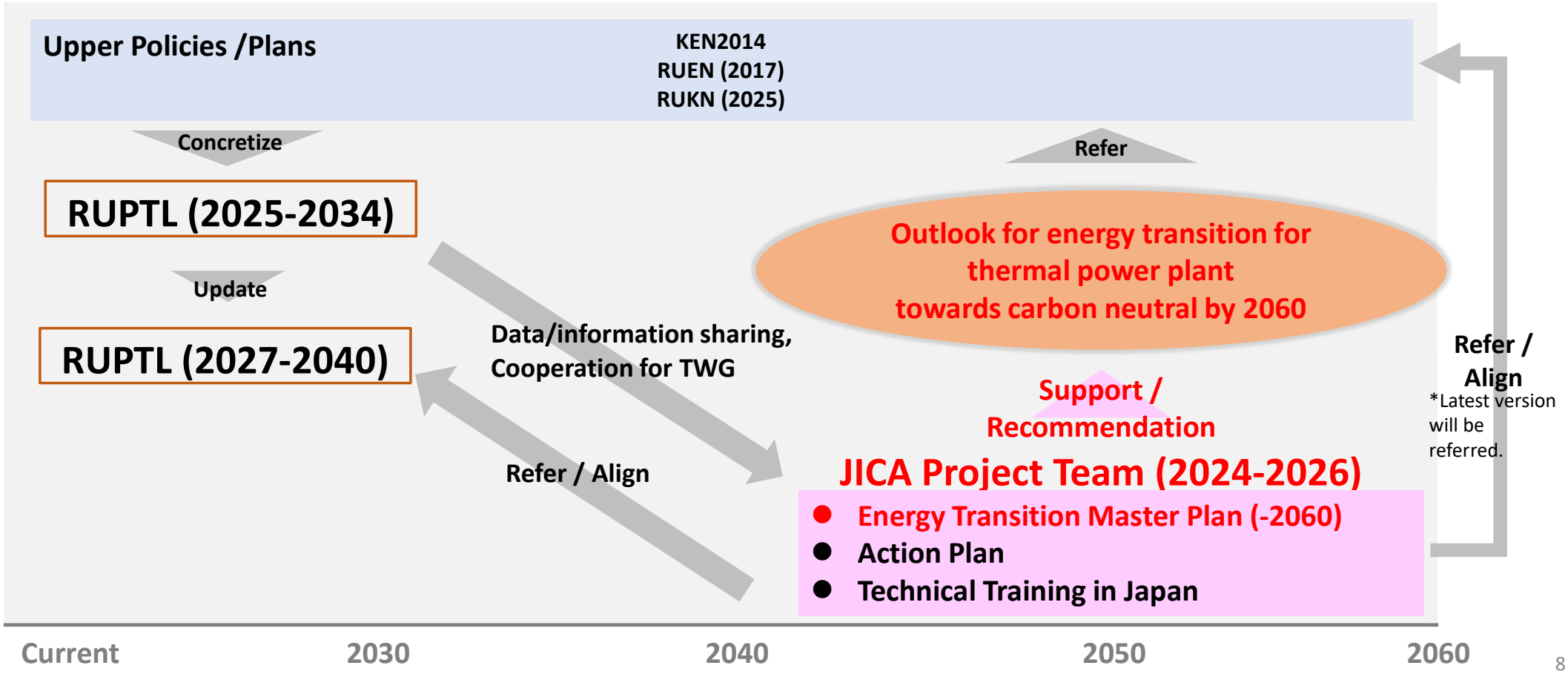



Reference: JICA Project Team created from data in RUKN2025, Wood Mackenzie

# Relationship between Existing Plans of Power Sector and this Project



✓ The master plan we create aligns with the plan that is authorized by Indonesia side



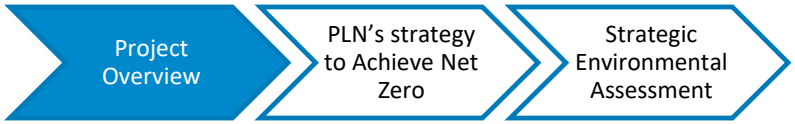
# Purpose of the Project



To contribute to the realization of a stable, affordable and sustainable power supply for achieving carbon neutrality by 2060 in Indonesia, by supporting the formulation of the master plan for energy transition and capacity building of the Indonesian officials.

| Review the carbon-neutral roadmap by 2060 | Develop electricity demand forecast & power development plan | Formulate a master plan for decarbonising thermal power plant | Create an action plan to implement the master plan | Enhance PLN's knowledge and capacity to applying decarbonization technologies for thermal power plant |
|---|---|---|---|---|

# Overall Schedule



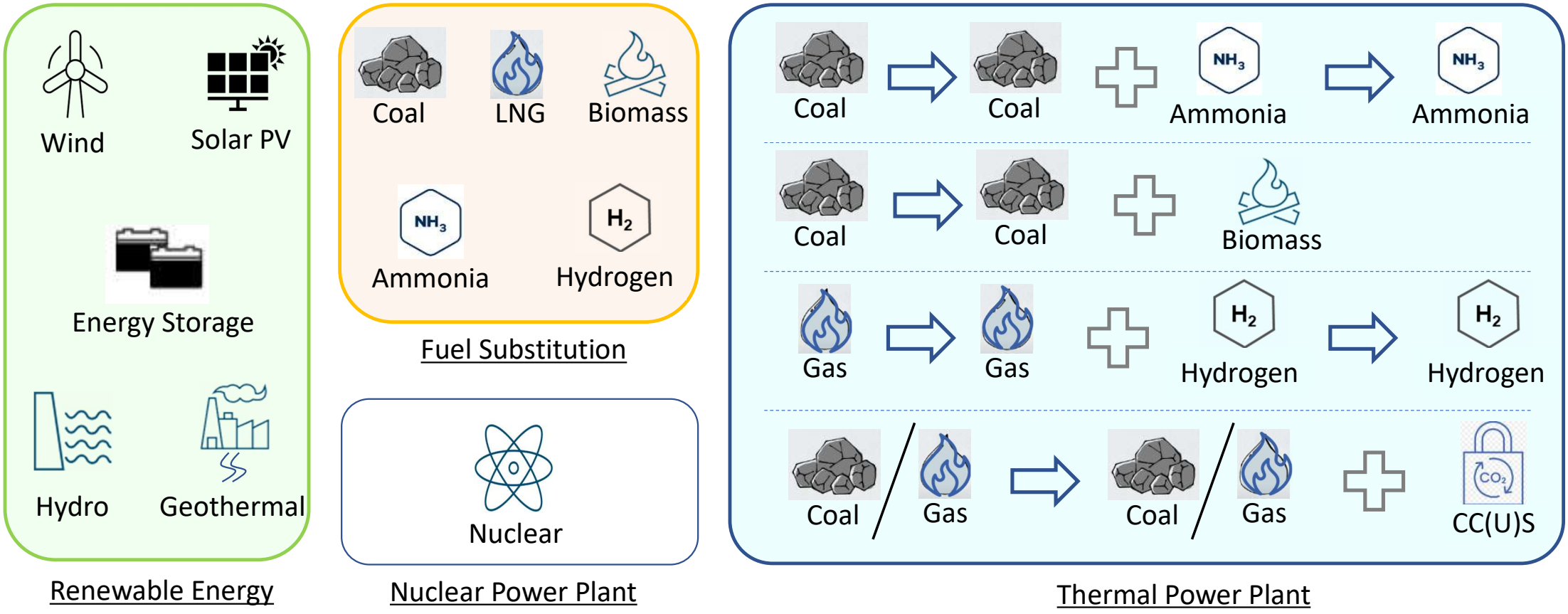

| Items \ Term | 2024 | | | | | | 2025 | | | | | | 2026 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 3 | 5 | 7 | 9 | 11 | 1 | 3 | 5 | 7 | 9 | 11 | 1 | 3 | 5 | 7 | 9 | 11 |
| 1. Review the carbon-neutral roadmap by 2060 | | | | | | | | | | | | | | | | | | |
| 2. Formulate electricity demand forecast and power development plan | | | | | | | | | | | | | | | | | | |
| 3. Formulate a master plan for decarbonization | | | | | | | | | | | | | | | | | | |
| 4. Formulate action plan for implementing the master plan | | | | | | | | | | | | | | | | | | |
| 5. Capacity Building | Technical Training Program in Japan for management staff | | | | | | Technical Training Program in Japan for working staff | | | | | | | | | | | |
| JCC (Joint Coordination Committee) | | | | | | 1st JCC | | | | | | | 2nd JCC | | | | | |
| Public seminar/ SEA stakeholder meeting | | | 1st Public seminar /SEA SHM | | | | | | | | | | 2nd SEA SHM | | 2nd Public seminar | | | |
| Reporting to JICA | | | | | | | Interim report | | | | | | Draft final report | | | Final report | | |

Bule: Work plan in Japan  Red: Work plan in Indonesia

## Assumption Setting – Decarbonization Technologies



✓ Kinds of decarbonization technologies are categorized as follows. In the Project, we will focus on the analysis of **Renewable energy** and **Decarbonization technologies for Thermal power plants through Fuel Substitution and introducing CC(U)S**



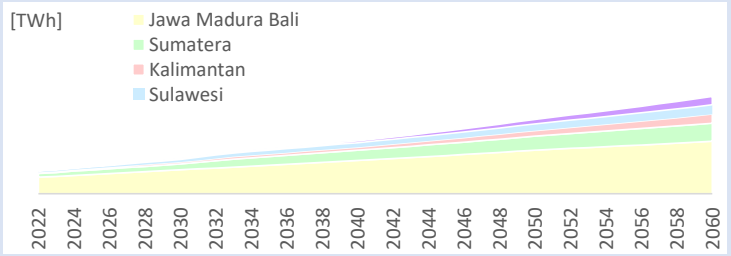
# Assumption Setting - Overview

Project Overview → Simulation Assumption Setting → Simulation Result

- ✓ Simulation software (PLEXOS) is used to explore power generation configuration minimizing total cost
- ✓ The goal of achieving carbon neutrality is set for 2060, in line with Indonesia's target
- ✓ Evaluation period is 2035-2060 (refer to RUPTL until 2034)

## Demand Forecast

✓ Electricity demand, load curves




## Nuclear

✓ Specifications ・Costs

✓ Development Speed/ introduction caps

## Interconnection lines

✓ Specifications ・Costs

## CCS

✓ Specifications ・Costs

✓ Capacity limits by CO2 storage limits

✓ Removal rate

## Carbon credit/offset

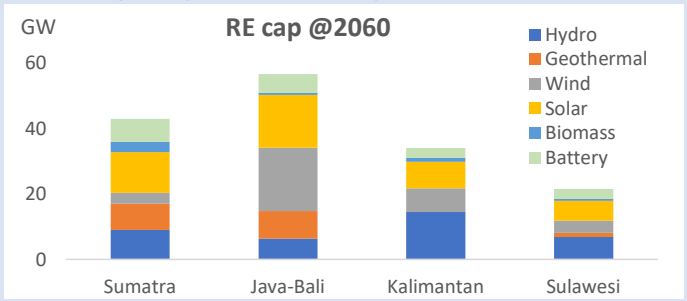
✓ Prices

## Renewable energy

✓ RE introduction caps

✓ Specifications ・Costs

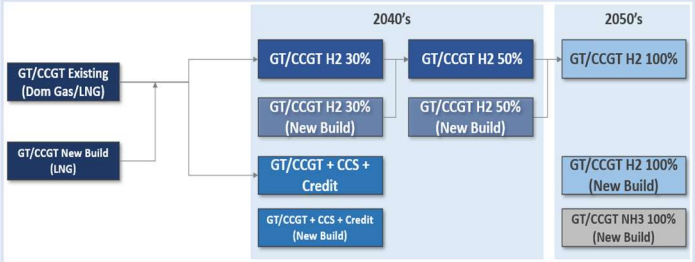
✓ RE capacity factor (hourly)




