

Greening The Fields: How Renewable Energy Enhances Oil Palm Plantation Operations

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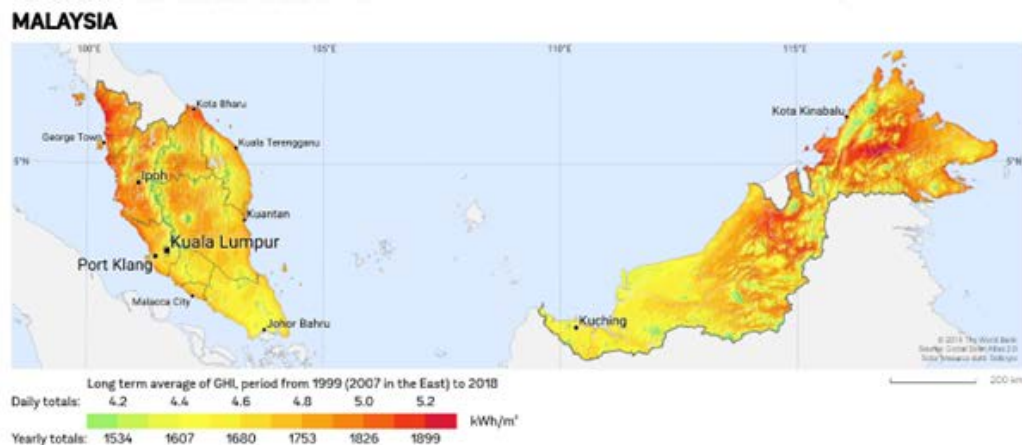
INTRODUCTION

The oil palm industry plays a significant role in the global economy, providing a versatile and highly efficient vegetable oil that is widely used in various sectors. However, concerns have been raised about the environmental impact of oil palm plantations, particularly about deforestation and greenhouse gas emissions. In the context of oil palm estates, renewable energy can play a crucial role in powering various operations such as irrigation systems, processing plants, and employee facilities. By harnessing natural resources like sunlight, wind, and biomass, oil palm estates can significantly reduce their reliance on non-renewable energy sources while contributing to overall environmental conservation efforts. Solar systems, biomass energy, and hydropower are among the most used renewable energy sources in agriculture and have been identified as viable options for oil palm estate operations as well. The application of renewable energy technologies in agriculture offers a range of benefits, including reduced operational costs, lower environmental impact, and greater energy independence. In addition to cost savings, renewable energy systems also contribute to environmental sustainability by reducing greenhouse gas emissions. Moreover, by utilising renewable energy sources in oil palm estate operations, the estates can showcase their commitment to sustainable and environmentally friendly practices. The application of renewable energy technologies in oil palm estate operations can have a significant impact on sustainability and cost-effectiveness (Kodirov *et al.*, 2020). This article explores how renewable energy enhances oil palm plantation operations and contributes to a greener and more sustainable future for the industry.

POTENTIAL ENERGY RESOURCES IN OIL PALM ESTATE

Solar power has emerged as a promising solution for oil palm plantations. The large land surface area available in plantations makes them ideal for the installation of solar panels. By harnessing solar energy, plantations can generate electricity to power their operations, reducing their reliance on fossil fuels. Malaysia receives between 300 and 600 MJ/m² of solar radiation on average every month (Muzathik, 2013). Malaysia's northern area receives more solar radiation than its southern portion, with yearly solar radiation ranging between 4.21 and 5.56 kWh/m²/d (Mekhilef *et al.*, 2012). *Figure 1* shows Malaysia's Global Horizontal Irradiation (GHI) from 1999 until 2018 (solargis.com).

Harnessing solar power in oil palm estates allows for greater energy independence. The estates can reduce their reliance on external energy suppliers and insulate themselves from fluctuating energy prices. Solar potential applications for oil palm plantations can be explored through optimised system designs, incorporation of other renewable energy sources and development of smart energy management systems. This approach enables oil palm plantations to minimise their environmental impact, attain sustainable energy independence and contribute to the transition towards cleaner energy for the future. A study conducted by Azwan *et al.*, (2017) explored the integration of photovoltaic (PV) technology into electric vehicles (EVs) in oil palm plantations. Despite the palm oil canopy blocking sunlight, the study revealed that solar energy had the potential to meet approximately 30% of the energy consumption. In another study by Azwan *et al.*,



Source: solargis.com.

Figure 1: Malaysia Global Horizontal Irradiation (GHI)

(2019), they tested a solar-powered system on a three-wheeled agricultural vehicle for spraying herbicides in oil palm plantations. The solar system provided power to the spraying mechanism and charged the battery. The study found that even with a small solar capacity, there were benefits such as extra power, stable battery levels, and easy setup.

