Feasibility study on use of solar energy in Malaysia's light rail transit

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Abstract. LRT System is an accessible urban public transportation in Malaysia, especially in Klang Valley. People can commute easily from one place to another. The operations of the LRT System are entirely dependent on the electric power supply, from the movement of trains between stations to the facilities inside the train itself. High consumption of electric grid has contributed to the increase in environmental pollution. In the long-term, the effect can be seen in the decrease in sea level as well as drop-in water supply. Due to that, renewable energy demand is continuously increasing, and current prediction shows that this trend is going to further continue yearly. Usage of electricity from renewable sources such as the solar panel has been proposed in this project paper in order to reduce the negative effect been encountered. The solar PV is a mechanism that can transform the sunlight into direct current electricity by using semiconductors. Hence, with the use of the solar panel, it will reduce energy pollution and climate change impact due to high consumption of electric grid. This research is meant to explore the possibility of using solar panels as an alternative for generating electricity for the Light Rail Transit (LRT) as renewable energy instead of using the power grid. The goal for this project report is to understand the requirements in implementing solar energy on the LRT System in Malaysia.

1. Introduction
The environment and energy crisis have been significant issues worldwide [1]. The emission of greenhouse gases, especially the CO₂ from the generation of power using coal, gas and steam, had decreased the ozone layer and thus created more pollution [2]. For instance, in Malaysia, researchers estimate that 339 million tons of CO₂ will be produced by the year 2030 [3]. Due to the importance of controlling the emission of greenhouses gases, the Malaysia Government has launched the green campaign in 2009 to mitigate issues regarding energy efficiency as well as environmental impact [4].

In general, an electric power system comprises of generation plants for energy creation, the network of transmission and the electrical distribution lines from the plant to consumers or industry. Each of it has it owns environmental impacts at various phases which are during the development, construction,
both power generation and during the declamation and treatment of wastes. As for Malaysia, the electricity output is produced primarily by using renewable energy like gas and coal. Burning the fuel will provide a solid residue called ash, which is discharged in the dumpsite and thus creating land pollution [5]. The land will become harmful to the animal and human who lives nearby. Aside from that, the electricity system also contributes to other environmental pollution, which includes the emissions of greenhouse gases [5]. These will also affect plants, animals and ecosystem that result from the use of land for power generation and transmission as well as the distribution lines. Some of these environmental effects can also trigger to human health if exposed to pollutant in air, water or soil. Naturally, there will always be some quantities of carbon dioxide in the atmosphere due to other human activity; however, with the process of generating electricity, it has added more of it and makes it worse. Many scientists believe that this will create an effect on the global climate, harming the animal population as well as changing the ecosystem.

The risk of emissions would generate a rising global Earth's surface temperature, leading to a higher drought. Other than that, with increased heat in the atmosphere and colder oceans will contribute to higher wind velocities in tropical storms. This condition leads to a tragedy for nature and humans. Thus, to stop this, it is recommended to use renewable energy. As demands on transportation's sector been predicted to continue growth for coming years, increased applications of renewable power, like the Solar photovoltaic (PV) is required to reduce the emissions. In a large scale of implementation, it will also give impacts to the grid operations, which are the excess production, lack of versatility and increased demand for localized peaks simultaneous charging of the engine [6]. Renewable solar power advantages are often mistaken, and most of the time assumed to be not cost-effective. It sometimes looks like a direct substitute to the existing technologies; thus, the advantages and costs are set out in the form of methods of evaluation built for current technical knowledge. LRT is an urban rail vehicle that operated within metropolitan areas in which covers relatively short distance among platforms and operated by electricity. Since rapid progress in Malaysian's public transportation, the facilities have been expanded to various other places and interconnection within other public transport such as the Monorail and buses be made available. Hence, there is a need for the use of alternative energy such as renewable energy like solar to minimize electrical energy consumption to reduce operational costs as well as on the environmental impacts. Decreasing consumption of fossil fuels by using renewable power further maintain the environment in the optimal conditions [2].