## Thermal Power

✓ Decarbonization patterns

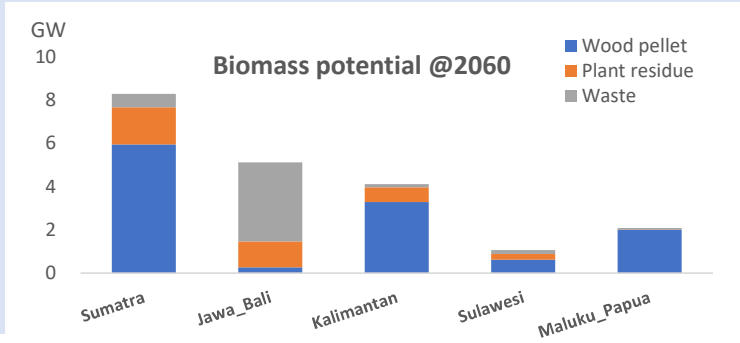
✓ Specifications ・Costs




## Biomass

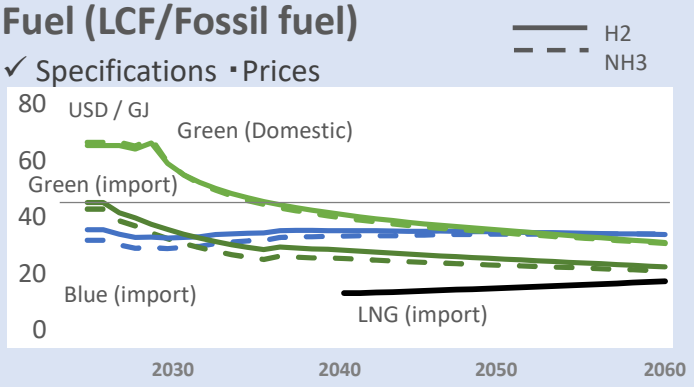
✓ Offtake limits

✓ Specifications ・Costs




## Fuel (LCF/Fossil fuel)

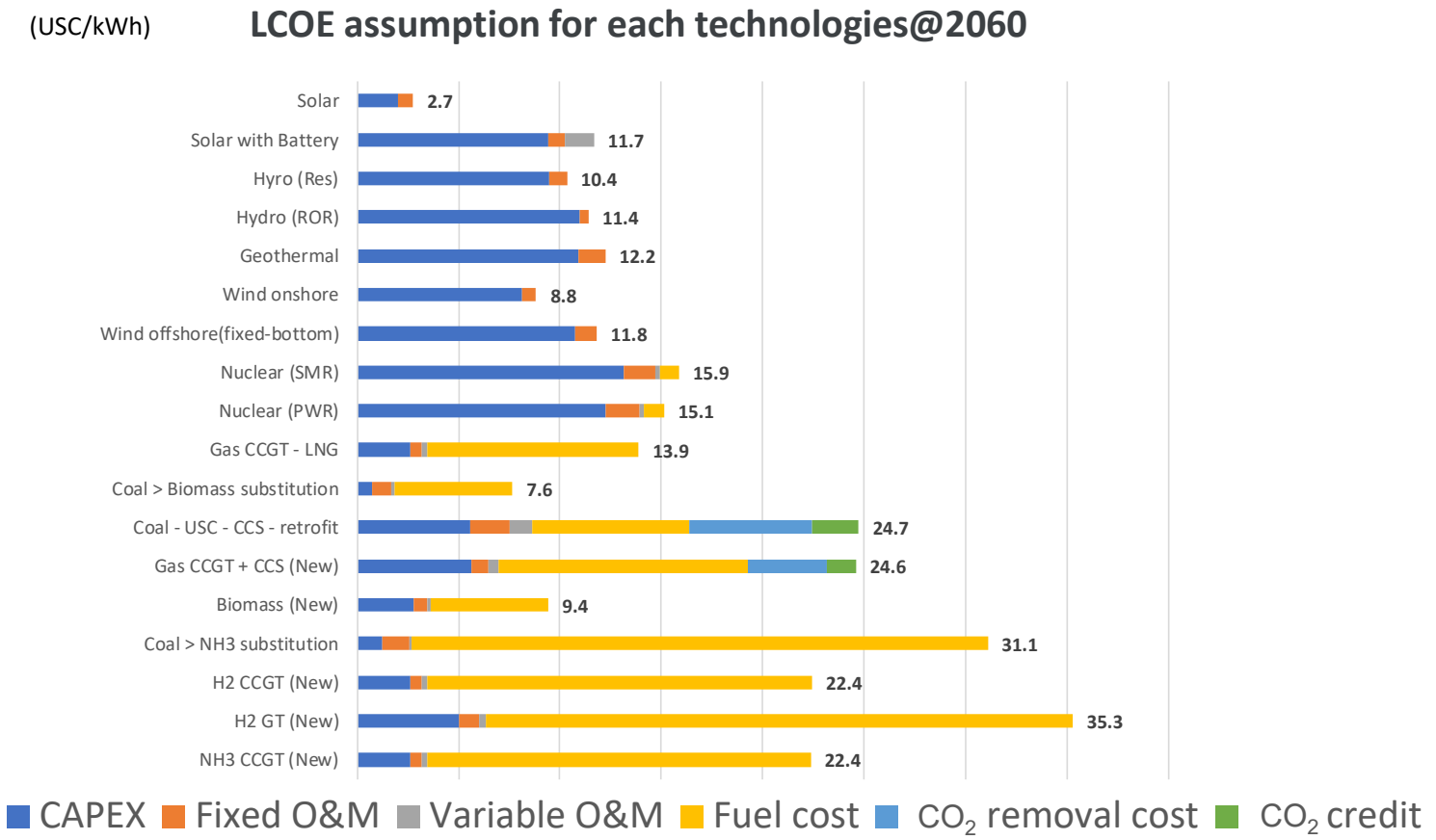
✓ Specifications ・Prices



# Assumption Setting – LCOE Comparison



- ✓ Developed Levelized Cost of Electricity (LCOE) for each decarbonized technology to determine the optimal power generation configuration
- ✓ Gathered necessary information from the latest decarbonization projects around the world



# Assumption Setting – Concept of Scenario Setting


✓ To compare the capacity mix, system LCOE and transition pathway under the different situation of demand growth and RE introduction limitation, 3 scenarios are prepared with different assumptions.

**Green**

**Aligned with Indonesia's nation vision(MEMR's vision)**

✓ Issues related to large-scale RE deployment are resolved, enabling power generation using abundant renewable potential.

**Base**

**PLN's decarbonization scenario as a state-owned utility(PLN's vision)**

✓ Decarbonization is achieved only within the PLN grid, which accounts for about 70% of national electricity supply. $CO_2$ emissions are expected to peak and start to decline in 2040, in line with PLN's vision.

**RE Conservative**

**Challenges in renewable energy deployment remain**

✓ Although $CO_2$ emissions are expected to peak and decline around 2040, fossil fuel-fired power plants will continue operating in the long term to ensure supply adequacy, with regulations tightening gradually.

**BAU**

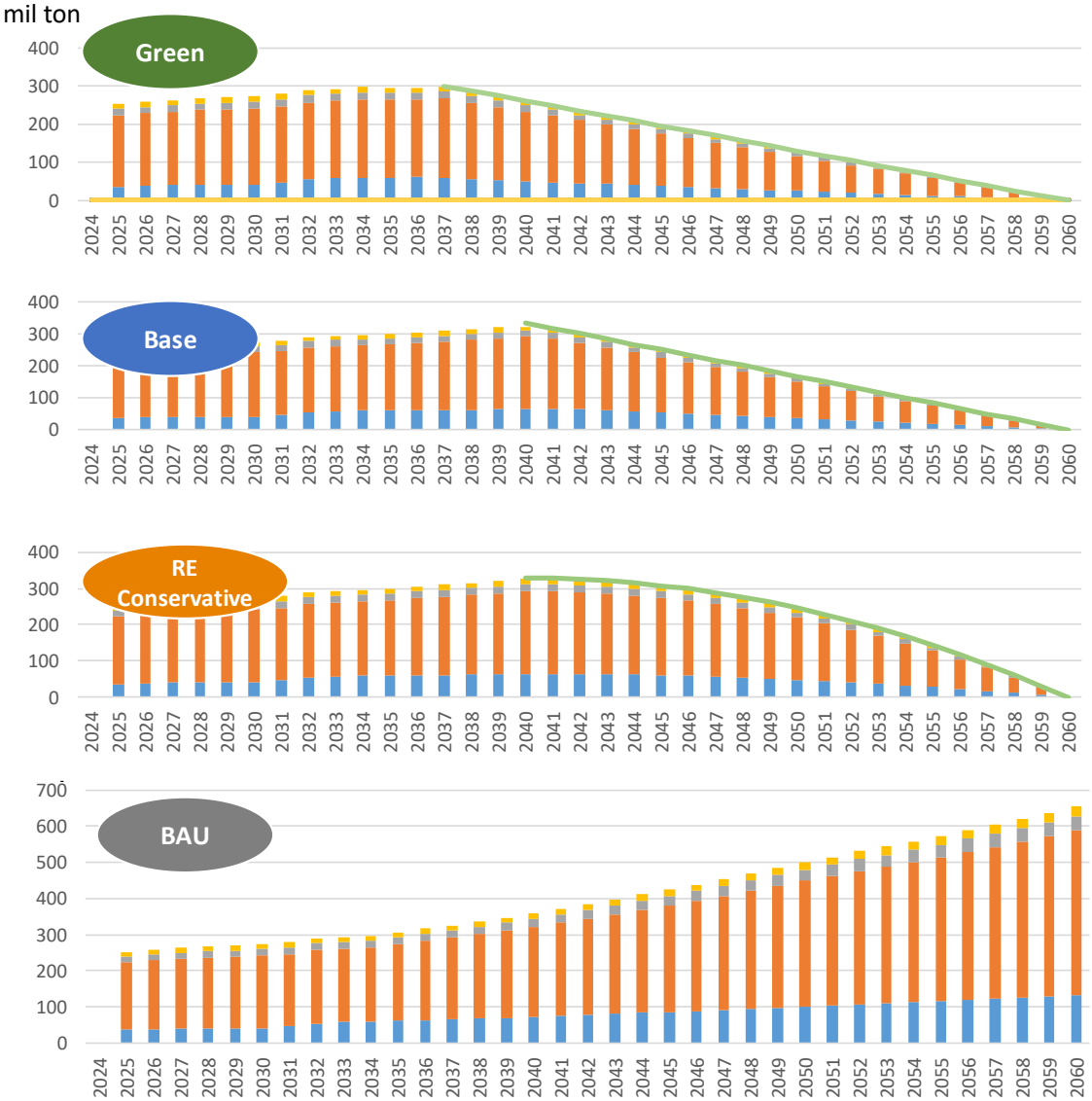
**Business As Usual**

✓ A scenario in which all demand growth after 2025 is met by coal power development

✓ $CO_2$ emissions will continue to increase

# Assumption Setting – $CO_2$ Emission Constraints






- ✓ Four Scenarios were compared and analyzed to examine power development plans in accordance with $CO_2$ emission

a. The Green Scenario peaks earlier but declines more gradually during the transition period.

b. Total $CO_2$ emissions are highest in the Conservative Scenario.

c. The Base Scenario shows an intermediate reduction speed and total emissions among the scenarios.

d. The emission reduction amount from BAU is about 650 mil ton-$CO_2$/year as of 2060.

