TECHNICAL CHALLENGES OF THE ENERGY TRANSITION PLTU PALABUHAN RATU PGU TO A CLEAN ENERGY SOURCE

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***Abstract*— The energy transition from the Palabuhan Ratu Steam Power Plant (PLTU) which uses coal as fuel to clean energy sources is an important step in facing the challenges of climate change and energy sustainability. This research aims to analyze the technical and economic challenges that arise in this transition process, focusing on PLTU Palabuhan Ratu as a study case.**

The technical challenges faced in this energy transition involve aspects of alternative technology. This study evaluates various alternative technologies that are suitable for replacing or reducing emissions from coal-fired power plants and analyzes the potential for integrating clean energy sources into the existing electricity network.

Using the SWOT method (Strengths, Weaknesses, Opportunities, and Threats), this research provides in-depth insight into the technical challenges in the energy transition from PLTU Palabahan Ratu to clean energy sources. The results of this research have important implications for the planning and implementation of an effective and sustainable energy transition, and contribute to broader discussions about the future of clean energy in Indonesia. One renewable energy source that has great potential in Indonesia is biomass, with an estimated potential of 32,654 MW.

This article reviews the implementation of biomass and electricity generation in Indonesia to gain insight into developments in the use of biomass in electricity generation in this country. Currently, electricity generation technology from biomass that has been implemented in Indonesia includes direct combustion as fuel for coal-fired power plants or co-firing, conversion into waste-based fuel, gasification, sanitary landfills, and incinerators. From 2011 to 2019, the installed capacity of biomass power plants reached 1857.5 MW or 33.78% of the target of 5500 MW in 2025.

Keywords—Co-firing, Biomass, Clean energy, PLTU Palabuhan Ratu, SWOT

I. INTRODUCTION

Global warming has become an environmental problem in the world today so that the Paris Agreement emerged in 2015, which is a global agreement between developed and developing countries to address the problems of global warming and climate change. With this agreement, every country, both developed and developing countries, must contribute to reducing their greenhouse gas (GHG) emissions, including Indonesia.[23], [15]

According to the Indonesia Third National Communication in 2017, the Electricity Sub-Sector of the Energy Sector was the largest contributor to GHG emissions in 2014, reaching 34.6% of the total inventory.[2], [6]

GHGs in the Energy Sector. GHG emissions in the electricity sub-sector are projected to remain the largest in 2030. In 2017 there is a new policy containing a renewable energy mix, the government targets achieving New and Renewable Energy (EBT) in the national energy mix as outlined in the National Energy General Plan (RUEN) reaches 23% in 2025 which is broken down into electricity and non-electricity. In PLTUs, a strategy is implemented, namely co-firing, which must be implemented in all PLTUs.[1], [4], [10]

Co-firing is the addition of biomass as a partial replacement fuel to the coal fired power plant boiler. Cofiring is used as one of the green boosters in the program to accelerate the increase in the use of renewable energy with a minimum investment due to using existing facilities at the existing PLTU. Therefore, the development of green energy sources is very important as an alternative fuel that is environmentally friendly. One form of developing green energy sources is by utilizing biomass as fuel. [3], [5], [7]

Biomass is organic material that can be used as an energy source and is renewable, such as wood, straw, rice husks and other agricultural wastes. However, because biomass has different characteristics from fossil fuels, such as higher water content and lower density, blending or mixing with fossil fuels such as coal can be done to increase combustion efficiency and reduce greenhouse gas emissions.[14], [22]

PLTU Pelabuhan Ratu is a power plant that uses coal as the main fuel. However, by utilizing the potential of existing biomass around the power plant area, it is expected to increase co-firing production and support the development of green energy sources. Therefore, an analysis of blending coal-

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biomass needs to be carried out to evaluate the efficiency and effectiveness of using the fuel mixture. [2], [6], [8]

II. METHOD

A. *SWOT (Strengths, Weaknesses, Opportunities, and Threats)*

The SWOT method is an analytical tool used to evaluate strengths, weaknesses, opportunities and threats in a particular situation or context. This method is often used in various contexts, including in business strategic planning, energy research, project development, and situation analysis involving various internal and external factors. The following is an example of a SWOT analysis of the use of biomass using the co-firing method in power plants in Indonesia.

B. *Equations*

Document analysis can assist in data collection techniques and identify the strengths and weaknesses of the technical and operational aspects of co-firing in PLTUs in Indonesia.

