# ASEAN Energy Booklet 2025

## Vol. 1

## Coal and Clean Coal Technology in ASEAN

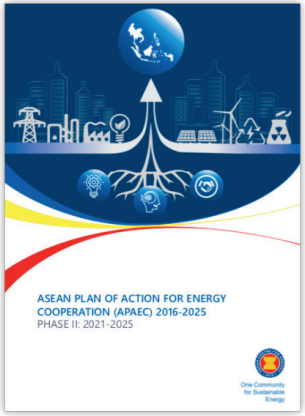
# Coal and Clean Coal Technology

For decades, coal has been a **key energy resource** for ensuring **energy security** and **affordability** in the ASEAN Member States (AMS). Coal and clean coal technologies are expected to play a new role in the impending energy transition, combining energy security with sustainable development goals and enhancing energy resilience as a result of the mounting pressure from climate change.

## What is Clean Coal Technology (CCT)?

Clean coal technologies are several generations of technological advances that have led to more efficient combustion of coal with reduced emissions of sulfur dioxide and nitrogen oxide (National Mining Association, 2016).

The ASEAN Coal Sub-sector Network was renamed the **ASEAN Forum on Coal (AFOC)**, a Specialised Energy Body that is in charge of implementing the **Coal and Clean Coal Technology (CCT) Programme Area (PA)** under the **ASEAN Plan of Action for Energy Cooperation (APAEC) Phase II: 2021-2025.** CCT PA's objective is to strengthen ASEAN coal sector collaboration, boost intra-ASEAN coal business, disseminate best practices, and expand CCT deployment in the region to assist energy transition and environmental sustainability.