# Simulation Result - Overview of 4 islands



✓ The following is a breakdown of future power supply trends under the base scenario:

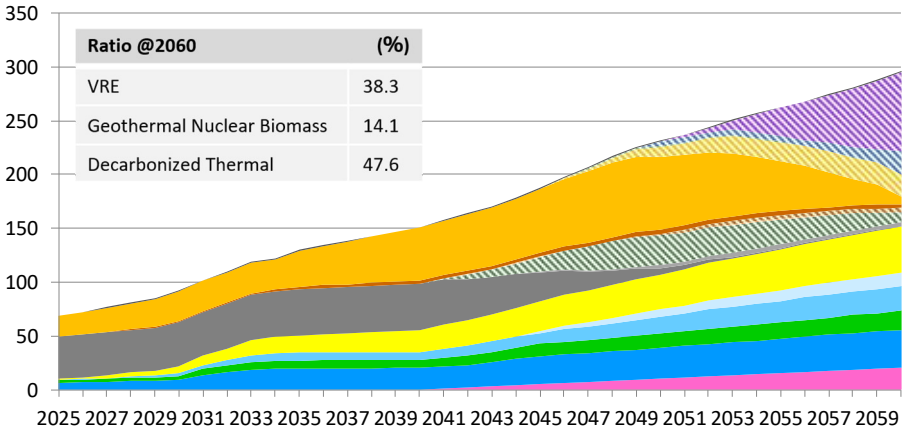
a. Renewable energy should be introduced as much as possible. However, if introduced on a large scale, problems related to system stability may arise.

b. Existing coal-fired power plants will continue to serve as a base load, but it will be converted to biomass/ammonia, or CCS facilities will be installed.

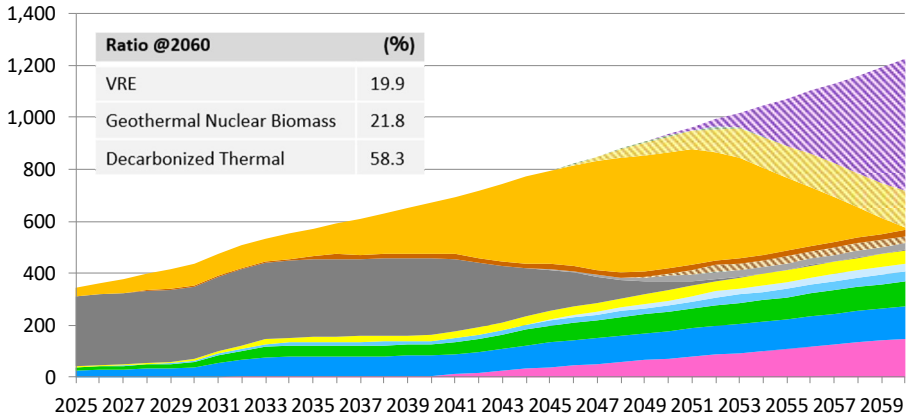
c. Gas and LCF power plants contribute to grid stability by leveraging their operational flexibility.

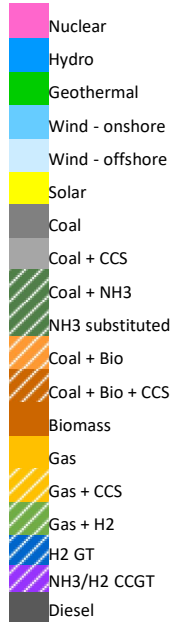
✓ In the power development plan, it is necessary to consider various aspects, including not only technology but also financial, regulatory and social acceptance.

**Installed Capacity（GW）**




**Generation（TWh）**

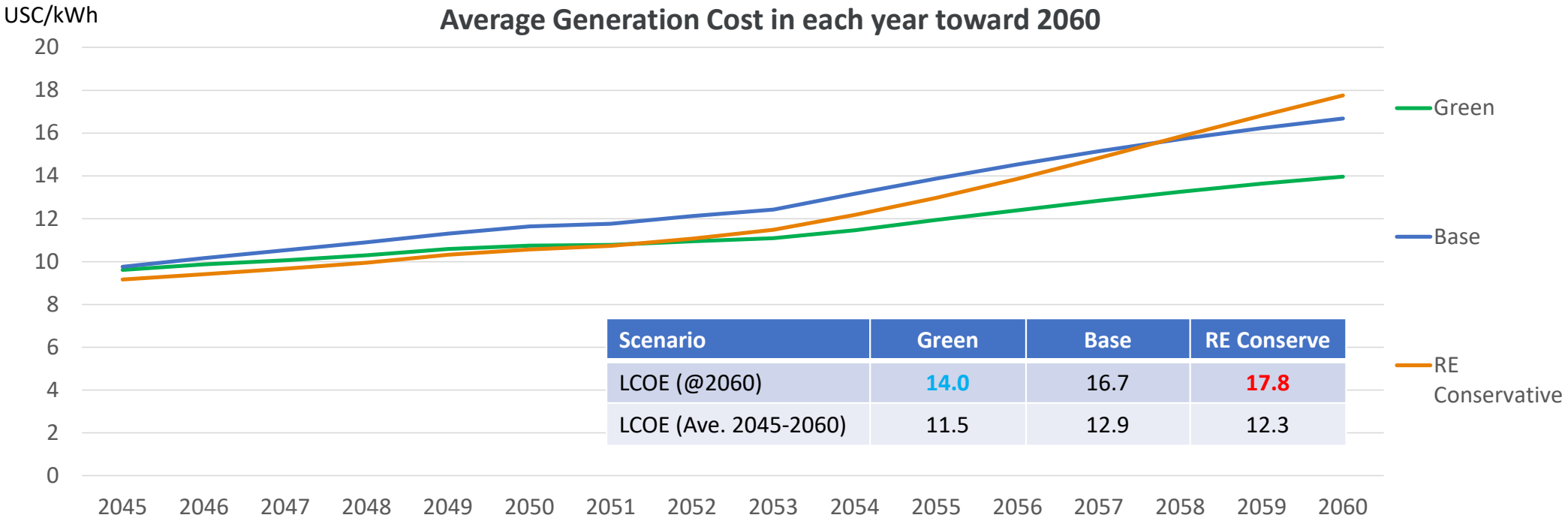


# Simulation Result - Comparison between Scenarios (Generation cost)



- ✓ In each scenario, costs increase as $CO_2$ emissions are reduced, and achieving decarbonization needs much cost.
- ✓ In the Conservative Scenario, the LCOE remains lower than the Base Scenario until the early 2050s but subsequently it exceeds Base Scenario by 2060.
- ✓ When considering the various constraints and challenges regarding power development, the Base Scenario is the most feasible.
- ✓ Meanwhile, initiative to address issues arising from renewable energy development and move toward a “Green Scenario” is an important measure, that contributes to cost reduction.




| Scenario | Green | Base | RE Conserve |
|---|---|---|---|
| LCOE (@2060) | 14.0 | 16.7 | 17.8 |
| LCOE (Ave. 2045-2060) | 11.5 | 12.9 | 12.3 |

# Strategic Environmental Assessment for Power Source Development

Eiichi Kato and Natsumi Takahashi,
Expert of SEA
Tokyo Electric Power Service Co., Ltd.

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# 1. Overview of the Strategic Environmental Assessment (SEA)

Objective of SEA

- ✓ The objective of SEA is to avoid or reduce significant environmental impacts in the early planning stage.
- ✓ Significant environmental impact is the case that the loss or degradation of conservation targets cannot be avoided based on the project and regional characteristics.

In other words;

(1) Case the impact can be avoided or reduced by taking environmental conservation measures.

(2) Case the impact is reversible, short-term, or limited.

Guideline* defines Cases (1) and (2) are not considered to pose a risk of significant impact.

*Guideline on Environmental Impact Assessment of Power Plants (Ministry of Economy, Trade and Industry, Japan)

# 1. Overview of the Strategic Environmental Assessment (SEA)

## Institutional Framework of Indonesia and Requirements by JICA Guidelines

✓ Institutional Framework of Indonesia

The Law on Environmental Protection and Management (EPMA No. 32/2009) covers the initial stages of project planning to post-closure, including SEA, project environmental impact assessment (EIA).

Government Regulation No. 46/2016 stipulates the procedure of SEA.

✓ Positioning SEA in Indonesia

SEA is the basis for decision-making on policies, plans, and programs.

SEA is coordinated, complementary, and reciprocal with spatial plans, other laws and regulations and so on.

✓ Requirements by JICA Guidelines

In conducting Master Plan studies and other relevant activities, JICA encourages project proponents to incorporate environmental and social considerations from the earliest stages through to the monitoring phase.

# 1. Overview of the Strategic Environmental Assessment (SEA)

## Institutional Framework of Indonesia and Requirements by JICA Guidelines

✓ The necessity of conducting SEA

In Indonesia, SEA is required in policies, plans formulated by the national and local governments.

This study aims to formulate the master plan concerning future power development.

It is important to incorporate environmental and social considerations in the early planning stage when advancing future power development.

Based on Indonesia's laws/regulations and JICA guidelines, SEA has been conducted.

# 1. Overview of the Strategic Environmental Assessment (SEA)

## Methodology of SEA Applied in This Study

✓ The workflow of SEA

The work for SEA is composed of the following four steps.

Step-1: Collecting information based on desk research
Step-2: Screening
Step-3: Scoping
Step-4: Prediction and Evaluation

# 1. Overview of the Strategic Environmental Assessment (SEA)

Methodology of SEA Applied in This Study

**STEP-1: Collecting information based on desk research**

Information for the case study should be collected through desk research. Attention should be paid to information on the distribution of the affected objects, especially the situation of vulnerable environments.

**STEP-2: Screening**

It is necessary to clarify the relationship between the following areas and the project site. Depending on the situation, the feasibility of the project will be considerably low.

(1) Restricted area under international treaties, laws, or regulations;

(2) Restricted area due to the presence of airports, military facilities, or other critical infrastructure;

(3) In case the proposed project area overlaps with designated areas of special social value, such as ethnic minorities or indigenous peoples

# 1. Overview of the Strategic Environmental Assessment (SEA)

Methodology of SEA Applied in This Study

**STEP-3: Scoping**

Scoping for each power development depends on the project characteristics. Construction work is expected to have an impact on the surrounding environment due to exhaust gas, noise from the operation of heavy machinery, and water pollution from excavation work and other activities. In addition, these impacts will vary depending on the construction scale and surrounding land use.

**STEP-4: Prediction and evaluation**

"Predicting" in the early planning stage will not involve analysis based on field survey or detailed simulation studies. But it will attempt to evaluate the project as quantitatively as possible.

Prediction methods are matrix, overlay, case study comparisons, and other methods based on literature sources.

The avoidance or reduction of significant environmental impacts is considered based on comparisons with evaluation indicators and multiple alternative proposals.

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# 2. Power Development based on Scenarios in This Study

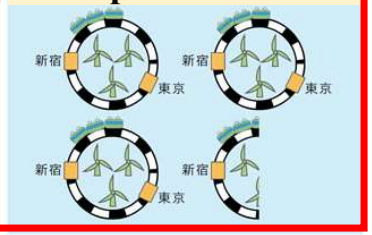
## Scenario Planning

- ✓ The core of energy policy is based on 3E+S: Energy Security, Economic Efficiency, Environment, Safety. This policy becomes the principle of stable power supply.
- ✓ By referencing General National Electricity Plan(RUKN) and other relevant documents, JICA project team projected scenarios for future power sources based on economic growth trends, electricity demand, electricity costs, etc.
- ✓ Rapid, large-scale deployment of renewable energy raises land acquisition issues and environmental concerns. It is more realistic to develop power sources in line with the progress of decarbonization technology.