1.1. The implementation: global tendency and conceptual deliberations
In recent years, there have been researchers dispensed to analyze the impact on renewable energy exploitation to the atmosphere, social and economic sectors [7]. Conducted fifty-seven interviews of face-to-face star solar photovoltaic initial investors of the urban domestic, organizational and industrial areas to learn about perceived barriers and policy preferences. However, the study is to investigate potential photovoltaic adopters within the Hong Kong domestic, corporate and industrial sectors regarding major obstacles and possible changes in policy. It also provides an enabling factor structure that has been utilized guideline innovations in the solar system. While another researcher conducted a survey using twenty-one questionnaires that includes on rewards, policies, awareness rates, information base, finance and cost, business model as well as on technical developments. The researcher covered aspects of social-cultural, economic, public, environmental, and technological perspectives, compared to [7] that looked only at related public policies. The researcher believed that their approach could aid in providing an advanced interdisciplinary approach to human sustainability in the environmental, scientific, cultural, economic and social fields. Exploiting renewable technologies has three benefits [8], which are:

i. Provide less impact on the environment as compared to other energy sources.

ii. No depletion on power resources includes fossil fuel and uranium resources. Only when it was well handled, it would be able to provide almost indefinitely secure and sustainable energy supply. Fossil fuel resources, by contrast, are re-finite and can be reduced by extraction and consumption.
iii. Decentralization of the energy market and the local approaches, more or less unconnected to the national network, improve system performances and enhances availability in technical resources for small isolated areas. It has made many different clean energy technologies are theoretically feasible for use in urban areas.

Researchers conducted studies on the practical usage of Photovoltaic Solar (PV) to reduce emissions in the Indian Railways environment [9]. They suggested that the design phase is the most important thing to consider when implementing a Solar PV train. It is the desire to attain high electricity output efficiency. In accomplishing it, photovoltaic plants must be run and maintained optimally. The operational will maximize the plant's output, while the support will make it more efficient because it will be easier to fail with low production levels [10]. Another study indicated that the photoelectronic effect on semiconductor materials is based on solar photovoltaic cells [10, 11]. A substance with a semiconductor is a crystalline structure working on the binding electron. Furthermore, a mechanism was developed to describe how an atom absorbs a particle within the conductive band and how it travels through the conductive group, in which it can contribute to the electric charge in the material and thus provide energy. However, it will only occur once the energy of the photon is equal to or greater than the generated energy with the semiconductor energy gap. Otherwise, the force could not be produced. Although [11] proposed that the smaller the distance between the materials of the solar cell, the simpler it would be to encourage an electron from one band to the other and thus improve the conduction of that material.

The trains installed with the solar photovoltaic (PV) system on the train rooftop such as South Africa, California, London, Belgium, Chile, New Delhi and Arizona have been successfully put into operation by many countries at present. A study on the use of solar energy using the photovoltaic system was conducted in Iran during 2013, showing that the photovoltaic system could supply 74% of the coach's power requirements during the hot month and 25% during the cold month. It has been recorded that around 37 tons of CO₂ emissions have been successfully reduced.

As for Malaysia, Solar power techniques could be divided into two main categories: solar thermal innovation and photovoltaic (PV) technology. Solar energy application is the technology that uses the range of solar panel cells to convert the solar energy into direct electricity for the heating and the photovoltaic application.

2. Materials and method

2.1. Implementation on light rail train

As for Malaysia, it is entirely operated using the electric power grid taken from the Tenaga Nasional Berhad. The system has been manage by RapidKL Sdn Bhd since the year 1996, and currently, there are 49 trainsets (4-car) which consist of 196 cars in total and connecting people within Klang Valley. This study aim to assess suitability of using solar power on the LRT, specifically those operating in Klang Valley. A 1-car train and one station will be considered as a sample for this study. The power usage per kilometre for a 1-car train is 2.5 kWh [12]. The study was conducted by using an observational and survey design in collecting required information. The method of observational analysis was then used to gather knowledge about the site location, station's environment and the physical structure of the train, which covering both internal and external built-up. While for the survey, it was conducted to collect information concerning the LRT's technical staff point of view in the implementation of solar energy train. It will be able to ensure that a more accurate sample and thus ease of concluding.

For this study, 1-car train and one station been considered. The station will be installed with a rechargeable battery where the energy is accumulated from the solar using the solar PV panel installed at the station. The rechargeable battery at a station only meant for recharging the battery in 1-car train. While on the train coach, a solar PV panel installed on the rooftop to retrieve solar energy directly from the sunlight. The solar energy will then directly be supplied to the electric double-layer capacitors (EDLC's) batteries and thus transmitted to other types of equipment in need. When the train stop at the station, the cells will be recharge with the EDLC's.
at the station if there is a need. For the rechargeable batteries, EDLC's been use as the charging devices. It will keep on charging and discharging. The cells are long-lasting with high operating power and low emission. The source of energy for the train's coach is from the solar PV panel and the EDLC's.