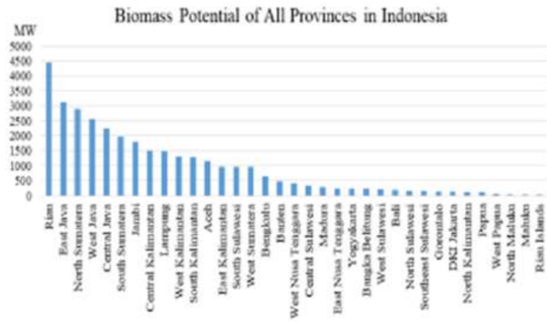
C. *Data analysis*

After Collect and analyze data on biomass production from reliable sources, such as relevant departments or statistical agencies. This data can be used to identify the potential use of biomass in Indonesia.
The following is an example of a SWOT analysis:

- Strength (Strengths):
  - What are the advantages of PLTU Pelabuhan Ratu in terms of infrastructure and resources that can support the implementation of cofiring?
  - How condition environment inaround PLTU Pelabuhan Ratu can support cofiring?.
- Weaknesses:
  - What are the internal barriers that might hinder the implementation of cofiring?.
  - How prepared is PLTU Pelabuhan Ratu in dealing with the changes needed for cofiring?
- Opportunities:
  - What external opportunities can PLTU Pelabuhan Ratu take advantage of to support cofiring?
  - How is the renewable energy market in the region developing, and how can the Pelabuhan Ratu PLTU take advantage of it?
- Threats:
  - What external obstacles could hinder the implementation of cofiring, such as changes in energy policy or competition from other energy sources?
  - How might environmental or social risks affect a cofiring project?

III. RESULTS AND DISCUSSION

Indonesia has great potential in utilizing biomass as a sustainable energy source. Biomass potential in Indonesia includes various sources, such as agricultural waste, forest waste and organic waste.[9], [12], [13]



Figures1Biomass Potential in All Provinces in Indonesia

Based on Figure 1, it can be seen that the largest biomass potential in Indonesia is in Riau Province, while the smallest potential is in the Riau Islands. Riau Province has enormous biomass potential because it has oil palm plantations covering an area of 2 million hectares out of the total area of Riau Province which reaches 8.7 million hectares. Meanwhile, the Riau Islands Province has the smallest biomass potential because it only has an area of 1 million hectares with 96% of its territory being marine waters.[5], [6], [7], [27]

Meanwhile, West Java Province, as the location of the Palabuhan Ratu PLTU province, occupies the top 4th position in Indonesia with an energy potential of 2.6 GW and Biomass potential with a radius of 100 km from the Palabuhan Ratu PLTU of 164,644 tons/year.[3], [4], [26]

A. *General Description of Research Objects*

PLTU Palabuhanratu is a Steam Power Plant (PLTU) located on Jalan Raya Cipatuguran Jayanti Village, Citarik, Pelabuhanratu District, Sukabumi Regency, West Java, Indonesia. This PLTU has a total capacity of around 3 X 350 megawatts (MW), which is an important source of electrical energy in the Java and Bali islands. As a coal-fired PLTU, Palabuhanratu PLTU uses coal as its main fuel to produce electricity. The process starts with burning coal in a boiler to produce heat. The heat is then used to convert water into steam in the boiler. The steam produced is fed to a steam turbine, which drives a generator to generate electricity.[1], [16], [20]

B. *Internal Factor Analysis*

TABLE OF INTERNAL FACTORS

Table 1 Table Of Internal Factors

No	Strength	Weakness
1	Indonesia has large coal resources as a raw material for steam power plants.	Produces carbon emissions as the main cause of pollution
2	PLTU is the main generator of electricity production in Indonesia	The low density of biomass during the rainy season will cause a high

No	Strength	Weakness
		moisture content of the biomass
3	Coal-fired electricity production is relatively easy compared to other plants	Biomass prices fluctuating causing there is no benchmark for the price of biomass
4	The facilities available at the Port PLTU are sufficient to implement co-firing	Biomass implementation has only occurred 5%
5	Fuel flexibility: Flexible cofiring can reduce operational risks	
6	Increase renewable energy mix: The use of biomass as a co-firing material in PLTU Indonesia can increase renewable energy mix in country	

