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Environmental Impact of Implementing Biomass Cofiring at Power Plant

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Abstract— This research examines the environmental impacts of implementing biomass cofiring in Steam Power Plants (PLTU). With increasing energy needs due to population growth and increasing living standards, the dominant use of fossil energy has become a major contributor to greenhouse gas (GHG) emissions. To overcome this problem, the use of renewable energy such as biomass in the cofiring process together with coal has been identified as a potential solution. This research uses qualitative methods by analyzing literature from various scientific sources over the last ten years which focuses on the environmental impacts of implementing biomass cofiring in PLTUs. The results show that biomass cofiring can significantly reduce GHG emissions, including CO2, SO2, and NOx, although challenges such as high costs for biomass collection and transportation still exist. The proposed solution includes optimizing the biomass supply chain and supporting government policies. With the right approach, biomass cofiring can support the transition to clean and sustainable energy.

Keywords— Biomass cofiring, Coal, Steam Power Plant, GHG Emissions,CO2,S02,NOx

I. Introduction

An increase in human population will encourage improvements in economic conditions and quality of living standards. Increasing human living standards will have an impact on high electrical energy consumption. Electrical energy is a basic need that is essential for economic development and social welfare. Continuous use of energy will cause an energy crisis and cause global warming because the energy sources used are fossil fuels which are the main cause of global warming and the main contributor to 25% of global Green House Gas (GHG) emissions [1].

Steam Power Plants (PLTU) using fossil fuels (coal) play an important role in energy supply, but also contribute significantly to greenhouse gas emissions and air pollution. Coal-fired power plants are the main source of CO2, SO2 and NOx emissions. To reduce GHG emissions by reducing the use of fossil energy, steps that can be taken are to use alternative energy, such as using renewable energy [2]. Biomass, as a renewable energy source, has the potential to reduce greenhouse gas emissions when used as an alternative or additional fuel in the cofiring process.

Cofiring is the process of burning a mixture of coal and biomass in the same boiler. Biomass cofiring has been introduced as a potential solution. This technology offers the benefits of reducing carbon emissions and increasing energy sustainability. The use of biomass energy as renewable energy has a significant contribution in that it can produce less CO2 than fossil fuel sources [3]. Burning coal and biomass contributes to reducing emissions, which shows that there is a synergy between the amount of biomass and the emissions produced [1].

Although fossil fuel power plants, especially coal, have contributed significantly to energy supplies throughout the world, we should not ignore the problems faced regarding their environmental impact. Air pollution and greenhouse gas emissions are important issues that need to be addressed urgently. It is important to take strategic steps to reduce these negative effects by incorporating renewable energy such as biomass. Cofiring, a mixture of coal and biomass combustion technology, offers a solution that can help reduce carbon emissions and support energy sustainability. By exploiting the potential of biomass as a renewable energy source, we can reduce our dependence on fossil fuels while reducing greenhouse gas emissions.

The aim of this paper is to determine the " Environmental Impact of Implementing Biomass Cofiring at Power Plant" to achieve a balance between energy needs and environmental sustainability.

II. Research Methodology

This research uses a qualitative approach, which analyzes the literature systematically. The steps in this research include literature searches, the literature referred to in this research is in the form of books, journals, theses/dissertations, as well as papers related to the title, filtering based on inclusion and exclusion criteria, and data extraction. The data used in this research are scientific publications over the last 10 years and focus on the environmental impacts of biomass cofiring implementation in power plants. The data is then analyzed to answer the research problem formulation. This method is a method that is suitable for use in research that aims to provide an overview of a particular problem or problem in this research [4].

III. Result and Discussion

Based on the results of the research that has been carried out, several articles were obtained

Table 1. Table results of journal review

No	Name	Research Title	Research result
1.	W. Wang (2023) [5]	Integrated Assessment of Economic Supply and Environment Effects of Biomass Co-Firing in Coal Power Plants: A Case Study of Jiangsu, China	The research results show that the potential supply of economically viable biomass for use as a co-fuel in coal-based power plants ranges from 0.7 to 12.5 million tons with a biomass price of between USD 50 and USD 100 per metric ton (MT). Co-burning of up to 20% biomass can replace a maximum of 10.2 million MT of coal when biomass prices reach USD 100/MT. Economic Impact Economically viable biomass production starts at a minimum price of USD 40/MT. Agricultural producers in Jiangsu will gain a profit of USD 463 million with a biomass price of USD 100/MT compared to a biomass price of zero.