Biodiesel, a renewable energy source has gained significant popularity as a petroleum-based diesel substitute in transportation. The introduction of palm oil biodiesel in Malaysia in 2011 has opened up opportunities for new technological developments. Sasmito *et al.*, (2022) investigated the performance of a four-wheeled tractor engine using a variety of biodiesel blends. B20 was found to have the highest efficiency of any continuous engine, whereas B100 had the lowest efficiency. In another study by Aybek *et al.*, (2011), B20 was found to be the most suitable biodiesel blend for tractors, maximising power take-off (PTO) and minimising specific fuel consumption when the tractor engine was running at 2100 RPM. While, Palled *et al.*, (2014) also discovered that B20 derived from Karanja biodiesel showed similar fuel consumption and efficiency as petroleum diesel when tested on an agricultural tractor at various speeds. The study also revealed that driving speed had a greater impact on the tractor's tiller performance compared to the biodiesel blends. In summary, studies conducted by various researchers on biodiesel blends have consistently shown that B20 performs comparably to petroleum diesel in terms of performance and fuel economy. Therefore, the utilisation of biodiesel or biodiesel blends in oil palm plantations can offer environmental benefits to users.

Biomass energy derived from the waste generated by the oil palm plantation, such as empty fruit bunches and palm kernel shells, offers a promising renewable energy source for the estates. This waste-to-energy approach not only helps in managing waste efficiently but also provides a sustainable alternative to fossil fuels for powering various operations within the estate. Oil palm estates can reduce their carbon footprint and mitigate the environmental impact associated with waste disposal. Additionally, this transition to renewable energy sources can contribute to a reduction in greenhouse gas emissions, savings on fuel expenditures, and improvements in the environmental sustainability of oil palm plantation operations (Shuit *et al.*, 2009).

Wind energy is another form of renewable energy that can be used in various sectors, including oil palm plantations. If the geographical location of the oil palm estates has sufficient wind resources, wind turbines can be installed to harness wind energy. The electricity generated from wind can then be used to power plantation operations, irrigation systems, processing facilities, or even to charge battery-operated vehicles and machinery used on the plantation. However, it is important to note that the effectiveness of wind energy depends greatly on the local climate and topography, and it may not be as viable in regions where the oil palm estates are located if those areas do not experience consistent and strong winds. In terms of oil palm plantation sector energy needs, biomass is often a more readily available and directly linked renewable energy resource, given the by-products of the industry itself.

CHALLENGES AND STRATEGIES

Implementing renewable energy solutions in oil palm estates comes with several challenges. One major obstacle is the initial investment required for installing the necessary infrastructure and equipment. The cost of solar panels and biodiesel production facilities make it difficult for oil palm estate owners to justify the expense. Additionally, integrating renewable energy systems into existing operations may require modifications to the estate's infrastructure and operations, which can further add to the costs and complexities of implementation. Another challenge is the variability of renewable energy sources. Solar energy generation can be affected by weather conditions, while biodiesel and biomass production depend on the availability of feedstock materials. This variability can impact the reliability and consistency of the energy supply, making it necessary to develop backup systems or alternative energy sources to ensure an uninterrupted power supply for the oil palm estate.

Developing environmentally friendly technologies suitable for oil palm plantation operations is important, but it still depends on many factors, such as terrain, soil type, source, skills, *etc.* Despite these challenges, adopting green technologies is necessary to improve the sustainability of Malaysian oil palm plantations. One approach is to engage in partnerships and collaborations with renewable energy technology providers, government agencies, and NGOs that can provide financial and technical support. This can help alleviate the financial burden and provide expertise in designing and implementing renewable energy systems. Another strategy is to identify cost-saving opportunities and develop business models that can help offset the initial investment. This could include selling excess energy back to the grid, utilising waste products or by-products from oil palm processing to generate energy, or exploring opportunities for carbon credits or renewable energy certificates. Overall, implementing renewable energy solutions in oil palm estates requires careful planning, collaboration, and innovative thinking to overcome challenges and make the transition towards sustainable energy sources.

CONCLUSION

The integration of renewable energy technologies in oil palm estates holds immense promise for fostering

profitability, environmental sustainability, and overall resilience. By embracing renewable energy sources such as solar, biomass, and wind, these estates can significantly reduce operational costs, minimise their environmental impact, and enhance their market competitiveness. As oil palm estates continue to prioritise renewable energy adoption, they are not only positioning themselves as leaders in sustainable agriculture but also contributing to the broader industry transformation towards greener and more resilient practices. The collective commitment to a greener and more sustainable future for agriculture showcases the potential for significant positive impacts on both the economic and environmental fronts. In conclusion, the application of renewable energy in oil palm estate operations offers numerous benefits, including cost savings, environmental sustainability, and increased market competitiveness.

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