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Renwable Bio Resource For Energy (A Sustainable Stratgey For Environmenmtal Protection, Cost Optimaztion and Rural Development)

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Abstract: *The growing dependence on fossil fuels has led to serious environmental degradation, rising carbon emissions, and economic challenges. This paper presents a successful industrial case study on the large-scale utilization of renewable bio-resources for energy generation, demonstrating substantial environmental, economic, and social benefits. In our plant by replacing some coal quantity with biomass fuels such as rice husk, bagasse pith, wood dust, and patta kutty in industrial boilers Biomass fuels, being carbon neutral, contribute directly to climate change mitigation while promoting effective utilization of agricultural and forestry waste.*

Additionally, coal substitution resulted in major cost savings in our plant, improving operational economics. To ensure boiler reliability, advanced technological modifications were implemented, including studded bed coil protection and fuel cap design enhancement, which improved thermal efficiency, reduced erosion, and extended boiler life. This initiative also strengthened rural economies by creating local employment across biomass collection, processing, and transportation chains. The study highlights renewable bio-resources as a vital component of future sustainable energy systems.

Keywords: *Renewable Energy, Biomass Fuel, Carbon Neutral, Boiler Modification, Rural Development, Waste Utilization, Sustainable Industry*

Introduction

India's rapid industrial growth has significantly increased energy demand, traditionally fulfilled by fossil fuels such as coal. While coal remains a reliable energy source, its environmental impact, high cost, and carbon footprint pose serious sustainability challenges. The transition toward renewable and carbon-neutral energy sources is no longer optional but essential for achieving national climate goals and ensuring long-term industrial viability.

Renewable bio-resources such as agricultural and forestry waste offer an effective are abundantly available, renewable, and carbon neutral. Their utilization not only reduces greenhouse gas emissions but also addresses waste disposal issues and supports rural livelihoods.

This paper documents our industry's strategic reduce coal quantity to maximum biomass fuel in boiler operations, highlighting the environmental benefits, cost savings, technological innovations, and socio-economic impact. The initiative aligns with ethical industrial practices and reinforces our commitment to environmental responsibility and sustainable development.

Materials and Methods

Biomass Fuel Selection

The primary biomass fuels used include:

- Rice husk
- Bagasse pith
- Wood dust
- Patta kutty
- Wood-Chips

Note - Patta Kutty is a seasonal biomass fuel made from leaves, wood pieces and twigs of eucalyptus trees, which are collected during pruning and harvesting.

These fuels are sourced seasonally from agricultural and forestry residues, ensuring efficient waste utilization and continuous fuel availability.

Boiler Fuel Replacement Strategy

Coal consumption in boilers was progressively reduced and replaced with biomass fuels. Fuel blending ratios were optimized to maintain stable combustion, heat output, and operational safety.

Challenges in Biomass Fuel in AFBC Boiler

- High erosion of Evaporator bed coils
- Erosion of Economiser outer coils
- Erosion and frequent choking of APH Tubes
- Erosion of ESP collecting plates and Body casing
- Thermal efficiency is less by around 1.5%

Technological Modifications

To ensure boiler health and reliable operation with biomass fuels, the following modifications were implemented:

1. **Studded Bed Coil Protection**
   - o 360-degree studded bed coils installed near and above fuel feeding nozzles to protect against direct erosion impact
   - o 270-degree and 180-degree studded coverage in selected zones to balance heat pickup and durability
2. **Fuel Cap Modification with SS Ring**
   - o Improved fuel distribution
   - o Reduced localized overheating
   - o Enhanced combustion stability

These modifications were designed to reduce wear, improve heat transfer, and extend boiler lifespan.

Results and Discussion

Environmental Benefits

- Lower Emission of CO2, SO2, Nox & SPM as compared to Coal

The use of biomass fuel resulted in substantial CO_2 emission reduction:

- FY 2024–25 : 290,076 tons CO_2
- FY 2025–26 (April–December) : 316,592 tons CO_2

As biomass is carbon neutral, the carbon released during combustion is offset by carbon absorbed during plant growth, making it a sustainable energy solution.

Economic Benefits

Reducing coal with lower-cost biomass fuels generated significant cost savings:

- FY 2024–25 : INR 14.81 crore
- FY 2025–26 (April–December) : INR 16.05 crore

These savings improved operational efficiency and enhanced financial sustainability.

Boiler Performance and Reliability

The technological modifications delivered multiple benefits:

- Reduced erosion and wear of bed coils
- Uniform heat distribution
- Improved thermal efficiency
- Extended coil lifespan
- Reduced maintenance frequency
- Enhanced operational safety

This demonstrates that with proper engineering design, biomass fuels can be reliably used in industrial boilers without compromising equipment health.

Rural Development and Employment Generation

Biomass procurement is seasonal and regionally distributed, creating employment opportunities in:

- Collection
- Processing
- Storage
- Transportation

This decentralized fuel supply chain boosts rural incomes, supports farmers, and strengthens regional economies, contributing directly to inclusive growth.

Conclusion

The transition from coal to renewable bio-resources for energy generation represents a practical, economically viable, and environmentally responsible strategy for modern industries. Our experience demonstrates that large-scale biomass utilization can significantly reduce carbon emissions, lower energy costs, and promote rural development while maintaining boiler safety and performance through appropriate technological upgrades.

By effectively utilizing agricultural and forestry waste, industries can address environmental challenges, support circular economy principles, and create sustainable employment opportunities in rural areas. The successful implementation of studded bed coil protection and fuel system modifications confirms that technology plays a crucial role in enabling renewable energy adoption.

Renewable bio-resources are not merely an alternative fuel but a key pillar of future energy systems. Our industry remains committed to ethically firm and environmental strong and continuous technological innovation, setting a replicable model for sustainable industrial energy transformation.