			The total surplus earned by agricultural producers increases by 10% when the biomass price reaches USD 100/MT at a co-firing rate of 10%. The net greenhouse gas (GHG) environmental impact that can be achieved ranges from 3.2 to 59 million MT CO2e, with the greatest mitigation potential achieved at the highest biomass price of USD 100/MT and a co-burning rate of 20%. Total GHG emissions from residue-based electricity range from 211 to 325 g CO2e/kWh, much lower than coal-based electricity emissions of 1230 g CO2e/kWh.
2.	D. T. Nugraheni (2023) [1]	Environmental Impact Assessment of Co-firing Implementation at X Steam Power Plant, West Java	The research results show that co-firing coal with sawdust biomass has the potential for positive and negative environmental impacts. The results of this research show that co-firing coal with sawdust biomass can causing important reductions in impact categories such as GWP (0.13%), acidification (0.40%), and eutrophication (0.14%) but increases the potential for ozone depletion (0.72%).
3.	M. F. Ilham (2022) [6]	Cofiring Effect of Using Sawdust on Exhaust Emissions at the Steam Power Plant	PLTU cofiring has an influence on exhaust gas emissions, in evaluating the impact of exhaust gas emissions as a benchmark for environmental parameters, cofiring testing is carried out by referring to the Emission Quality Standards (BME). As a result, the exhaust gas emission test during cofiring was slightly higher than during coal firing but not significant. The good NOx value during cofiring is slightly higher than during coal

			firing but not significant and the NOx value both during cofiring and coal firing still meets the emission quality standard limits. The effect of cofiring using 5% sawdust still does not have a significant effect on flue gas emissions at CEMS (Continuous Emissions Monitoring System) PLTU considering that the percentage of biomass used is still very small.
4.	A. H. Truong (2018) [7]	Impact of Co-firing Straw for Power Generation to Air Quality: A Case Study in Two Coal Power Plants in Vietnam.	The results show that co-burning of straw in this power plant with a mixing ratio of 5% based on heat can reduce greenhouse gas emissions as well as air pollutant emissions (SO2, PM10 and NOx) from 3% to 13%. The improvement in air quality by removing thatch in large coal-fired power plants compared to open field burning is more than ten million USD per year. This is the same order of magnitude as the technical costs of co-firing.
5.	R. R. Kommalapati (2018) [8]	Life Cycle Environmental Impact of Biomass Co-Firing with Coal at a Power Plant in the Greater Houston Area	Result of studies show that life cycle air emissions of CO2, CO, SO2, PM2.5, NOX, and VOC can reduced by 13.5%, 6.4%, 9.5%, 9.2%, 11.6%, and 7.7% when 15% of coal was replaced with residue forest. Potential life cycle impacts decrease across the 9 midpoint impact categories, namely toxicity in human/aquatic, respiratory organic/inorganic, global warming, non-renewable energy, extraction minerals, water acidification, and terrestrial acidification/nitrification. Potential impact across categories impacts of damage/end points on human health, ecosystem quality,

			climate change, and sources power reduced by 8.7%, 3.8%, 13.2%, and 14.8% respectively for firing ratio together 15%.
6.	M. Verma (2016) [9]	Drying of biomass for utilization in co-firing with coal and its impact on the environment	Results of research on biomass drying and co-combustion with Coal-fired power plants are seen as raw materials Raw biomass contains large amounts of water vapor. Therefore, before use as fuel, it must be dried to increase combustion efficiency. Co-burning biomass with coal has a number of environmental benefits such as reduction of CO2, NOx, SOx, particulate matter, etc.
7.	D. W. C. Martinez (2017) [10]	An Evaluation Methodology with Applied Life-Cycle Assessment of Coal-Biomass Cofiring in Philippine Context	The results show that net GHG emissions have potential increased in the geographical area studied with the use of cofiring, especially portioned cofiring higher biomass, which is largely due to additional emissions from transport biomass from the field to the power plant site. However, potential avoidable emissions from reduced sea transportation of coal imports due to the potential movement of biomass has not been considered in this study. this factor can lead to significant reductions in net GHG emissions within and outside the region geographical area studied through coal-biomass burning.
8.	M. Nurariffudin (2017) [11]	Opportunities of biomass co-firing with coal for CO2 mitigation in Malaysia: A spatially-explicit assessment	The results show that up to 1.31 million tons of CO2 can be minimized annually in Johor through co-firing practices. The cost factor for implementing co-firing technology in existing coal-fired power plants ranges from 59.17 to 60.01 USD/MWh. The difference is very small if you factor in the

			cost of fossil fuel power generation which is at 59.49 USD/MWh compared to the highest cost factor of co-firing technology. With these results, it should be possible to encourage the implementation of bioenergy on a large scale in industry.
9.	L. E. Arteaga-Pérez (2015) [12]	Life-Cycle Assessment of coal–biomass-based electricity in Chile: Focus on using raw vs torrefied wood	The research results show that Energy production from burning unprocessed coal/wood pellets or dried coal/pellets, shows a significant reduction in environmental impact, compared to pure coal-fired power plants. Indeed, reduced acidification (28-26%), abiotic depletion (15-7%), eutrophication potential (15-12%), global warming potential (16-6%), photochemical oxidation (28-23%), human toxicity (17-15%), terrestrial ecotoxicity (12-9%), and marine ecotoxicity (17-15%) is obtained when unprocessed or processed pellets are used instead of coal.
10.	L. J. R. Nunes (2014) [13]	Biomass waste co-firing with coal applied to the Sines thermal power plant in Portugal.	The research results show that there are advantages to the system of using biomass waste as fuel in coal-fired steam power plants. Combustion of biomass waste, from forestry operations, with bituminous coal showing reduced CO2 emissions into the atmosphere from the Sines Geothermal Power Plant in Portugal more than 1,000,000 tons of CO2 per year.