**Required site area for 1000MW Thermal power (1 year operation)1 km2**

**Solar power 58km2**


**Wind power 214km2**




(Source: JICA Project Team)

Assumptions setting → Capacity planning simulation → Scenario setting → Scenario analysis

<Assuming Multiple Scenarios for Renewable Energy Adoption>

_ **Green scenario** (Aggressive renewable energy deployment scenario)：351GW

_ **Base scenario** (Scenario aligned with advancements in decarbonization technologies)：177GW

_ **RE Conservative scenario**：128GW

- Electricity Demand
- Fuel Prices and Constraints
- Power Generation Facility Costs
- CO2 Emissions and Storage Constraints
- Nuclear Power Introduction Restrictions etc.

Scenario Planning Process

- Grid Planning and Operation Challenges
- Decarbonization Technology Challenges
- Energy Security Challenges
- **Challenges from Environmental and Social Considerations Perspectives**

# 2. Power Development based on Scenarios in This Study

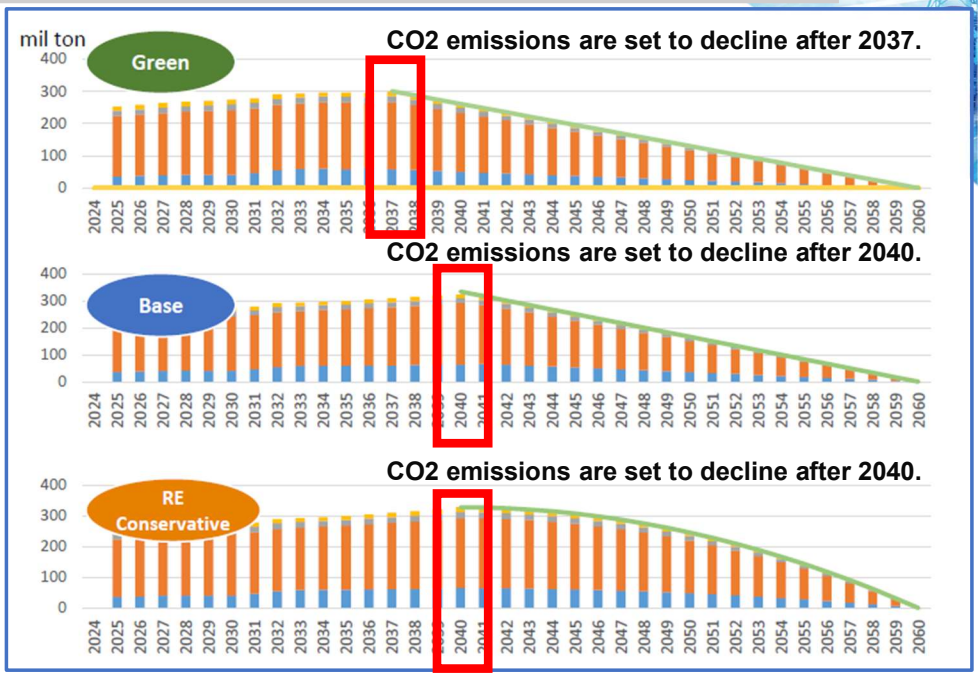
## Scenario Comparison

**Green Scenario** offers faster CO2 reduction; however, it requires extensive land use, which poses potential environmental risks.

Therefore, **Base Scenario**, aligned with advancements in decarbonization technologies, is more appropriate.

| Item | Green scenario | Base scenario | RE Conservative scenario |
|---|---|---|---|
| **Required site area (km2)** | | | |
| Thermal Power Plants (Fuel Substitution & CCS) | 28 | 29 | 29 |
| Hydroelectric Power Plants | 6,280 | 3,500 | 2,200 |
| Solar Photovoltaic Power Plants | 2,670 | 645 | 360 |
| Wind Power Plants | 3,940 | 3,500 | 2,300 |
| Geothermal Power Plants | 1,044 | 720 | 480 |
| Nuclear Power Plants | 21 | 21 | 21 |
| **Comparison of required site area (km2)** | **13,983** | **8,415** | **5,390** |
| **CO2 emission amount [2037-2060] (million ton)** | **3,590** | **4,430** | **5,485** |

Note; Thermal power:1(km2), Hydro power:100,Solar power:15,Wind power:100,Geothermal power:40,Nuclear power:1 was assumed on a 1000MW power plant basis.




(Source: JICA Project Team)

**Green Scenario needs 1.7 times the area of Base Scenario.**

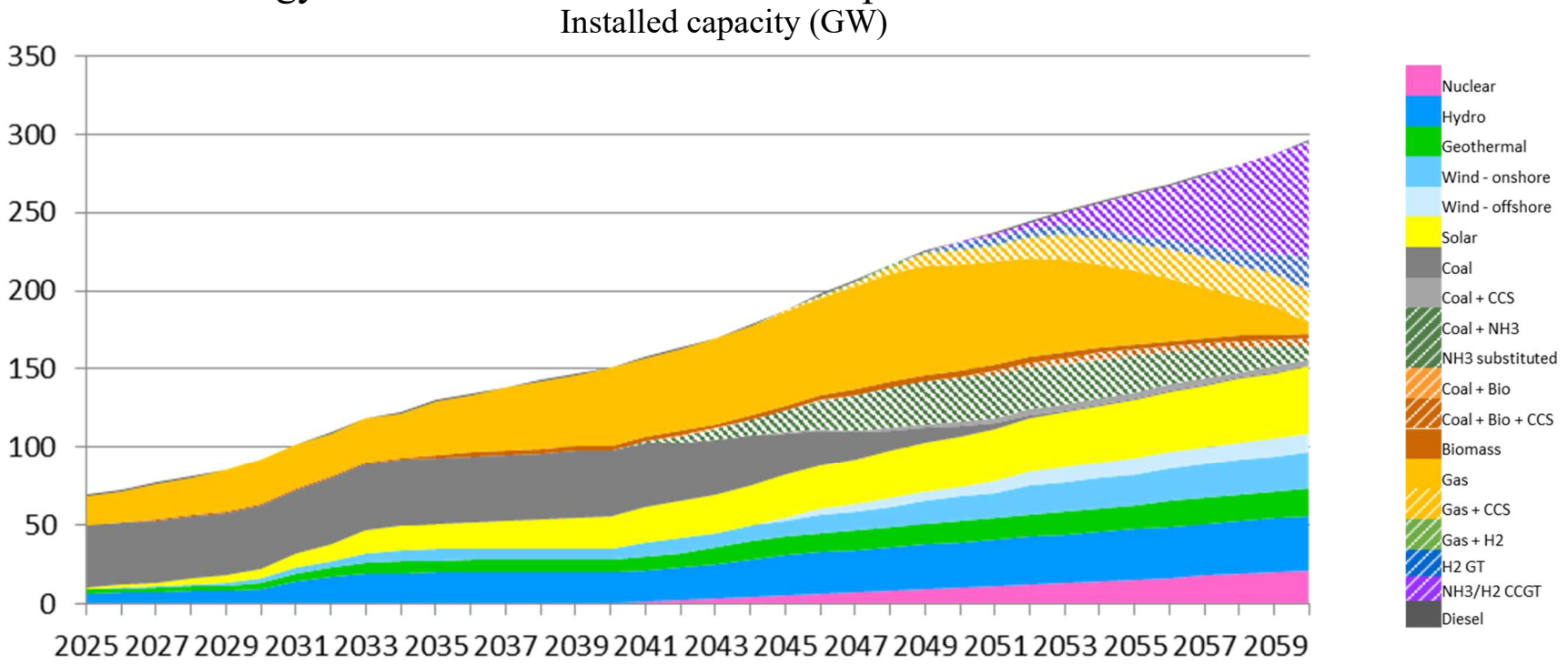
**RE Conservative scenario generates 1.2 times the CO2 emission of Base Scenario.**

Therefore, **Base Scenario** is more appropriate.

# 2. Power Development based on Scenarios in This Study

## Overview of Power Development based on Base scenario

✓ Diversification of power sources will be introduced to achieve net-zero CO2 emissions, including fuel substitution (utilization of low-carbon fuels) , co-located CCS/CCUS facilities in thermal power generation, and renewable energy sources such as solar and wind power.




(Source: JICA Project Team)

# 2. Power Development based on Scenarios in This Study

## The necessity of conducting SEA in This Study

The purpose of SEA is to avoid the loss or degradation of conservation targets caused by direct alterations, that is to avoid significant environmental and social impacts.

For example, suitable sites for hydroelectric power are limited, and there are concerns regarding deforestation and changes to river environments, depending on the scale of development.

Geothermal power is in a similar situation, as suitable sites are highly restricted to specific locations such as mountainous areas.

Wind and solar power may require large areas of land

For these reasons, it is necessary to introduces environmental and social considerations in the early planning stage.

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# 3. SEA in This study

✓ Environmental Factors Affected by the Power Development

| Category | Environmental Item | Thermal (including LCF, Biomass) | | Hydro | | Wind | | Solar photovoltaic | | Geothermal | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Construction | Operation | Construction | Operation | Construction | Operation | Construction | Operation | Construction | Operation |
| Anti-pollution Measures | Air Quality/ Odor | ○ | ○ | ○ | — | ○ | — | ○ | — | ○ | ○ |
| | Water Quality | ○ | ○ | ○ | ○ | ○ | — | ○ | — | ○ | ○ |
| | Soil Contamination/ Sediment pollution | ○ | ○ | ○ | — | ○ | — | ○ | — | ○ | ○ |
| | Noise and Vibration | ○ | ○ | ○ | — | ○ | ○ | ○ | — | ○ | ○ |
| | Waste | ○ | ○ | ○ | ○ | ○ | — | ○ | ○ | ○ | ○ |
| Natural Environment | Protected Areas/ Ecosystem and Biota | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Social Environment | Resettlement, Living and Livelihood, Landscape etc. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Other | Accident | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Transboundary Impacts, and Climate Change | ○ | ○ | ○ | — | ○ | — | ○ | — | ○ | — |