C. *External Factor Analysis*

External factor analysis describes the various factors that influence the power company (PLTU Palabuhan Ratu) to develop strategies to reduce GHG emissions from outside. Technological factors that continue to develop are great opportunities for reducing emissions, because environmentally friendly technologies for energy management continue to be pursued to meet energy needs. External factors are in the form of company opportunities and challenges that have the potential to threaten the sustainability of the power plant company. External analysis is intended to capture opportunities while minimizing potential threats. Identification of external factors can be formulated in the analysis table as follows. [7], [17], [25]

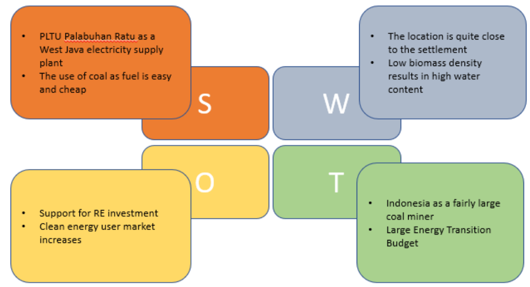
EXTERNAL FACTOR TABLE

Table 2 Table Of External Factors

No	Strength	Weakness
1	Biomass density that is low for mass production needs, such as PLTU Palabuhan Ratu, requires large areas of land for storage	Energy conversion and transition policies from fossil fuels
2	Large countries are returning to using fossil fuels, for example China	EBT investment is increasing
3	PLTU Power Purchase Agreement (PPA) until 2050	Public interest is increasing in environmentally friendly products
4		Environmental campaigns are getting easier through digital media

D. *SWOT analysis*

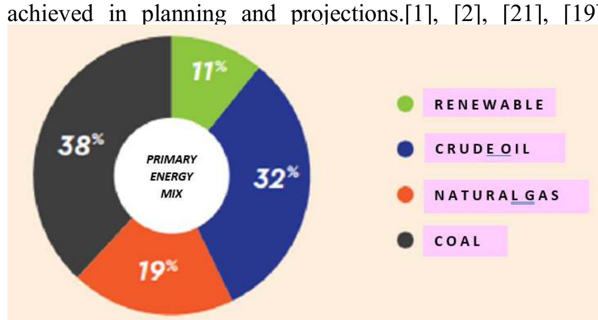
Data analysis in this research uses SWOT which is aimed at analyzing emissions reduction strategies at PLTU Cilacap. Analysis was carried out using internal and external analysis as a basis for strategy development. SWOT analysis is used to analyze existing conditions, formulate problem solving strategies, and collaborate on policies related to reducing emissions from the side of policy makers (Ministries and Institutions) and from the PLTU side as the company implementing the Power Plant. SWOT analysis includes policy components combined with current real conditions, namely policies, technological aspects, economic aspects and environmental aspects. The analysis aims to find the right strategy to achieve reducing GHG emissions in Indonesia in the form of reducing emissions from the Palabuhan Ratu PLTU.



Figures2SWOT Matrix

E. *Discussion*

The achievement target for reducing electricity generation emissions in Indonesia must certainly be in accordance with national energy policy. This is reinforced by Indonesia's commitment to a special mission to reduce emissions from fossil fuels. New and renewable energy is the main alternative in the emission reduction program so that massive EBT development continues to be carried out. However, in reality, up to now, the contribution of NRE to replace fossil fuel-based power plants, which in fact still dominate national electricity production, has not been able to meet the targets to be achieved in planning and projections.[1], [2], [21], [19]



Figures3 Current Energy Conditions in Indonesia

Most recently, the Ministry of Energy and Mineral Resources shows that the dominance of coal is still high in 2020 compared to other energy sources. However, the emissions from coal are very high, so a strategy is needed to reduce these emissions. The strategy that can be used to reduce emissions from electricity generation from fossil fuels is simply to reduce emissions using the co-firing method using biomass. [5],[7],[24],[18]

PROGNOSIS OF BIOMASS ABSORPTION SEMESTER 1 OF 2023

TARGET 1st SMT	21890	MWH
DEADLINE 1st SMT	30/06/2023	
TODAY	12/06/2023	
REMAINING TIME	18	DAY
REALIZATION	23521	MWH
REMAINING TARGET	-1635	MWH
NK BIOMASS	2995	KCAL/MWH
GREEN COEFISIEN KWH	1.02	
REMAINING TONNAGE	-1597	TON
USAGE PLAN		
DAILY	450	TON/DAY
WEEKLY	3150	TON/WEEK
ESTIMATED SEMESTER 1 TARGET REACHED		
DURATION	-4	DAY
DATE	08/06/2023	