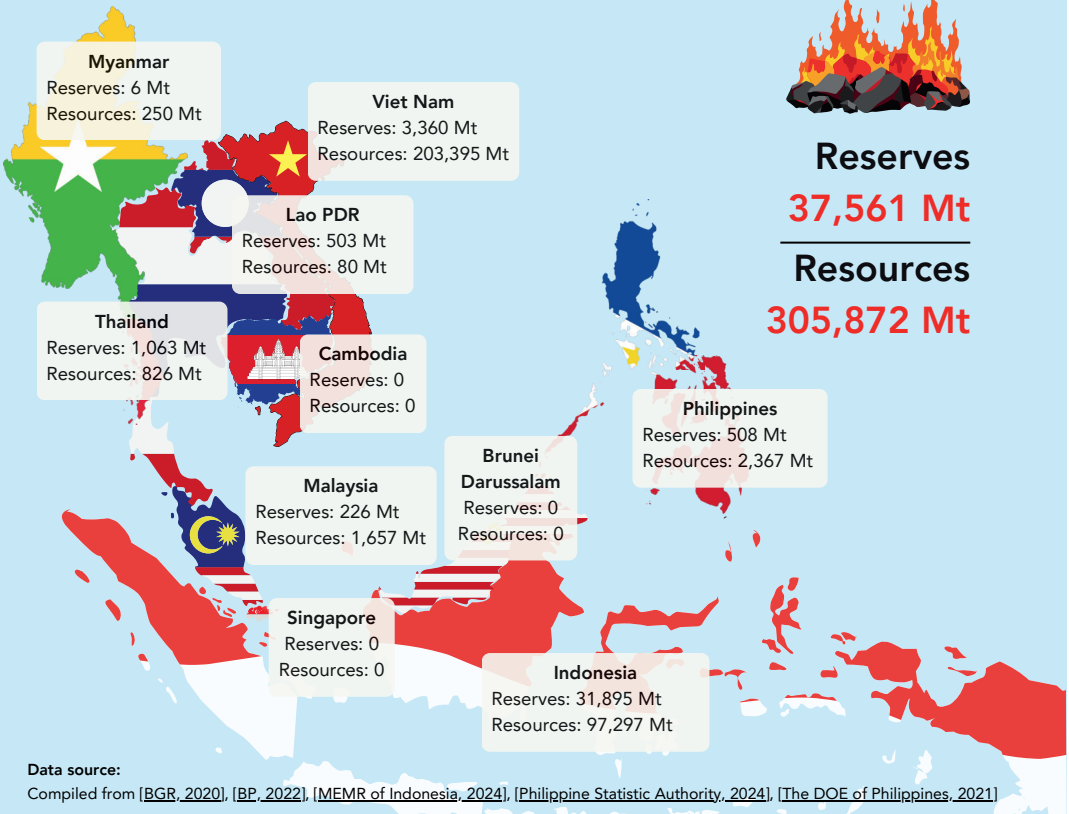



## Outcome-based Strategies of Programme Area No. 3 - Coal & CCT

- Promote the Role of Clean Coal Technology (CCT) towards Energy Transition and Low Carbon Economy
- Conduct Strategic Outreach to Advance Regional Actions to Enhance Public Awareness and Image of CCT
- Facilitate Investment, Innovation and Partnership on CCT through the ASEAN Coal Business Roundtable and Conference
- Advanced CCT Research, Development, and Innovation

# Coal Reserves and Resources in ASEAN

## Amount of Coal in ASEAN




**Reserves**
**37,561 Mt**

**Resources**
**305,872 Mt**

**Data source:**
Compiled from [BGR, 2020], [BP, 2022], [MEMR of Indonesia, 2024], [Philippine Statistic Authority, 2024], [The DOE of Philippines, 2021]

## Coal Reserves

The portion of coal resources that **can be mined** using today's technology and under current economic conditions (The U.S. Geological Survey). Reserves are the coal that **can realistically be extracted** and used. So, coal reserves represent the **'available'** portion of resources that can be profitably extracted and utilised.

## Coal Resources

Coal resources, as defined by the U.S. Geological Survey, are **naturally occurring** coal deposits in forms and quantities that are **currently or potentially** feasible to extract economically. This includes all coal in a given area, regardless of whether it is accessible with current technology or economic conditions, such as deposits that are too deep or difficult to reach. Essentially, it refers to the **total amount of coal in the ground.**

# AMS' Coal Power Commitments and Policies

The ASEAN region is experiencing a significant shift in its approach to coal power, as evidenced by the **varied commitments** of its member countries. This diverse landscape of policy positions reflects the complex balance ASEAN countries are striking between energy needs, economic development, and environmental concerns.

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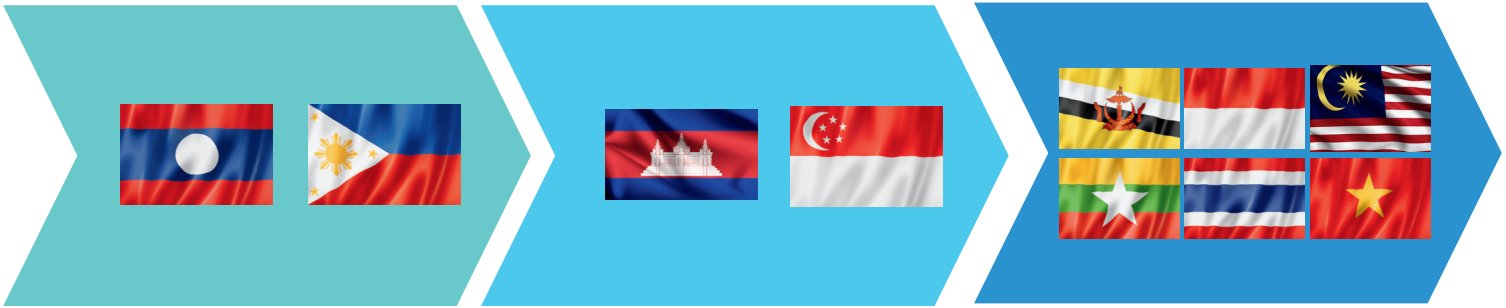
## AMS Commitments and Policies on Coal