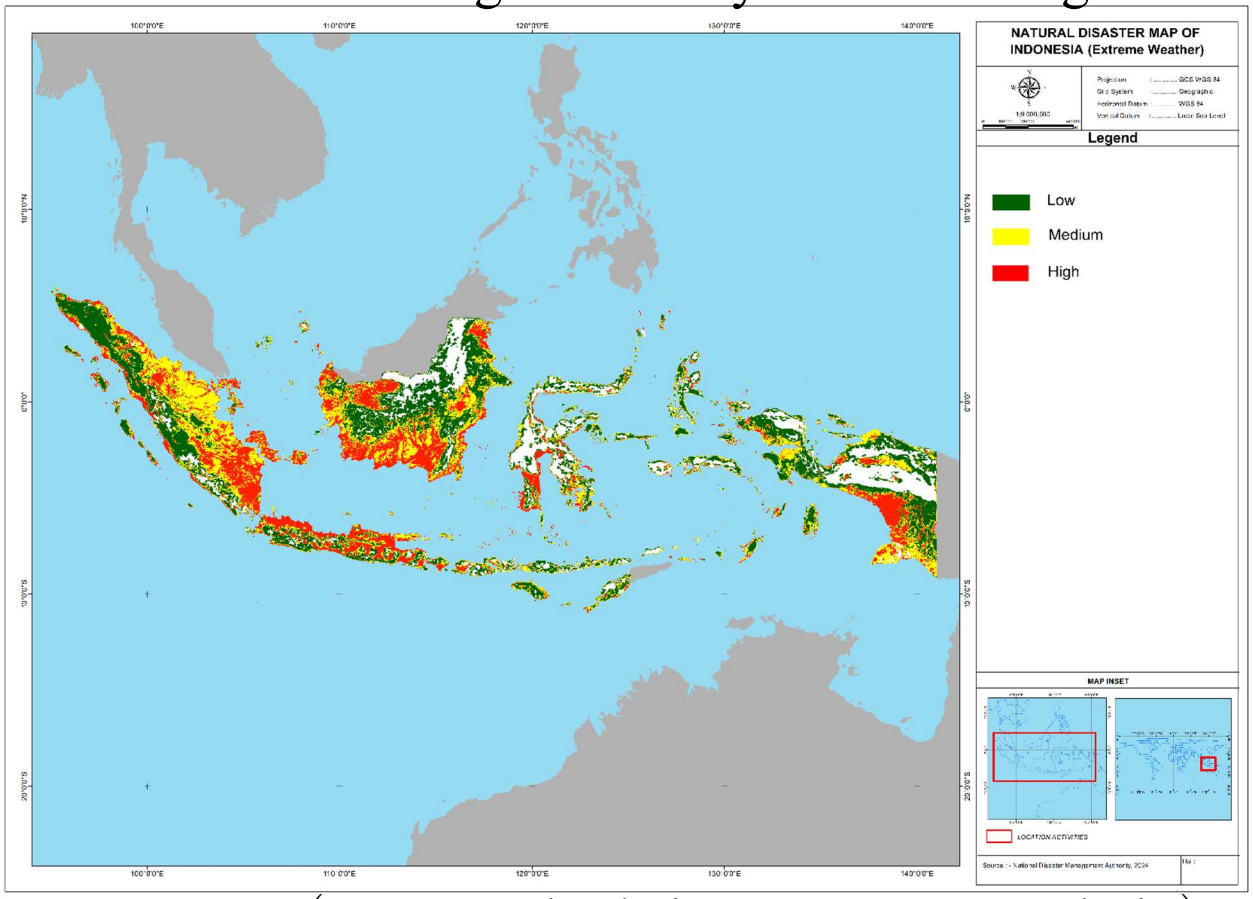
(Source: JICA Project Team)

Note; ○: There is the relationship. —: Not relevant.
Nuclear power plants will be explained later.
From SEA perspective, it is important to consider decommissioning and restoration such as facility removal, the impact on the local economy.

# 3. SEA in This study

## Natural Condition in Indonesia

Some areas in Indonesia are at high risk of hydrometeorological disasters.

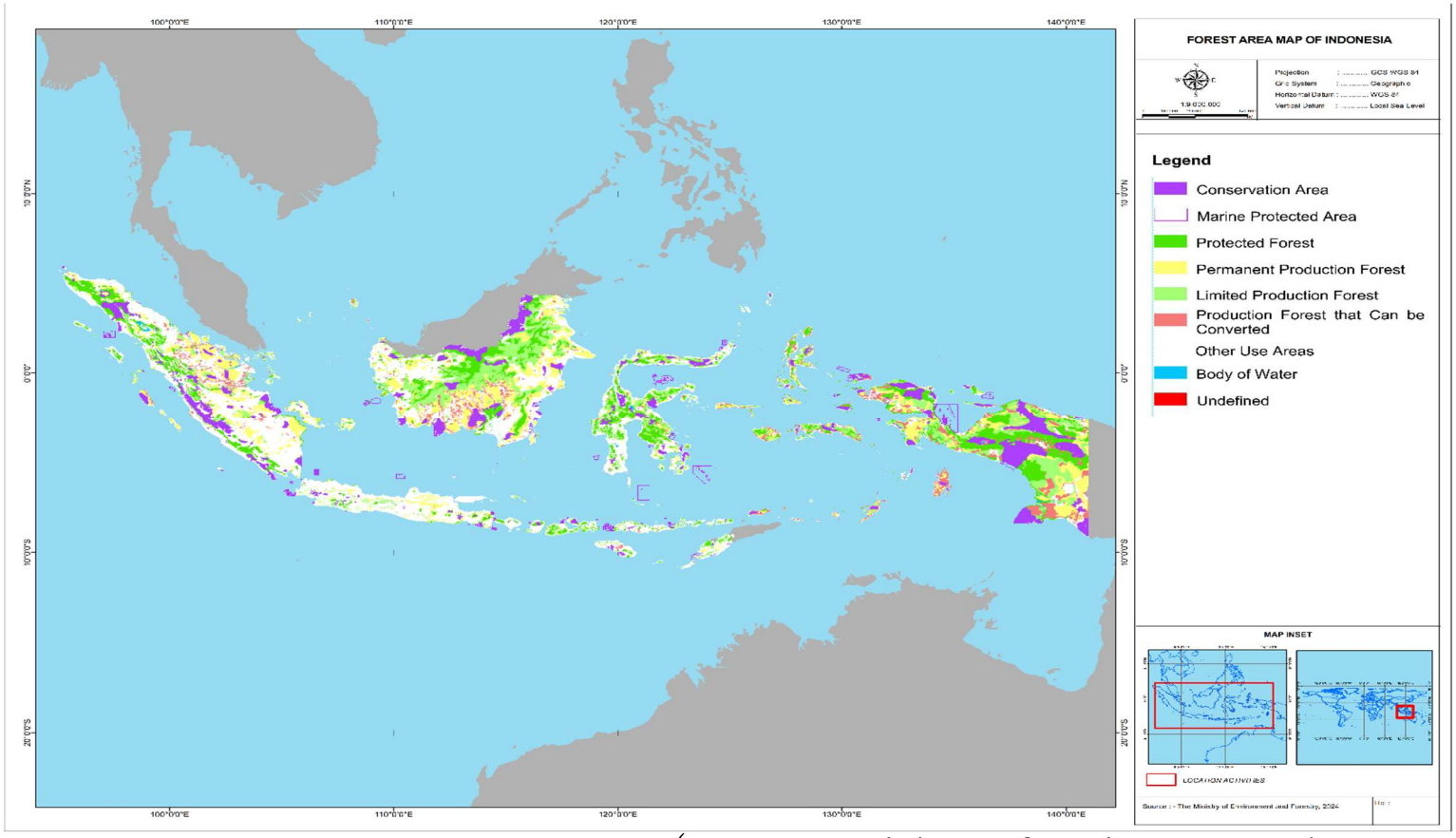



（Source：National Disaster Management Authority）

# 3. SEA in This study

## Natural Condition in Indonesia

Indonesia, rich in natural beauty, has designated numerous protected areas.

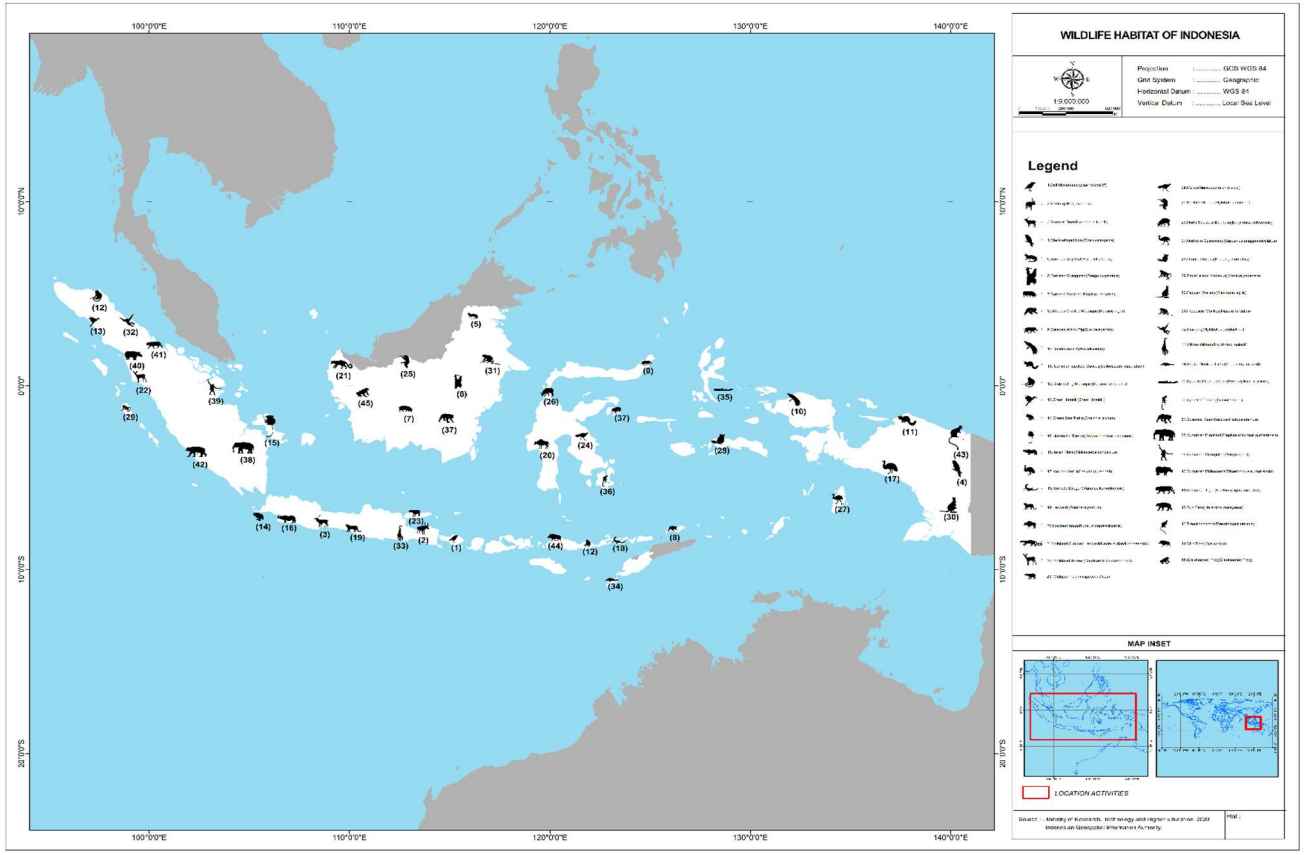



（Source： Ministry of Environment and Forestry）

# 3. SEA in This study

## Natural Condition in Indonesia

Indonesia is rich in natural resources and serves as a habitat for a wide variety of precious wildlife.



