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Evolution of palm oil mills into bio-refineries: Technical and environmental assessment of six bio-refinery options

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This paper reports the mass and energy balances, the carbon foot print, eutrophication potential and the Net Energy Consumed (NEC) per ton of Fresh Fruit Bunch (FFB) processed for six concepts that could be implemented to convert existing Palm Oil Mills (POMs) into bio-refineries. These parameters were also calculated per ton of product obtained using an allocation strategy based on the contribution of each product to the total sales of the bio-refinery. These bio-refinery concepts were developed as part of an evolution strategy consisting in the hypothetical gradual addition of emerging technologies to POMs. The technologies added to build new bio-refinery concepts were: (i) Production of biogas from the anaerobic treatment of the Palm Oil Mill Effluents (POME) and its utilization for electricity generation, (ii) Composting of Empty Fruit Bunches (EFB), oil palm fiber (fiber) with POME and electricity generation from biogas, (iii) High pressure steam Combined Heat and Power (CHP) unit for the utilization of 100% of the biomass and biogas combustion for the production of electricity, (iv) Pellets production from dried biomass and biogas production and combustion in a gas engine, (v) Bio-char production and combustion of pyrolysis vapors for heat recovery, and (vi) Bio-char and bio-oil production plus biogas and syngas combustion. The studies were conducted using as starting point (or baseline) a traditional POM technology with a throughput capacity of 30t Fresh Fruit Bunches (FFB) h^{-1}. The baseline scenario was created using averaged data from POMs and oil palm plantations in Colombia. The results of the mass and energy balances of the studied bio-refinery concepts allow us to conclude that the available biomass residues used in integrated bio-refineries schemes could result in the production of up to: 125 kWh t FFB^{-1} electricity, 232 kg t FFB^{-1} compost, 125 kg t FFB^{-1} pellet, 46 kg t FFB^{-1} bio-char and 63 kg t FFB^{-1} bio-oil. The carbon footprint based on a life cycle assessment of the bio-refinery concepts studied concludes that, compared with the baseline case studied, reductions in the range from 12 to 76% could be achieved through products diversification.

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