TARGET 1st SMT	24079	MWH
DEADLINE 1st SMT	30/06/2023	
TODAY	12/06/2023	
REMAINING TIME	18	DAY
REALIZATION	23521	MWH
REMAINING TARGET	558	MWH
NK BIOMASS	2995	KCAL/MWH
GREEN COEFISIEN KWH	1.02	
REMAINING TONNAGE	546	TON
USAGE PLAN		
DAILY	450	TON/DAY
WEEKLY	3150	TON/WEEK
ESTIMATED SEMESTER 1 TARGET REACHED		
DURATION	1	DAY
DATE	08/06/2023	

COFIRING REALIZATION SMT-1 2023

JANUARY	1831.77	
FEBRUARY	5083	
MARCH	4242.75	
APRIL	4931.61	
MAY	5084.00	
JUNE	2347.04	
TOTAL	**23521.05**	**MWH**

COEFISIEN GREEN KWH

2415.00	0.76
4663.00	1.09
3946.00	1.08
4697.803	1.06
5020.00	1.01
2955.00	1.14
AVERAGE	1.02

Figures4. Semester 1 Data

Based on Figure 3, Semester 1 data which ran from January 2023 to June 2023 shows that the Palabuhan Ratu PLTU succeeded in exceeding the target of 110% biomass energy absorption using 450 tons/day and producing green kwh of 24079 MWH with a Biomass nik of 2995 Kcal/Kwh .

PROGNOSIS OF BIOMASS ABSORPTION SEMESTER 2 OF 2023

TARGET 2th SMT (100%)	44515	MWH
DEADLINE 2th SMT	31/12/2023	
TODAY	21/08/2023	
REMAINING TIME	132	DAY
REALIZATION	29711	MWH
REMAINING TARGETS	14804	MWH
NK BIOMASS	2995	KCAL/KWH
GREEN COEFISIEN KWH	1.12	
REMAINING TONNAGE	13194	TON
USAGE PLAN		
DAILY	460	TON/DAY
WEEKLY	3160	TON/WEEK
ESTIMATED SEMESTER 2 TARGET REACHED		
DURATION	29	DAY
DATE	19/09/2023	

TARGET 2th SMT	46957	MWH
DEADLINE 2th SMT	31/12/2023	
TODAY	21/08/2023	
REMAINING TIME	132	DAY
REALIZATION	19255	MWH
REMAINING TARGETS	14804	MWH
NK BIOMASS	2995	KCAL/KWH
GREEN COEFISIEN KWH	1.12	
REMAINING TONNAGE	13194	TON
USAGE PLAN		
DAILY	460	TON/DAY
WEEKLY	3160	TON/WEEK
ESTIMATED SEMESTER 2 TARGET REACHED		
DURATION	38	DAY
DATE	19/09/2023	

COFIRING REALIZATION SMT-2 2023

SEMESTER 1	**24410.56**	
JULY	2587.12	
AUGUST		
SEPTEMBER		
OCTOBER		
NOVEMBER		
DESEMBER		
TOTAL	29711.68	MWH

COEFISIEN GREEN KWH

SEMESTER 1	1.02
2380.00	1.09
2713.88	1.26
AVERAGE	1.12

Figures5Semester 2 Data

From Figure 4, the realization in semester 2 which occurred from July 2023 to December 2023, the realization of Biomass cofiring has reached 29711 MWH from the Semester 2 target of 44515 MWH. Semester realization has reached around 65% with a Biomass nk of 2995 Kcal/kwh.[6], [7], [11], [18]

IV. CONCLUSION

This research stage shows that Biomass cannot completely replace coal, even though the potential for Biomass is very large in Indonesia. At PLTU Palabuhan Ratu Co-Firing Biomass is only 5% of the main composition of PLTU Palabuhan Ratu itself, namely coal, where the coal requirement for PLTU Palabuhan Ratu is ± 14,350 tons per day and the Biomass requirement for Co-Firing needs is only ± 236,520 tons per year which can be concluded Biomass is only an effort to reduce GHG emissions with a target of 29% to 41% by 2030.

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