Net Zero Emissions Target but No Coal Commitment

Agreed internationally not to develop new unabated coal power

Commit to phase-out coal power

**Data source:** [COP26 Global Coal to Clean Power Transition, 2021], [Asian Power, 2024], [ADB, 2024], [ICEDS ANU, 2024], [Myanmar Updated NDC, 2021], [IEA, 2024]

# Boiler Technologies for CFPPs

## Typical specifications of different boiler technologies in CFPPs

| Boiler Technology | Efficiency | Coal Consumption | $CO_2$ Intensity | Steam Temperature |
|---|---|---|---|---|
| | % | Kg per MWh | $KgCO_2$ per MWh | Celsius Degree |
| **Subcritical** | Up to 38% | ≥ 380 | ≥ 880 | < 550 |
| **Supercritical (SC)** | Up to 42% | 340 - 380 | 800 - 880 | 550 - 600 |
| **Ultra-supercritical (USC)** | Up to 45% | 320 - 340 | 740 - 800 | 600 |
| **Advanced Ultra-supercritical (A-USC)** | Up to 50% | 290 - 320 | 670 - 740 | 700 |

**Data source:** [IEA, 2012]

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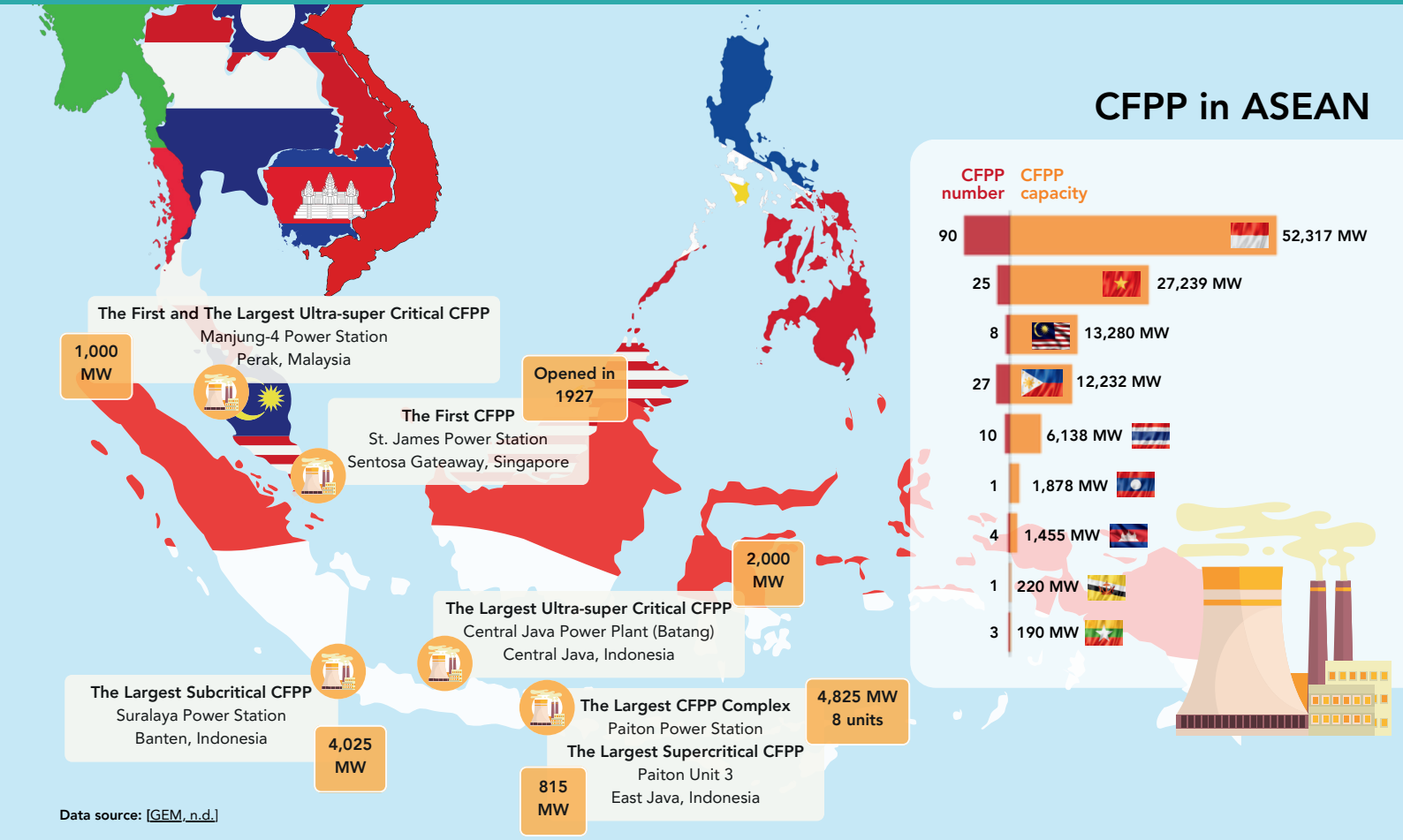
Boiler technologies play a critical role in coal-fired power plants, with **High Efficiency Low Emissions (HELE)** systems being a key advancement. These include supercritical (SC), ultra-supercritical (USC), and advanced ultra-supercritical (A-USC) boilers, which **enhance efficiency and reduce environmental impact**. A-USC boilers achieve up to 50% efficiency, making these technologies essential for ASEAN countries where coal is a major energy source. This discussion will explore the implementation of HELE and subcritical technologies across Southeast Asia's coal-based power generation infrastructure.