The amount of energy supplied by the solar PV and the EDLC is calculated to measure its performance and thus make comparison with the use of an electric grid. The main reason is to figure how much solar energy can be accumulated by the solar PV on one coach and does it able to accommodate the need for lighting, air-conditioned, door sensor for opening and closing as well as the panel display in one particular coach. Due to that, data regarding the usage of electricity and the maintenance cost involved been collected base on interview among the selected staff of LRT. Table 1 illustrates the calculations of maintenance cost in using electric and solar energy.

**Table 1. Current Implementation Using Electric Energy and Solar Energy**

| No | Item                              | Electric Energy                                      | Solar Energy                                      |
|----|-----------------------------------|------------------------------------------------------|--------------------------------------------------|
| 1  | Power usage per KM per-train (1-car) | 2.5 kW per km (LRT line is about 27 KM length)       | 2.5 kW per km (LRT line is about 27 KM length)   |
| 2  | Time taken per KM                 | 1km = 1 minutes 20 seconds 27km= 36 minutes (end to end) | 1km = 1 minutes 20 seconds 27km= 36 minutes (end to end) |
| 3  | Power usage per train (1-car)     | Per Day = 67.5 kWh (end to end)                       | Per Day = 67.5 kWh (end to end)                   |
|    |                                   | Per Month = 2092.5 kWh                               | Per Month = 2092.5 kWh                           |
| 4  | Cost per kWh                      | 38.53 cent (Malaysia Tariff & Price)                | 300 Watt = per panel 1-car train required 67.5kWh to run. The train required 225 panels to give enough power for 27km. |
| 5  | Cost per kWh per train (1-car)    | Per Month = RM 80,624.03                             | RM1383.00 per panel 1-car train required 67.5kWh to run. The train required 225 panels to give enough power for 27km. |
|    |                                   | Per Year = RM 967,488.36                             | RM30,426.00 per panel 10kW Battery = RM41,400.00 67.5kW will cost about – RM289,800.00 |
| 6  | Cost to setup power grid          | TPSS = >RM15 Million per building & equipment       | RM1383.00 per panel 1-car train required 67.5kWh to run. The train required 225 panels to give enough power for 27km. |
|    |                                   | BSS = >RM50 Million                                  | RM30,426.00 per panel 10kW Battery = RM41,400.00 67.5kW will cost about – RM289,800.00 |
|    |                                   |                                                      | RM1383.00 x 225 panel = RM62,350.00 10kW Battery = RM41,400.00 x2 unit = RM82,800.00 |

**3. Result and discussion**

Base on the collected information, the solar panel installation station is proposed to be applied, as shown in Figure 1. While for the train itself, the installation suggested as in Figure 2.

The solar panel proposed to be installed on the roof of the station as to get direct sunlight. As can be seen, the placement of the solar panel is the most suitable place since any buildings or shades have not blocked it. The architecture itself allows a greater selection of sunlight.
As for the train itself, it is proposed to be installed on the rooftop to ensure direct sunlight can be retrieved more. The solar energy from the solar panel will then be supplied to the battery and DC motor. From the battery itself, it has subsequently been provided to the electronic circuit board that then been used for the air-conditioning system, panel display system and the lighting system.

4. Conclusion
Malaysia's urban rail services are currently using electric power system in their daily operation. Due to that, it has been part of the environmental pollution contributor that requires attention. As to minimize its impact on environmental pollution, the urban rail services operated using solar energy been proposed in this project paper. This project paper is focusing on understanding the level of knowledge among the staff in solar energy technology, its implementation, their readiness in adopting it, requirements in need at the station and on the train itself. By analyzing the findings, it could be defined that the company's management and technical personnel already have experience in solar energy replacement capability of the electric grid. However, they are quite concerned about the costs of implementation, as there is a need to modify the train, the tracks and also the station.

Furthermore, the energy storage devices with solar recharge capacity have reached the reliability level required for transportation applications as defined in the present research. Its benefits include energy efficiency and enhanced device performance, along with potential greenhouse gas emission reductions. Besides that, changes in the energy performance of railways can be another factor of increasing their efficiency through systematic and operational optimization.
For this research paper, the studies have only been conducted in Kelana Jaya Line, which explicitly involved a 1-car train and one station (Kelana Jaya) only. While the sample population in this study only included technical staff of the Kelana Jaya Line.

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