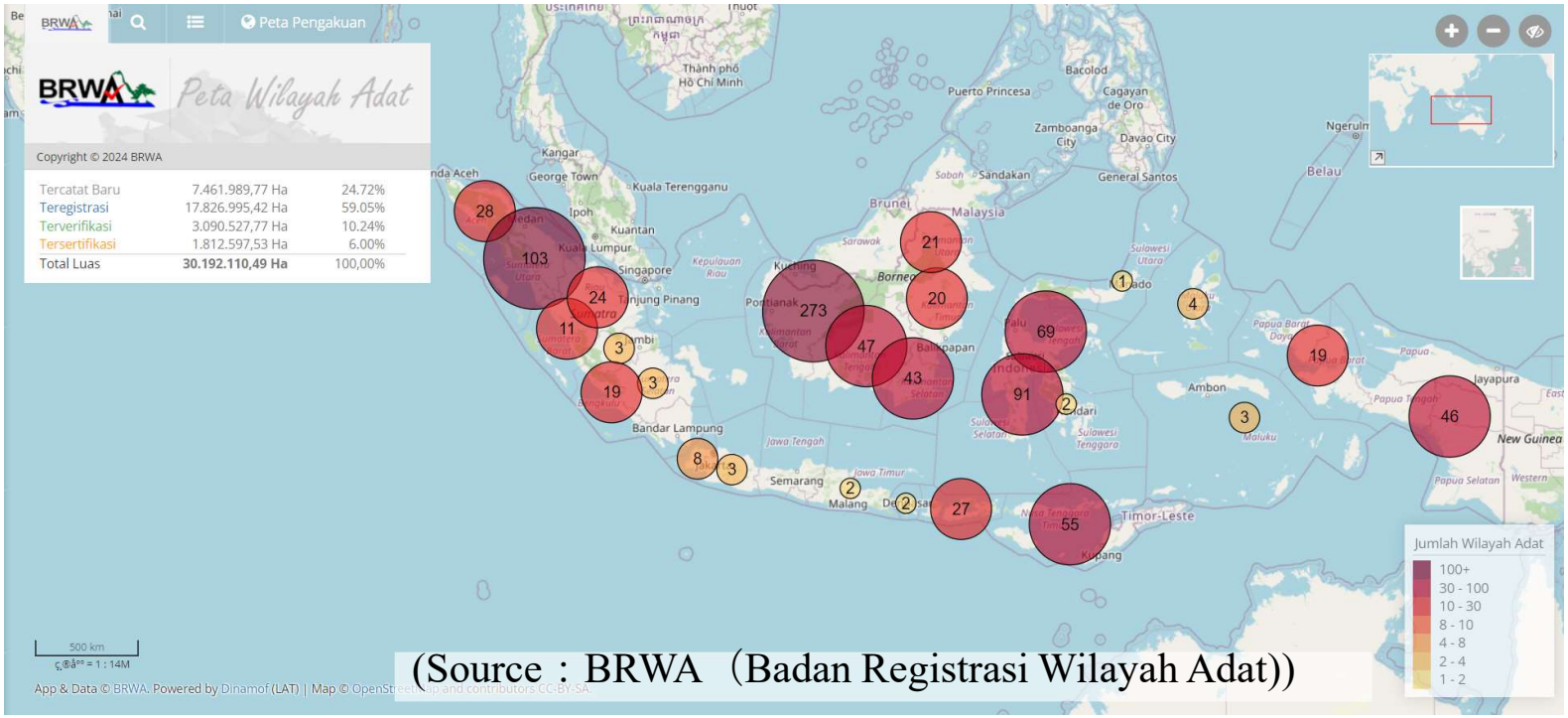

（Source：Ministry of Research, Technology and Higher Education, Indonesian Geospatial Information Authority）

# 3. SEA in This study

## Social Condition in Indonesia

Many indigenous peoples live in Indonesia.

Government has established 131 Customary areas /Traditional regions across 18 provinces and 40 districts (total 244 thousand ha). NGO BRWA registered 1,424 Customary areas /Traditional regions covering as area of 28 million ha.

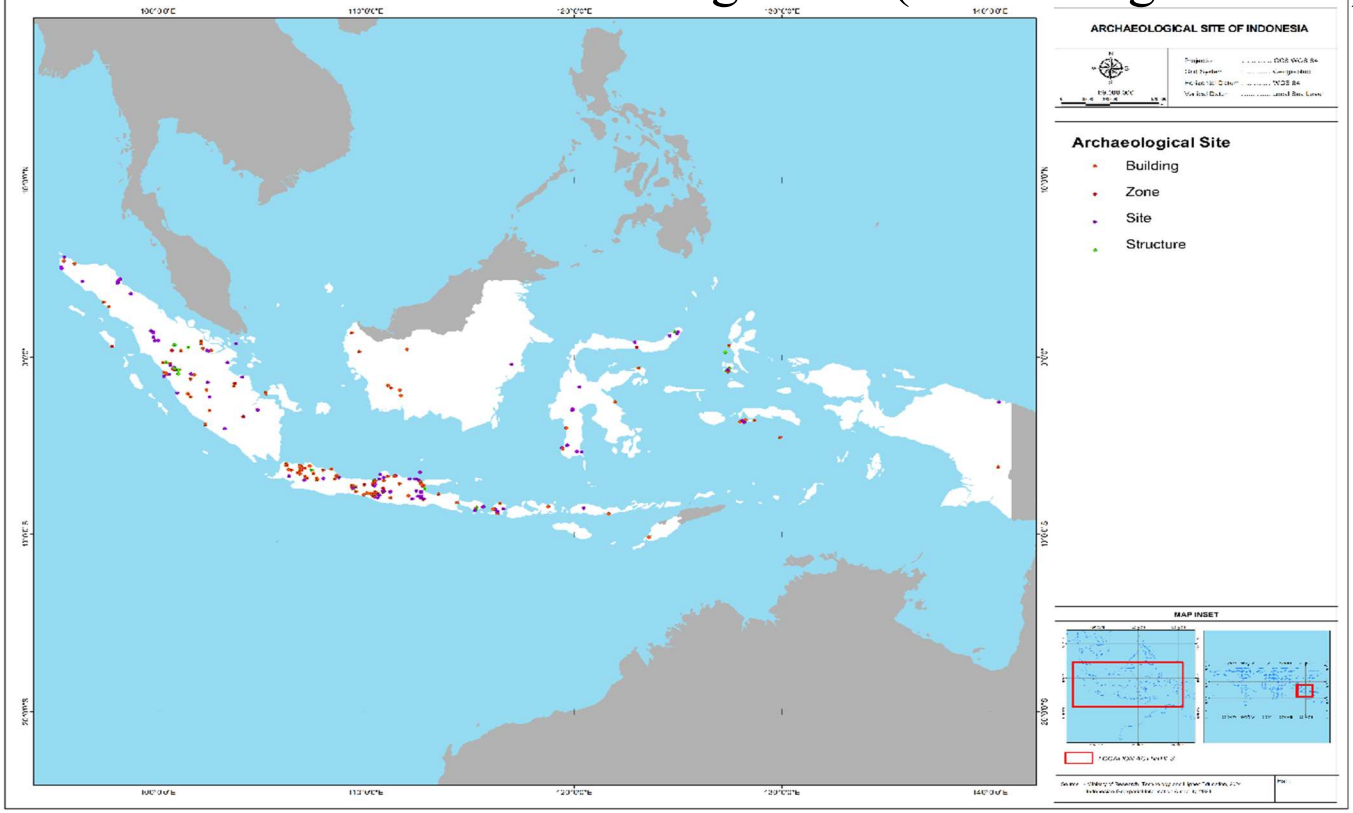



(Source ： BRWA （Badan Registrasi Wilayah Adat))

# 3. SEA in This study

## Social Condition in Indonesia

Diverse ethnic groups have shaped the culture, and Indonesia is dotted with numerous historical and cultural heritage sites (archaeological sites).




（Source：Ministry of Research Technology and Higher Education, Indonesian Geospatial Information Authority）

# 3. SEA in This study

✓ Key future power sources

| Item | Characteristic |
|---|---|
| Thermal power plant | Indonesia can procure natural gas and coal domestically. Thermal power plants provide stable response to power demand but come with CO2 emissions.<br>CO2 emissions are expected to be reduced through fuel substitutions to hydrogen and ammonia, which do not emit CO2, and through the introduction of CCS, but this is a relatively new technology and there are technical issues to be overcome. |
| Hydropower plant | Energy conversion efficiency is high, and management costs are low. On the other hand, the construction work will take a long time and there are concerns about environmental impacts. |
| Solar photovoltaic power plant | Indonesia consists of more than 15,000 islands. Indonesia is expected to respond to future increases in electricity demand and switch from existing thermal power plants. On the other hand, there are challenges such as land acquisition, ensuring stable supply, and the disposal of degraded solar panels etc. |
| Wind power plant | Indonesia consists of more than 15,000 islands. It has the potential for onshore and offshore installations and is expected to meet future increases in electricity demand. On the other hand, there are challenges such as land acquisition, impacts on ecosystems (e.g., bird strikes), and fishing rights etc. |
| Geothermal power plant | In general, the development of geothermal power plants is conducted in undeveloped areas near volcanoes, and it takes a long time from survey to operation. Indonesia is the world's second largest geothermal power country, and there are high expectations for the country's ability to meet future increases in electricity demand.<br>However, attention must be paid to the environmental impact of development. |
| Nuclear power plant | Nuclear power plants do not emit CO2. However, careful consideration must be given to environmental impacts during construction and operation.<br>According to RUPTL, 500 MW (2025–2034) is planned for introduction, with challenges including safety, legal/institutional frameworks, human resource development, and cost. |

# 3. SEA in This study

✓ Contents

The outline and potential analysis clarify the characteristics of the project, development possibility and the relationship between the scale of development and the EIA procedures.

Subsequently, this section involves organizing Impact factors and Environmental factors for each power development project and identifying prioritized items that could have significant impacts.

(1) Outline /Potential analysis
(2) EIA Procedures
(3) Pollution control measures
(4) Natural environment
(5) Social environment

# 3. SEA in This study

## Thermal Power Plant

✓ Outline

The primary low-carbon technologies for thermal power generation are as follows:

(1) Fuel Substitution (utilization of low-carbon fuels)

(a) Hydrogen or ammonia substitution （Domestic manufacturing/Overseas procurement ）

(b) Biomass substitution

(2) CO2 capture, utilization, and storage (CCS/CCUS)

(3) High-efficiency power generation technology

In SEA/EIA, hydrogen and ammonia power generation are categorized as thermal power. Many challenges remain to be addressed regarding Fuel Substitution, CCS/CCUS.

The construction or expansion of fuel receiving and storage facilities is subject to EIA from the perspective of construction work and accident safety as well as coal, LNG.

While EIA primarily focuses on the project site, SEA requires an essential perspective encompassing the supply chain, including fuel procurement.

# 3. SEA in This study

## Thermal Power Plant

✓ EIA and environmental permits

For new project plans, the following EIA procedures are required depending on the scale of the project.

However, in case of introducing CCS to the existing thermal power plant, if the existing activity is to be changed after already obtaining the environmental permit, the project owner will apply for modification of the environmental permit.

In this case, the procedure is based on the scale of the existing activity and the type of document required for the modification depends on the initial environmental document. For example, if the scale of the existing activity is AMDAL, then it would be an Addendum ANDAL & RKL-RPL document. In addition, there are no Addendum for UKL-UPL or SPPL.

| Category | AMDAL | UKL-UPL | SPPL |
|---|---|---|---|
| Thermal Power Project (PLTU(Steam), PLTG(Gas), PLTGU (Combined Cycle), PLTD(DIESEL), PLTDG(Diesel Gas), PLTMG(Gas Engine), PLTMGU (Gas Engine & Stream), IGCC, Marine Vessel Power Plant, Mobile Power Plant, Hybrid EBT(Renewable energy) | ≥ 100 MW (in one location) | < 100 MW (in one location) except PLTD : 5 - < 100 MW | PLTD < 5 MW |

# 3. SEA in This study

## Thermal Power Plant

✓ Pollution control measures

### 1) Air Quality

When ammonia is used as fuel, increased NOx and ammonia emissions are possible.

In CO2 separation process of CCS, SOx, low volatile metals, and PM emissions into the atmosphere tend to decrease, while NOx, carbon monoxide, ammonia, and other emissions into the atmosphere tend to increase.

However, these changes of characteristics of exhaust gas can be addressed with conventional measures.

### 2) Water Quality

Wastewater including ammonia and thermal effluent from thermal power plant operations, leachate from coal storage and coal ash disposal sites, etc. can be treated with conventional wastewater treatment.