# Coal-Fired Power Plant in ASEAN




**Data source:** [GEM, n.d.]

## St. James Power Station, Singapore

The **first coal-fired power plant in Southeast Asia**, the **St. James Power Station (SJPS)**, is located in Harbour Front, Singapore. It officially opened on **November 7, 1927**, and marked a significant milestone in the region's energy sector development. At its full output capacity, the power plant produced approximately **22,000 kW of electricity**. This historic power station played a crucial role in meeting the growing electrical needs of Singapore during its early years, providing power to around **28,255 people**, which was at least 18 times more people on the island than before. SJPS **decommissioned in 1976**, it became an automated warehouse, deteriorated, and then became an entertainment complex. In 2019, restoration work began to transform it into Dyson's new global headquarters.

**Sources:**
compiled from [Bradshaw, T. 2023], [Liu, G. (2001). *A pictorial history 1819-2000]*

**Image source:** Westliche


**Image source:** Dyson Singapore

## Suralaya Power Plant, Indonesia

The **largest subcritical coal-fired coal power plant in Southeast Asia** is the **Suralaya Power Station** in Indonesia. Located in Cilegon, Banten, this power complex has a total capacity of **4,025 MW**, consisting of multiple units. Suralaya's coal supply primarily comes from Bukit Asam Coal Mining operations in South Sumatra, delivered through an attached coal terminal.

### Specifications of Suralaya Power Station Units

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start Year | 1984 | 1985 | 1988 | 1989 | 1996 | 1997 | 1997 | 2011 |
| Unit Name | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 (PLTU Banten 1) |
| Fuel(s) | coal: subbituminous | | | | | | | |
| Capacity (MW) | 400 | 400 | 400 | 400 | 600 | 600 | 600 | 625 |
| Technology | subcritical | | | | | | | |

**Data source:** [Global Energy Observatory, n.d.]

Image source: PLN

## Paiton Power Plant Complex, Indonesia

The **largest coal-fired coal power plant complex in Southeast Asia** is the **Paiton power station** in Indonesia. Located in Probolinggo, East Java, Indonesia, this power complex has a total capacity of **4,825 MW**, consisting of 8 units. **Paiton Thermal Power Station** in Indoensia is the **largest supercritical coal-fired power plant in Southeast Asia**. Specifically, the Paiton Unit 3, which has a capacity of 815 MW, it is also noted as Indonesia's first supercritical pressure coal-fired facility.

