



# Techno-economic analysis and environmental impact assessment of a 10 MW biomass-based power plant in Malaysia



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## ABSTRACT

Considering that renewable energy is the primary energy source in the future, this study investigates biomass power for sustainable and secure energy supply. Biomass fuels in Malaysia include empty fruit bunch, mesocarp fiber, palm kernel shell, oil palm frond, oil palm trunk from palm oil plantation, and woody biomass from forests. The moisture content and heating value of palm oil-based biomass fuels are analyzed relative to their cost savings in a 10 MW biomass power plant. The net present value, internal rate of return, and payback period for various finance options and at various system efficiencies are also presented. Results indicate that for an empty fruit bunch priced at MYR 20/t without loan, the net present values are MYR 45.31 million, MYR 54.32 million, and MYR 57.74 million, with 20%, 30%, and 40% system efficiencies, respectively; the internal rates of returns are 21.88%, 22%, and 21.11%, respectively; and the payback periods are 4.16, 4.20, and 4.22 y, respectively. The 10 MW plant releases 50,130 t less CO<sub>2</sub>, 750 t less SO<sub>2</sub>, 218.65 t less NO<sub>x</sub>, and 22.83 t less CO emissions in the environment compared with the existing energy mix.

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## 1. Introduction

Energy is the key input and a basic need for social development, economic growth, and modernization. Energy consumption continuously increases worldwide (Climent-Font and Perlado, 2013; Hasanuzzaman et al., 2012; Abdelaziz et al., 2011). The power consumption in five ASEAN countries (i.e., Indonesia, Malaysia, Philippine, Thailand, and Vietnam) increased by nearly three times in the past 20 years (1990–2010) (Vithayasrichareon et al., 2012). The demand for the continuous development of power generation mainly depends on the use of fossil fuels (Bazmi and Zahedi, 2011; Johansson, 2013). Natural gas, coal, and petroleum products are the major primary sources of energy. IEA, 2012, more than 92% of power generated in Malaysia was from fossil fuel power plants (coal, 48.3%; oil, 7.4%; natural gas, 39.4%; and fuel oil, 4.7%) (STM, 2012). The use of coal, oil, and natural gas severely pollutes the

environment. Among the ASEAN countries, Malaysia produces the highest level of emissions, as shown in Fig. 1 (IEA, 2013); the emission levels in the country continuously increases. In 2005, the emission level in Malaysia was 189 million tCO<sub>2,eq</sub>, which will reach 328 million tCO<sub>2,eq</sub> by 2020 (CDM, 2013). The power sector in Malaysia will produce 47% of the total emission by 2020 compared with only 32% in 2005 (Lim and Lam, 2014; Mok et al., 2014).

Malaysia has pledged to reduce its carbon emission intensity by 40% (2005 level) by the year 2020 (Hossain et al., 2015). According to a report by the Intergovernmental Panel on Climate Change (IPCC), global warming will continue to increase unless a quick shift toward clean energy is performed (Hosenuzzaman et al., 2015). To mitigate greenhouse gas (GHG) emission and ensure energy security, researchers aim to discover alternative energy sources (Climent-Font and Perlado, 2013; Gonzalo et al., 2013; Johansson, 2013). Renewable sources (i.e., biomass, hydropower, solar, wind, geothermal, ocean energy) are sustainable and clean (Ahmed et al., 2013; Hasanuzzaman et al., 2015; Sanaeepur et al., 2014).

Malaysia is rich in renewable energy (RE) resources, such as palm oil and rubber plantations, forest residues, and agricultural

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