Potency

Co-firing biomass with coal in steam power plants (PLTU) has great potential to provide significant environmental benefits. Studies have shown that co-firing can drastically reduce greenhouse gas emissions, especially carbon dioxide (CO2), which is a major contributor to climate change.

A study by [13]entitled "Biomass waste co-firing with coal applied to the Sines thermal power plant in Portugal", shows that the use of forest biomass in co-firing can reduce CO_2 emissions by more than one million tonnes per year. Apart from that, research in Malaysia[11]with the title "Opportunities of biomass co-firing with coal for CO_2 mitigation in Malaysia: A spatially-explicit assessment" indicates that with co-firing, CO_2 emissions can be reduced by up to 1.31 million tonnes per year. This reduction in emissions occurs because biomass has a lower carbon content compared to coal, so that when it is burned, the emissions produced are much less.

Apart from CO_2, co-firing also has the potential to reduce emissions of other dangerous gases such as sulfur dioxide (SO_2) and nitrogen oxides (NO_x). Research shows that biomass contains less sulfur than coal, which means burning biomass produces less SO_2.

Study [6]with the title "Cofiring Effect of Using Sawdust on Exhaust Emissions at the Steam Power Plant" at PLTU Pelabuhan Ratu, Indonesia, also shows that co-firing with sawdust can reduce NO_x emissions although the increase in particle emissions still needs to be watched out for.

Overall, this research shows that co-firing biomass with coal has great potential to reduce greenhouse gas emissions and support the clean energy transition.

Challenges Faced

Studies conducted in various journals on the potential for co-burning biomass with coal reveal a number of challenges.

Co-firing biomass with coal in steam power plants (PLTU) faces a number of significant challenges despite its potential for large environmental benefits. One of the main challenges is the high costs associated with biomass collection, processing and transportation. Biomass often has a lower energy density and higher moisture content than coal, requiring a drying and grinding process before it can be used in co-firing. This process increases operational costs and can reduce the economic benefits of co-firing. Apart from that, the cost of transporting biomass which is spread out and often located far from the PLTU also adds to the cost burden [13].

To overcome these challenges, several solutions have been proposed and tested. One solution is optimizing the biomass supply chain through the use of geographic information systems (GIS) and mixed integer linear programming (MILP) to determine the optimal location of biomass processing facilities and the most efficient transportation routes. In this way, transportation costs can be reduced and biomass supply can be managed more efficiently [11]. In addition, biomass processing technologies such as torrefaction and pelletization can be used to increase energy density and reduce biomass moisture content, thereby increasing combustion efficiency and reducing transportation costs [13].

Policy support and incentives from the government are also very important to encourage the adoption of co-firing technology. Incentives such as feed-in tariffs and subsidies for the development of biomass processing infrastructure can help overcome economic barriers and accelerate the adoption of these technologies in the energy industry. With a holistic approach and adequate support, the challenges faced in implementing biomass co-firing in PLTUs can be overcome, so that the environmental and economic benefits of this technology can be fully realized.

IV. Conclusion

Implementation of biomass cofiring in PLTUs has great potential to reduce greenhouse gas emissions and other air pollutants. Based on various studies, the use of biomass in cofiring can reduce CO_2 emissions by up to millions of tonnes per year. Biomass has a lower carbon content than coal, so it produces fewer emissions when burned. In addition, biomass also contains less sulfur, which means burning biomass produces less SO_2. Research shows that cofiring with biomass can reduce NO_x and particulate emissions, although some studies show increased particulate emissions that need to be watched out for.

However, implementing biomass cofiring also faces challenges, including high costs associated with biomass collection, processing, and transportation. Biomass often has high water content and low energy density, requiring a drying and grinding process before it can be used. Proposed solutions to overcome this challenge include optimizing the biomass supply chain with the use of GIS and MILP technology, as well as policy support and incentives from the government to encourage the adoption of cofiring technology.

Thus, implementing biomass cofiring in PLTUs can be an effective solution for reducing greenhouse gas emissions and supporting energy sustainability, provided that technical and economic challenges can be overcome with a holistic approach and adequate support.

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