### Specifications of Paiton Power Station Units

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Start Year** | 1994 | 1994 | 1999 | 1999 | 2000 | 2000 | 2012 | 2012 |
| **Unit Name** | Unit 1 | Unit 2 | Paiton-1: Unit 7 | Paiton-1: Unit 8 | Paiton-2: Unit 5 | Paiton-2: Unit 6 | Paiton Baru: Unit 9 | Paiton-3 |
| **Fuel(s)** | coal: subbituminous | | coal: subbituminous<br>bioenergy: wood & other biomass (solids) | | coal: subbituminous | | | |
| **Capacity (MW)** | 400 | 400 | 615 | 615 | 610 | 610 | 660 | 815 |
| **Technology** | subcritical | | | | | | | super-critical |


Image source: topbisnis.id

**Data sources:** compiled from [Global Energy Monitor, n.d.], [Global Energy Monitor, n.d.], [Global Energy Monitor, n.d.], [Global Energy Monitor, n.d.], [Jawa Power. n.d.], [MEMR of Indonesia. 2012]

## Manjung Unit 4, Malaysia

**The first ultra-supercritical coal-fired power plant in Southeast Asia is the Manjung Unit 4 power plant** in Malaysia. Located in Perak, Manjung 4 has a capacity of **1,000 MW** and was **commissioned in April 2015**.

### Specifications of Manjung Power Plant Units

| | | | | | |
|---|---|---|---|---|---|
| **Start Year** | 2002 | 2003 | 2003 | 2015 | 2017 |
| **Unit Name** | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 |
| **Fuel(s)** | coal: bituminous | | | | |
| **Capacity (MW)** | 700 | 700 | 700 | 1,000 | 1,000 |
| **Technology** | subcritical | | | ultra-supercritical | |

**Data sources:** compiled from [Global Energy Monitor, n.d.] and [Power Technology, n.d.]

**Image source:** JML Project Consulting

# The Largest Ultra-Super Critical CFPP in ASEAN

## Batang Power Plant, Indonesia | Manjung Unit 4 and 5, Malaysia

**The largest ultra-supercritical coal-fired power plants in Southeast Asia** are the **Batang Power Plant in Central Java, Indonesia, and the Manjung Power Plant Units 4 and 5 in Perak, Malaysia**. The Batang Power Plant, also known as the Central Java Power Plant (CJPP), has a total capacity of **2,000 MW**, consisting of two units of 1,000 MW each. Similarly, the Manjung Power Plant Units 4 and 5 also have a combined capacity of **2,000 MW.**

### Specifications of Batang Power Plant Units

| | | |
|---|---|---|
| Start year | 2022 | |
| Unit name | Unit 1 | Unit 2 |
| Fuel(s) | coal: subbituminous | |
| Capacity (MW) | 1,000 | 1,000 |
| Technology | ultra-supercritical | |

