Towards Net Zero and Decarbonisation: Technical Evaluation of Biomass–Solid Fuel Co-Firing for Emissions Reduction and Operational Feasibility at a Thermal Plant in Malaysia

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Abstract

In pursuit of Malaysia's Net Zero 2050 target, a biomass co-firing investigation was undertaken at a 300 MW sub-critical pulverized-fuel boiler (Unit 3), integrating empty fruit bunch (EFB) pellets at a substitution rate equivalent to 1.45% of total thermal input on a calorific basis. The study sought to quantify the impacts of partial biomass displacement on combustion performance, gaseous emissions, and plant operability under commercial-scale conditions, while ensuring full compliance with the Clean Air Regulation 2014 (CAR14) stipulated by the Department of Environment (DOE). Experimental results indicated a net reduction of 7% in nitrogen oxides (NO_x) and 11% in sulfur oxides (SO_x) relative to baseline solid-fuel operation, with negligible perturbation to steam cycle integrity, as evidenced by stable main steam temperatures, pressures, and economizer outlet profiles. Visual and boroscopic inspections confirmed only superficial ash deposition consistent with expected fouling behaviour, and no significant slagging was observed across furnace walls, superheaters, reheaters, or economizer sections. Thermodynamic and milling system analyses further established that beyond a 3% calorific substitution threshold, elevated mill differential pressure and motor loading may impose operational constraints, thereby delineating a practical limit for co-firing ratios in this unit configuration. These findings substantiate the technical feasibility of EFB pellet co-firing as a decarbonisation strategy for sub-critical solid-fuel-fired power plants, offering quantifiable emissions abatement while preserving unit reliability, and provide an empirical reference for scaling biomass integration within Malaysia's transitional energy framework.