SOLAR PHOTOVOLTAIC PANEL COMPACT BIN: A PRELIMINARY SUSTAINABILITY ASSESSMENT IN UNIVERSITI MALAYSIA PAHANG

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Abstract

Globally, waste keeps increasing every year due to several factors. Thus, managing this waste will be considered a major economic and environmental challenge. The idea of developing the compact solar energy bin with an intelligent system could reduce the burden to the environment, as well as the cost associated with waste collection activity. The built-in system with an Arduino microcontroller was applied to monitor the level of fullness and triggered automatic compacting. This may increase the capacity of the bin up to 5 times. The results indicate that transportation costs could be reduced by at least 30% and Global Warming Potential impact decreased from 18.5 tonnes to 6.2 tonnes annually. The Solar Photovoltaic Panel Compact Bin has the potential to support not only waste management, but has an edge in the economy and the environment.

Keywords Solar powered waste, economic, environment.

Introduction

The concern of waste generation has triggered the technologies to find innovative solutions associated with waste management. In Malaysia, at least 1.17 kg/day of waste was generated per capita and more than 80% will end up in landfills (Yong et al., 2019).

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Faculty of Civil Engineering Technology, UMP Research Series: Water, Energy, and Environment, Vol. 1, [insert doi here later]

According to a previous study, food waste, paper and plastic are the highest compositions of waste generated from one of the institutions in Malaysia (Zulkifli et al., 2019). Waste collection activities were identified as one of the major problems due to the high cost of operating expenses such as labour, fuel and maintenance (Babaee Tirkolaee, Abbasian, Soltani, & Ghaffarian, 2019). Commonly, vehicle-mounted collection units will be used to handle the waste managed by local authorities.

Compacting waste management has been used for many years. This procedure involves the use of a compactor to reduce the solid waste and normally was applied in the landfills. Therefore, the idea to utilise a similar technology at the collection point could reduce the frequency of trips. It is also expected could minimise the cost and emission released by the waste collector transportation. In addition to that, solar photovoltaic (PV) will be installed together with this compacted bin, so that it could run with zero energy from the grid. This bin automatically compacts the waste when the inner surface reaches a certain level. This process continue until the waste is collected.

This Solar PV Compact Bin is a portable bin designed to have the capability to store up to five times more waste than a standard bin. Thus, this study aims to determine the impact on the economy and environment of this invention if it will be installed in the UMP areas. The result from this study could give an overview to the UMP to implement this project to support the green campus ideas.

Methodology

Model development

A cost-benefit model based on Excel was developed to evaluate the economic and environmental gains from implementing the Solar PV Compact Bin for waste management in UMP areas. The study includes the variables influencing waste transport, including workers per truck, fuel economy and location factors which shown in Table 1. The Global Warming Potential (GWP) impact was

derived as Equation 1 from the emission of diesel consumed in the transport-related. Carbon dioxide (CO_2) and nitrogen oxides (NO) emissions are determined directly from emission coefficients for diesel, which are 2.7 kg/L and 0.005 kg/L, respectively (US EPA, 2015).

$$GWP\ (kg\ CO2\ eq) = Volume\ od\ diesel\ fuel\ consumed\ (L)\ \times Emission\ factor \quad (1)$$

The model was simulated using the parameters below.

Table 1: Assumption and parameters that are being used in the simulation.

Assumption / Variables	Value	units	
Total pickup points in UMP	7	-	
Distance amongst pickup within UMP	0.1	km/ point	
The average time at each bin pickup points	4	minutes	
Effective working hour	8	hr/d	
Workers per truck	2	person	
Labour cost	93.75	RM/hr	
Average truck speed on the highway	75	km/hr	
Average truck speed within the city centre	50	km/hr	
Distance from landfill to UMP	48	km	(SWCorp, 2020)
Trash truck fuel economy	4.46	L/km	(Davis, S. C., & Boundy, 2020)
Idling at stop fuel	3.78	hr/L	(Davis, S. C., & Boundy, 2020)

Assumption / Variables	Value	units	
Average time idling at stoplights during travel within the highway	13	minutes	
Diesel price	2.18	RM/L	(CompareHero. my, n.d.)

Location of research

In this assessment, the solar PV compact bin was assumed to be in the seven pickup points in UMP Gambang campus, as shown in the figure below.