**Data sources:** [Global Energy Monitor, n.d.] and [KPPIP, n.d.]

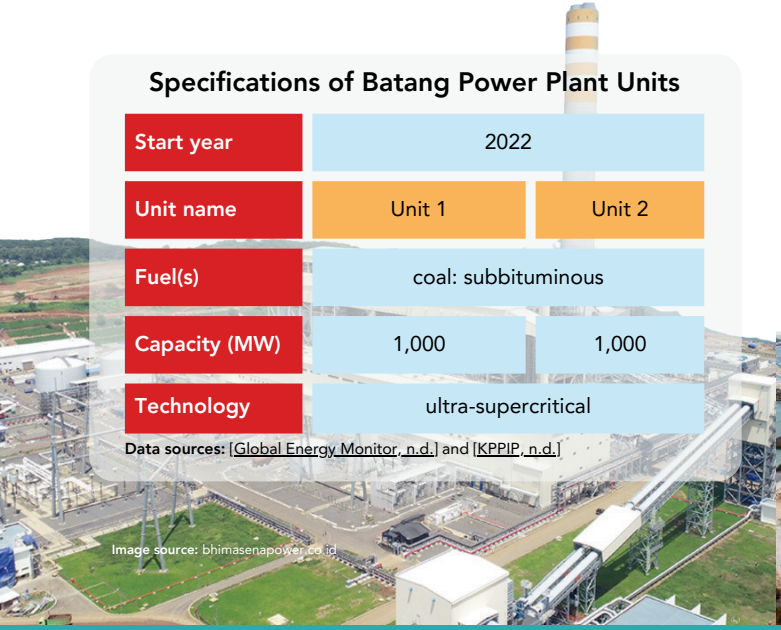


Image source: bhimasenapower.co.id

### Specifications of Manjung Power Plant Units 4 and 5

| | | |
|---|---|---|
| Start Year | 2015 | 2017 |
| Unit Name | Unit 4 | Unit 5 |
| Fuel(s) | coal: bituminous | |
| Capacity (MW) | 1,000 | 1,000 |
| Technology | ultra-supercritical | |

**Data sources:** compiled from [Global Energy Monitor, n.d.] and [Power Technology, n.d.]

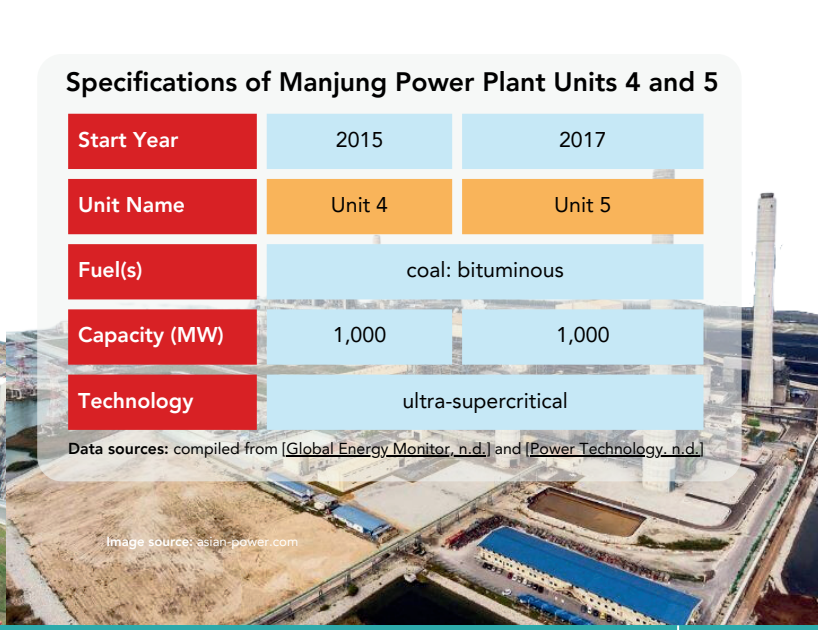


Image source: asian-power.com

# Co-firing with Biomass

Co-firing efficiently and cost-effectively integrates alternative fuels with coal in CFPPs, **reducing coal use and greenhouse gas emissions**. It supports sustainability by broadening the energy mix and potentially fostering circular economy principles, improving the environmental performance of existing infrastructure while advancing the transition to a more sustainable energy future.

Biomass is the **most common alternative fuel** for co-firing, sourced from **agricultural residues, forestry residues, and wood waste.** These materials are processed into forms like pellets or briquettes to meet the technical needs of co-firing systems in power plants. However, the limited availability of sustainable biomass resources and the **potential competition with food production** are significant concerns. There are also issues related to the carbon neutrality claims of biomass, as the carbon cycle and land use changes need to be carefully considered.