# 3. SEA in This study

Thermal Power Plant

✓ Natural environment (Protected areas & Ecosystem and biodiversity)

[Consideration for Concerns of Significant Impact]

If the project site is located in close proximity to a restricted development area, the location and layout of the facility should be considered, while giving due consideration to the characteristics of the surrounding area.

✓ Social environment (Resettlement)

Depending on scale of facilities, if facilities can be installed within the existing power plant site, no land acquisition is required. However, if land acquisition is required for facilities and pipeline installation, the presence and scale of relocation of residents should be identified, and a relocation plan, compensation, and post-relocation monitoring plan should be developed.

In addition, biomass is expected to use industrial waste from industries such as lumber, paper production, as well as agricultural residues. New deforestation and land reclamation are not anticipated.

# 3. SEA in This study

## Hydroelectric Power Plant

✓ Outline

In hydroelectric power generation projects, considerations are given to the amount of water used, effective head, intake weir, etc. according to the output scale.

Advantage; Hydroelectric power generation has high energy conversion efficiency (about 80%) and low management costs. Areas with many mountains and abundant water resources are best.

Disadvantage; It is difficult to find new large land. Dam construction costs are expensive. Depending on precipitation, if there is extremely little rainfall, electricity cannot be generated.

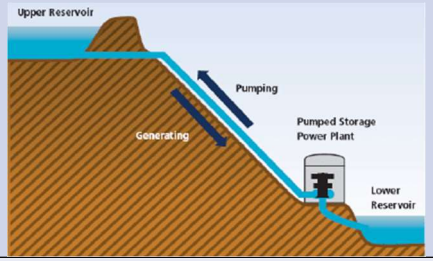
(Source: Kyushu Electric Power Co., Inc)

(Source: NTT Smile Energy Co., Ltd.)

# 3. SEA in This study

## Hydroelectric Power Plant

✓ Outline

| Item | Canal type (Run-of-river type) & Storage type (Reservoir type) | Pumped storage (Reservoir type) |
|---|---|---|
| Characteristic |  |  |
| Composition | Intake weir, sedimentation basin, spillway, headrace | Reservoir, spillway, headrace |
| Terrain | Steep terrain is advantageous. | A deep or wide valley upstream is advantageous, but narrow valley makes it difficult to build a large reservoir. |
| Geology | Strength is required for the installation of equipment. | It is necessary to consider the strength of the facility and sediment deposition. |
| Environmental and social impact | Environmental and social impacts are expected due to the occurrence of low-water areas downstream. | Submerged areas will occur depending on the reservoir, and low-water areas downstream will have environmental and social impacts. |
| Cost | Compared to reservoir-type facilities, construction costs can be kept low. | The larger the facility, the greater the benefits of economies of scale. |



(Source: ANDRITZ, ResearchGate)

# 3. SEA in This study

## Hydroelectric Power Plant

✓ EIA and environmental permits

For new project plans, the following EIA procedures (AMDAL, ULK-UPL, and SPPL) are required depending on the scale of the project.

| Category | AMDAL | UKL-UPL | SPPL |
|---|---|---|---|
| Hydropower Project | a. Weir Height (≥ 15 m)<br>b. Inundation area (≥ 200 ha)<br>c. Capacity (≥ 500,000 m3)<br>d. Capacity (≥ 50 MW) | a. Weir Height (< 15 m)<br>b. Inundation area (< 200 ha)<br>c. Capacity (< 500,000 m3)<br>d. Capacity (< 50 MW) | --- |

# 3. SEA in This study

## Hydroelectric Power Plant

✓ Pollution control measures

### 1) Water Quality

Changes in water quality in dam reservoirs include cold water/warm water, long-term turbidity, and eutrophication. Hypoxic water or water containing harmful substances may lead to bad impact on fish and other animals downstream. Appropriate measures, including environmental monitoring, are necessary..

### 2) Wastes

Huge waste will be generated by development of dam. Recycle becomes important key for waste measures. This table shows recycling measures of main waste. It is necessary to consider from early planning stage.

| Item | Waste | Recycle/Reuse |
|---|---|---|
| Construction | Concrete mass | Filling material, road material etc. |
| | Excavated soil, Muddy water sludge, Dredged soil | Filling material etc. |
| | Felled trees, Driftwood | Composting |
| Operation | Driftwood | Composting, Recycle（Charcoal, furniture etc.） |
| | Dredged soil | Construction Materials, Landfill |

# 3. SEA in This study

## Hydroelectric Power Plant

✓ Natural environment

1) Protected areas & Ecosystem and biodiversity

[Consideration for Concerns of Significant Impact]

If the project site is located in close proximity to a restricted development area, the location and layout of the facility should be considered, while giving due consideration to the characteristics of the surrounding area.

2) Hydrology

As with changes in water quality in dam reservoir, there are any concerns about flow conditions, groundwater, water resources and so on by the presence of dam. Therefore, it is necessary to consider them from early planning step.

3) Topography and Geology

There may be important topographical or geological features within the reservoir planned, and they may be submerged or lost due to impoundment. These matters must be avoided by screening to ensure that the project area does not extend into development-restricted areas.

# 3. SEA in This study

## Hydroelectric Power Plant

✓ Social environment

1) Resettlement & Socially vulnerable group

[Consideration for Concerns of Significant Impact]

If large-scale resettlement is assumed, it is necessary to consider potential sites, and the location and layout of facilities.

Regarding the living areas of indigenous peoples and ethnic minorities, project area and its surrounding conditions shall be confirmed.

2) Living and livelihood

Since dam development involves in large/long construction, work safety, traffic safety are important. In operation phase, there are some downstream impacts by the discharge of water and changes in the water system. Consideration from the early stages is required including the establishment of warning system.

3) Heritage & Landscape (Aesthetic scenery)

[Consideration for Concerns of Significant Impact]

Consideration should be given to the characteristics of the surrounding area, such as areas (Heritage etc.) to be noted, as well as the location and layout of the facility.

# 3. SEA in This study

## Solar Photovoltaic Power Plant


(Source: ABB Ltd.)

✓ Outline

Indonesia is country consisting of many islands, often inhabited by indigenous peoples and ethnic minorities and formed by various cultures. In this case, it is often preferable the development of small-scale power sources.

The largest Cirata floating solar power project in Southeast Asia (192 MW) is in operation at the Cirata Reservoir in West Java, covering 250 ha and expected to reduce CO2 emissions by more than 200,000 tons per year.

✓ EIA and environmental permits

EIA procedure is required depending on the project scale. However, in the case of floating solar power projects in existing reservoirs, the project owner is required to apply for a modification of the environmental permit based on existing activity (Hydroelectric Power Plant) that already has an environmental permit.

In this case, the procedure is based on the scale of the existing activity and the type of document required for the modification depends on the initial environmental document. For example, if the scale of the existing activity is AMDAL, then it would be an Addendum ANDAL & RKL-RPL document.

| Category | AMDAL | UKL-UPL | SPPL |
|---|---|---|---|
| Solar Power Generation | ≥ 50 MW | ≥ 1 MW – < 50 MW | < 1 MW |

# 3. SEA in This study

## Solar Photovoltaic Power Plant

✓ Pollution control measures

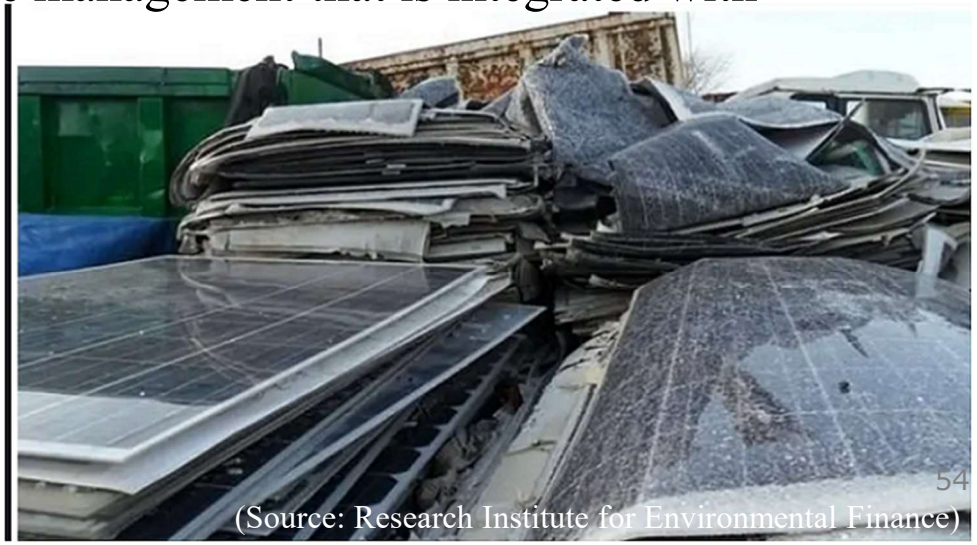
### 1) Waste

Solar panels can be installed in diverse condition, such as on land, building rooftop, floating on lake surface and so on. However, solar panels will eventually degrade.

Indonesian Regulation requires proper treatment and disposal of solar panels.

Solar panels include harmful substances. The project owner must make the plan to dispose of solar panels and prepare technical permit for B3 waste management that is integrated with the AMDAL document.

It is necessary to consider treatment/storage against wastes of solar panels including recycle method in the early planning stage.



(Source: Research Institute for Environmental Finance)

# 3. SEA in This study

## Solar Photovoltaic Power Plant

✓ Natural environment

1) Protected Areas & Ecosystem and biodiversity

[Consideration for Concerns of Significant Impact]

If the project site is located in close proximity to a restricted development area, the location and layout of the facility should be considered, while giving due consideration to the characteristics of the surrounding area.

(Reference)

Kushiro Marsh in Hokkaido, Japan is wetland designated under the Ramsar convention. There is the plan to construct mega-solar power plant near Kushiro Marsh. According to media reports, it is raising concerns about environmental destruction and impacts on rare species.

(Source: : https://www.nikkei.com)

# 3. SEA in This study

Solar Photovoltaic Power Plant

(Source: Guidelines for Design and Construction of Solar photovoltaic Power Generation Systems Installed on Sloping Sites (2023 edition).

✓ Natural environment

2) Topography and Geology

Especially when installing solar power facilities in area that there are large cuts, fills with deforestation…, mudslides and landslides are a concern.

Slope protection and land stability should be taken into consideration.

✓ Social environment

1) Resettlement

[Consideration for Concerns of Significant Impact]

If large-scale resettlement is assumed, it is necessary to consider potential sites, and the location and layout of facilities.

# 3. SEA in This study

## Solar Photovoltaic Power Plant


(Source: Kyocera, Kinki Regional Development Bureau)

✓ Social environment

2) Living and livelihood

[Light pollution]

Solar panels cause glare in the surrounding area.

It is necessary to pay attention to the tilt angle of solar panels in consideration of reflections or installing shielding plates considering living space.

[Regional fragmentation]

If the project area is large, the project may be the obstacle to the movement of residents in the vicinity. It is necessary to consider the location and layout at an early stage to ensure no disruption to residents' life.

3) Heritage & Landscape (Aesthetic scenery)

[Consideration for Concerns of Significant Impact]

If the project site is located near heritage, aesthetic scenery, the facility layout should be planned considering the characteristics of the surrounding area.

# 3. SEA in This study

## Wind Power Plant

### ✓ Outline

Indonesia is a country consisting of many islands, often inhabited by indigenous peoples and ethnic minorities and formed by various cultures, which often favors the development of small-scale power sources.

In case power supply is already provided by small-scale thermal power sources, they can be expected to serve as alternative power sources for decarbonizing power sources.