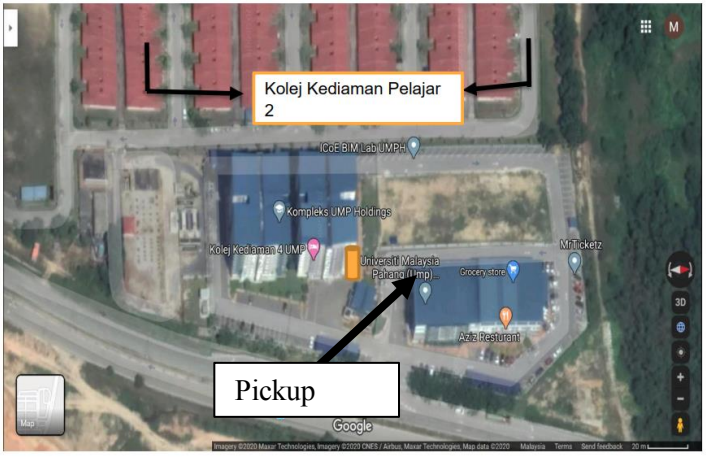

Figure 1: Trash pickup point within KK4

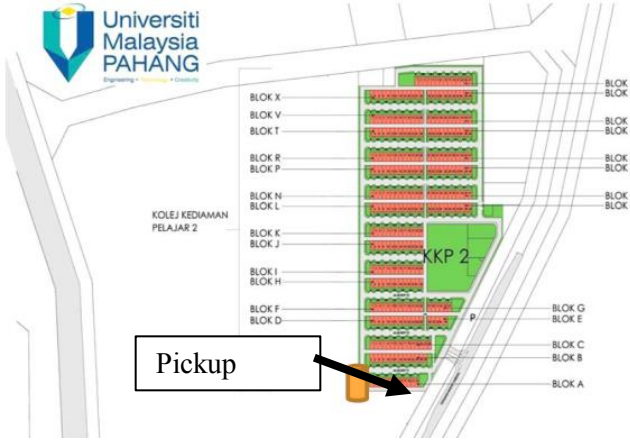

Figure 2: Trash pickup point within KK2

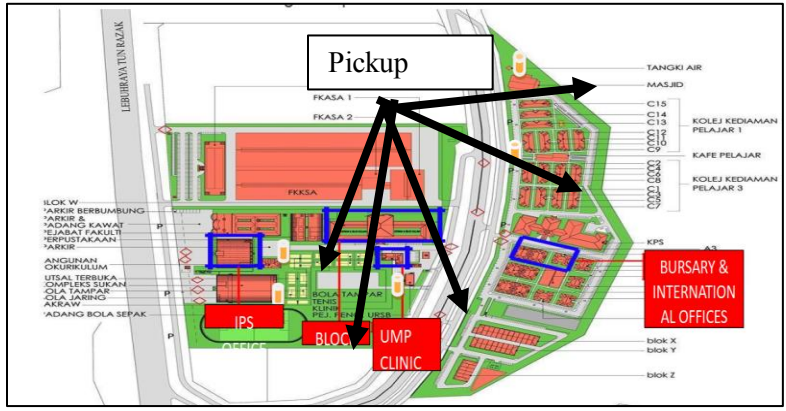

Figure 3: Five-point for trash pickup point within UMP main location.

The landfill location is assumed to be in Terang Bersih, Jalan Beserah, Kuantan. This is the nearest landfill to the UMP Gambang campus. The distance between these two places is indicated in Figure 4.

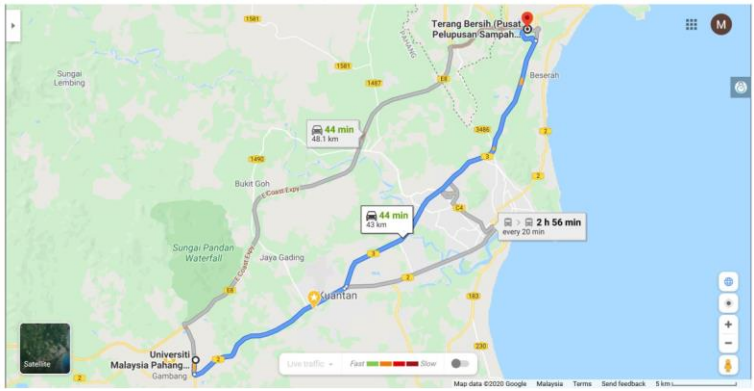

Figure 4: Location of the waste landfill in Terang Bersih

Result and Discussion

Table 2 shows the economic impact before and after the implementation. The calculation is based on the bin capacity; the trip needed for trash collection will be reduced by one trip per week while indirectly projecting the annual expenditure for waste collection operation. The anticipated cost-benefit model reduction, which will be used to determine the SWCorp before and after adopting the product. The annual expenses are minimised significantly from RM 30,442.57 to RM 10,147.52, which is a 30% reduction by only exploiting the product. Furthermore, the labour cost declined significantly. This reduction grants the benefit of moving or transferring the workforce to other sectors, and providing more workforce to open jobs.

Table 2: Economic performance before and after implementation

	Before implementation	**After implementation**
Fuel (litre/trip)	87.20	29.06
Labour cost (RM/year)	16,200.00	5,400.00
Total cost (RM/year)	30,442.57	12,147.52

The GWP analysis is another potential benefit to show the sustainability of product implementation. The impact was evaluated from the transport-related emission. From the analysis, it managed to shape the decline of the GHG emission that affected the worldwide GWP. The GHG discharge of CO_2 is reduced from 18.497 tonnes to 6.166 tonnes kg equivalent annually, while NO emitted a minuscule amount of 132.70 grams from 398.11 grams per year.

Furthermore, the PV system's usage as the internal power source for this compact bin reduces fossil fuel burning, directly abolishing the fossil fuel consumption for the waste compact bin and pollutant to the atmosphere.

Conclusion

An excel-based model was developed to evaluate the economic and environmental benefits of the Solar PV Compact bin in the UMP Gambang campus. Based on the results of the simulation, the invention is viable for implementation. It demonstrates the advantage of choosing a compact solar energy bin in managing MSW in Malaysia. Hence, an economic comparison between sending the compacted waste to landfills and recycling paper companies would be recommended for future study. It will present which method could have more benefits toward sustainability.

Acknowledgement

This work is supported by the Faculty of Civil Engineering Technology, Universiti Malaysia Pahang (Senior Design Project).

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