# Types of Biomass Feedstock


Palm Fiber


Palm Kernel Shell


EFB (Empty Fruit Bunch) Pellet


Palm Frond


Palm Replanting Trunk


Sugarcane Bagasse


Sugarcane Leaves and Tips


Coconut Coir


Coconut Shell


Rubber Replanting Trunk


Rice Husk Pellet


Rice Straw


Corn Cob


Corn Stalk and Leaves


Industrial Wood Waste


SRF (Solid Recovered Fuel) Pellet

**Images sources:** canva, getty images, pixabay, pixelshoot, WKE ltd.,

# Calorific Values of Biomass Feedstock (kcal/kg)


**Data source:** PLN, 2022

# ASEAN Policies and Regulations on Biomass Co-firing

Major policies, regulations, and initiatives in biomass use (including co-firing) in ASEAN

| Country | Policy/Regulation/ Initiative | Stakeholder | Year | Objectives |
|---|---|---|---|---|
| **Indonesia** | Regulation of the Minister of Energy and Mineral Resources Number 12 of 2023 | Ministry of Energy and Mineral Resources | 2023 | The regulations cover the domestic supply of biomass, the highest reference prices, as well as safety and environmental protection measures. Additionally, the regulation outlines reporting and monitoring mechanisms, while also offering incentives for those who meet the targets in the implementation of biomass co-firing. |
| | Regulation of Co-firing Biomass with Coal Power Plant Generator Number 004/DIR/2022 | PT Perusahaan Listrik Negara (PLN) | 2020 | (1) Provide the basis for the implementation of co-firing in existing CFPPs, as well as to synergise and accelerate the implementation of co-firing; (2) accelerate the aim to reach renewable energy share targets; (3) ensure co-firing is implemented at PLN's CFPP; (4) monitor implementation of co-firing; and (5) ensure the use of biomass in a controlled manner. |
| **Malaysia** | Malaysia Renewable Energy Roadmap | Sustainable Energy Development Authority (SEDA) Malaysia | 2021 | Provide 4 strategic pillars to determine the renewable energy targets in the power generation composition to 2035 and determine strategies to achieve RE targets, with pillar number 2: bioenergy,for which one of the key actions is to explore the implementation of equitable and feasible support mechanism for biomass co-firing. |
| **Thailand** | Alternative Energy Development Plan (AEDP) 2018 | Electricity Generating Authority of Thailand (EGAT) | 2018 | Aimed to increase the renewable energy share target to 30% by 2037 through several subinitiatives, of which one is adding a "Community-Based power Plant for Local Economic Project" which accounts 1,993 MW (biomass, biogas, and solar hybrid). |
| **Viet Nam** | Power Development Plan VIII (PDP VIII) | Ministry of Industry and Trade (MOIT), and Government of Viet Nam | 2022 | Launch initiatives to help Viet Nam to reach its RE share target; (1) Viet Nam will stop building new coal power plants after 2030; (2) after 20 years of operation, CFPPs will burn biomass fuel, starting at 20% and gradually increasing to 100%; and (3) by 2050, there will be no CFPPs in the power system. |

**Data source:** ACE, 2024

## Paiton Power Plant Unit 1 and 2, Indonesia

PLTU Paiton 1-2 is a power plant that employs biomass co-firing and is recognised as Southeast Asia's largest biomass co-firing power plant. By November 2023, it had consumed 126,000 tons of biomass, Paiton mainly uses wood sawdust as its biomass source. This substantial biomass usage contributes to the generation of 134,530 MWh of green energy, which supports Indonesia's transition to cleaner energy sources.

Image source: PT PJB

Additionally, the biomass co-firing at PLTU Paiton 1-2 has contributed to a significant reduction in carbon emissions, amounting to **128,229 tons of $CO_2$**.

The percentage of biomass in the total fuel mix, or co-firing rate, at PLTU Paiton 1-2 is recorded at 3.25%.

# The Highest Percentage Biomass Co-firing Mix

## Hotelkamp Power Plant

**Hotelkamp Power Plant**, located in Holtekam, Muara Tami District, Jayapura City, Papua, stands out as a remarkable power plant with the highest co-firing percentage in Southeast Asia at **7.14%**.

## Indonesia

The power plant's biomass consumption reaches **1,118 tons**, which is converted into green energy production of **1,807 MWh**. Through its advanced co-firing technology, Hotelkamp Power Plant has successfully achieved a significant emission reduction of **3,274 tons of $CO_2$**.

**Image source:** Google Maps

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