### ✓ EIA and environmental permits

For new project plans, EIA procedures are required for the following project sizes.

| Category | AMDAL | UKL-UPL | SPPL |
|---|---|---|---|
| Wind Power Generation | ≥ 50 MW | ≥ 1 MW – < 50 MW | < 1 MW |

When selecting candidate sites, based on the results of the wind analysis, it is necessary to avoid installing the wind turbines near residences and living spaces considering the noise impact on the surrounding area.

In addition, the height of the wind turbine is about 200 m, so the impact on scenic resources should also be taken into consideration.

Multiple proposals for the location and facility layout will be prepared for comparative evaluation of the environmental and social impacts.

# 3. SEA in This study

## Wind Power Plant

✓ Pollution control measures (Noise)

Health effects and sleep disturbance are identified by epidemiological study on infrasound and noise from wind power generation.

It is necessary to pay attention to land use of surrounding area in the early planning stage.

✓ Natural environment (Protected Areas & Ecosystem and biodiversity)

[Consideration for Concerns of Significant Impact]

If wind power facilities are located in the flight routes of migratory birds, bird flights may be intercepted due to bird strikes.

Surveying the flight routes of migratory birds is important.

In this case, the site location and the facility layout should be considered.

(Source: https://karapaia.com/archives/52294142.html)

# 3. SEA in This study

## Wind Power Plant

✓ Social environment

1) Resettlement & Socially vulnerable group

[Consideration for Concerns of Significant Impact]

If large-scale resettlement is assumed, it is necessary to consider potential sites, and the location and layout of facilities.

2) Living and livelihood

There is concern that the operation of wind power generation will cause noise and shadow flicker that will affect the living of residents.

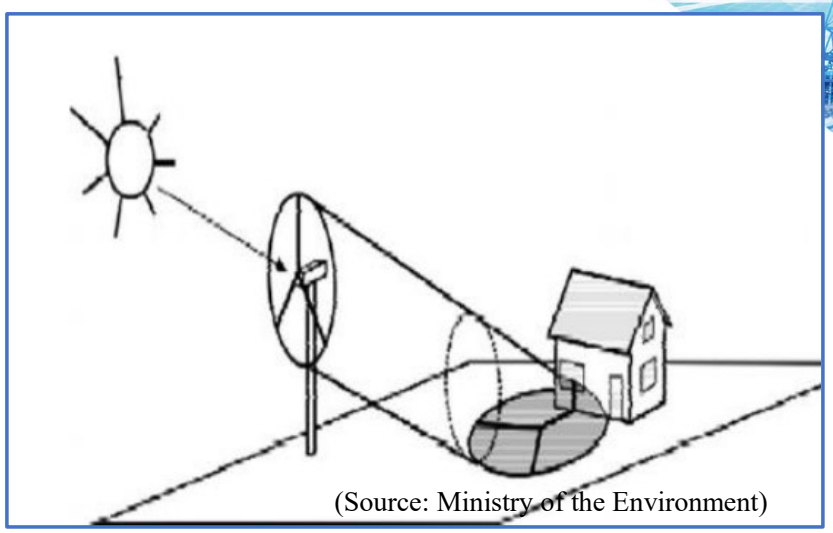
From the planning stage, the layout of facilities, etc., should take these effects into consideration.

3) Heritage & Landscape (Aesthetic scenery)

[Consideration for Concerns of Significant Impact]

Wind power is quite high. When you see them at scenic spots or cultural heritage sites, don't you find it disappointing?

It is necessary to pay attention to land use of surrounding area, and the location and facility layout should be fully considered.



(Source: Ministry of the Environment)

(Source: Cosmo Eco Power Co., Ltd)

# 3. SEA in This study

## Geothermal Power Plant

✓ Outline

Indonesia‘s geothermal resources are second only to those of the United States. Geothermal energy becomes promising option for the use of renewable energy. Geothermal power generation is not affected by weather, season, time fluctuations like solar power or wind power.

But successful development of geothermal power is difficult, and geothermal power plants larger than 10 MW may take more than 10 years until operation phase.

Source: Tohoku Sustainable & Renewable Energy Co., Inc)

(Source: Japan Organization for Metals and Energy Security)

# 3. SEA in This study

## Geothermal Power Plant

✓ EIA and environmental permits

EIA procedure requires all developments of geothermal power generation.

It is reasonable to conduct surface surveys and studies to avoid or minimize significant environmental impacts in parallel in the early planning stage.

| Category | AMDAL | UKL-UPL | SPPL |
|---|---|---|---|
| Geothermal Power Projects | All Output (Exploitation Stage and/or Utilization Stage) | All Output (Exploration Stage) | --- |

# 3. SEA in This study

## Geothermal Power Plant

✓ Pollution control measures

### 1) Air Quality

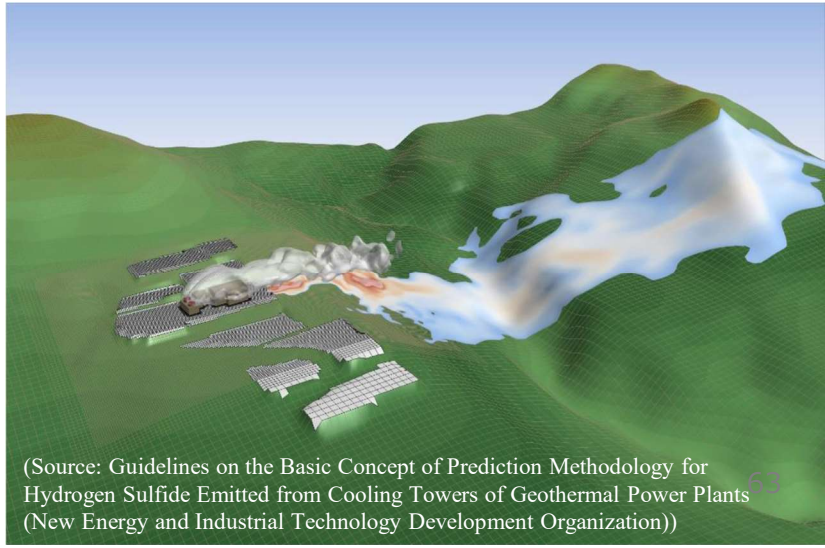
In case of the use of geothermal fluid containing hydrogen sulfide, hydrogen sulfide is discharged from the cooling tower together with steam. It is expected to affect the living environment near the power plant. In the study phase of the EIA, the detailed impact area will be confirmed by atmospheric dispersion simulation.

But paying attention to surrounding land use in the early planning stage is effective for project site selection.

### 2) Subsidence & Groundwater

When deep geothermal fluid is collected and hydrothermal fluid is returned to deep underground, land subsidence, impact on groundwater are expected near the power plant.

Facility layout considering topography, geology and groundwater surveys, and project scale should be thoroughly reviewed in the planning stage.



(Source: Guidelines on the Basic Concept of Prediction Methodology for Hydrogen Sulfide Emitted from Cooling Towers of Geothermal Power Plants (New Energy and Industrial Technology Development Organization))

# 3. SEA in This study

## Geothermal Power Plant

✓ Natural environment

### 1) Protected areas & Ecosystem and biodiversity

[Consideration for Concerns of Significant Impact]

If the project site is located near restricted development area, the location and layout of the facility should be considered, while giving due consideration to the characteristics of the surrounding area.

### 2) Topography and Geology

If the topography and geology are important area for the preservation of natural environment, they are affected by changes in the shape of the land and the installation of structures.

This will be avoided by screening in order to ensure that the project area does not extend beyond the development restricted area.

# 3. SEA in This study

## Geothermal Power Plant

✓ Social environment

### 1) Resettlement & Socially vulnerable group

[Consideration for Concerns of Significant Impact]

Land acquisition is required for geothermal power. If large-scale resettlement is assumed, it is necessary to consider potential sites including location and layout of facilities.

### 2) Living and livelihood

The presence of geothermal power plant (e.g., release of hydrogen sulfide, wastewater, use of geothermal fluid, etc.) is expected to affect the living environment of the surrounding community. It is necessary to pay attention to land use of surrounding area.

### 3) Heritage & Landscape (Aesthetic scenery)

[Consideration for Concerns of Significant Impact]

If the project site is located near the heritage and aesthetic scenery, the characteristics of the surrounding area, the location and facility layout should be fully considered.

# 3. SEA in This study

## Nuclear Power Plant

✓ Recent movements

Nuclear Energy Regulatory Agency (BAPETEN) approved the Site Evaluation Program (PET) and Site Evaluation Management (SMET) in Bangka Belitung Province in July 2025.

On the other hand, Ministry of Energy and Mineral Resources (ESDM) requires the completion of procedures such as AMDAL before transitioning to the construction phase.

✓ Current Situation for EIA

Indonesia has not yet finalized formal EIA* for nuclear development. World Bank is only recently developing specific operational frameworks for nuclear-related environmental and social considerations.

It is necessary to reevaluate the situation once the international framework is established.

*Based on regulation Permenlhk 4/2021, there are currently no established criteria for determining the type of environmental documentation for nuclear power plants.

# 3. SEA in This study

## Nuclear Power Plant

- ✓ According to "Managing Environmental Impact Assessment for Construction and Operation in New Nuclear Power Programmes" (IAEA), types of expertise required for EIA are as follows.

  Environmental science, Biology, including human health, Meteorology, Oceanography, Hydrology, Geology, Seismology, Volcanology

- ✓ Environmental Impact Matrix proposed by JICA Project Team

| Category | Environmental Item | Nuclear | |
|---|---|---|---|
| | | Construction | Operation |
| Anti-pollution Measures | Air Quality/ Odor | ○ | — |
| | Water Quality | ○ | ○ |
| | Soil Contamination/ Sediment pollution | ○ | ○ |
| | Noise and Vibration | ○ | ○ |
| | Waste | ○ | ○ |
| Natural Environment | Protected Areas/ Ecosystem and Biota | ○ | ○ |
| Social Environment | Resettlement, Living and Livelihood, Landscape etc. | ○ | ○ |
| Other | Accident | ○ | ○ |
| | Transboundary Impacts, and Climate Change | ○ | ○ |

(Source: JICA Project Team)

# 3. SEA in This study

## Nuclear Power Plant

✓ Screening/Scoping for SEA

In parallel with surveys conducted by BAPETEN on earthquakes, volcanic activity, radioactive material dispersion etc., it is important to consider Screening/Scoping in the early planning stage with a view to the EIA.

✓ Future Directions for Development of Nuclear Infrastructure

- Policy & Governance: Establish nuclear policies and legal/institutional frameworks
- Sustainability: Conduct environmental and social impact assessments

## 3. SEA in This study – Key Takeaway

- ✓ In development projects, SEA process is crucial. SEA prevents project implementation and progress from being hindered.
- ✓ SEA identifies and extracts environmental factors that are difficult to avoid or mitigate in the project, examines them in the early stage and incorporates them into the plan.
  Significant Items Prioritized for power source development are as follows:
  Natural environment: Protected Areas, Ecosystem and biodiversity
  Social environment : Resettlement, Socially vulnerable group, Heritage, Landscape
- ✓ In SEA, explanation to local stakeholders is key, and it is also important to incorporate various opinions into the plan at an early stage.
- ✓ SEA is primarily based on desk research and existing data. Impacts are estimated using simple prediction methods such as overlay analysis based on existing literature (Field surveys, detailed simulations, and mitigation measures are addressed during the EIA process.).
- ✓ To enable the introduction of nuclear power plant, legal frameworks and SEA/EIA procedures should be established.

Terima kasih atas perhatian Anda

Thank you for your attention