Faculty of Mechanical Engineering

ENERGY PERFORMANCE OF RAPID BUS ROUTE

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ENERGY PERFORMANCE OF RAPID BUS ROUTE

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DECLARATION

I declare that this project entitled “Energy Performance of Rapid Bus Route” is the result of my own research except as cited in the references. The project has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

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Date : .....

APPROVAL

I hereby declare that I have read this report and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Engineering in Mechanical Engineering (Automotive Engineering).

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Date	:	.....

DEDICATION

I would like to present my work to those who did not stop their daily support since I was born, my dear father, and my kindness mother, they never hesitate to provide me all the facilities to push me foreword as much as they can. This work is a simple and humble reply to their much goodness I have taken over during that time. Thank you for giving me a chance and I love them.

I also dedicate this project to my brothers and my wife who have supported me through my life. I always miss and I cherish the memories that we had. I love all of you.

MOHANAD SABRI SEHEN

ABSTRACT

The transportation sector contributes significantly to the use of global energy and emissions due to its traditional dependence on fossil fuels. Climate change, security of energy supplies and the significant increase in demand for public transportation are causing the governments to embark studies on sustainable transportation. Fortunately, there are immediate opportunities to reduce hazardous emissions through the adoption of the latest technologies in buses. One of the potential solutions to the sustainable public transportation is with the use of Rapid Bus System (RB). This system has significantly gained popularity around the world as it is a cost-effective alternative to the expensive urban rail system. However, the main problem with this system is the quantity of hazardous emissions particulary carbon dioxide gas that can result to global warming, which eventually can be catastrophic. In this work, the evaluation and analysis of the optimal energy consumption of the Rapid Bus System (RB) through different route and criteria was performed. The energy consumed was calculated with the aid of smart phone applications namely MotionX-GPS. Online map was also utilized. From the raw data obtained, analysis was conducted and the results obtained shows that the average energy consumed for a particular bus on route is approximately 5.01 MJ. The routes selected are located around Melaka city. The data obtained can be further used to study the strength and weaknesses of RB system so that a more efficient RB can be realised in future.

ABSTRAK

Sektor pengangkutan menyumbang dengan ketara kepada penggunaan tenaga dan pelepasan global akibat kebergantungan terhadap bahan api fosil. Perubahan iklim, jaminan bekalan tenaga bahan api dan peningkatan permintaan untuk mobiliti kenderaan telah menyebabkan kerajaan di seluruh dunia menggembleng usaha dan tenaga dalam mendapatkan sistem pengangkutan awam yang mampan dan mansang. Antara perkaran yang boleh diambil untuk secara segera mengurangkan pelepasan gas-gas tidak mesra alam adalah dengan penggunaan bas yang dilengkapi teknologi bas baharu. Sistem bas ini juga dikenali sebagai Sistem Bas Cepat (RB) dan telah mendapat perhatian dari seluruh dunia sebagai alternatif kepada pengangkutan awam sedia ada yang lebih murah dan effisien. Ianya dijangka dapat mengurangkan perlepasan asap yang menyebabkan pencemaran teruk kepada alam sekitar. Di dalam penelitian ini, penilaian dan analisis terhadap penggunaan tenaga secara optimum melalui sistem pengesanan global (GPS) telah dijalankan. Kiraan tenaga yang digunakan oleh Sistem Bas Cepat (RB) dalam beberapa laluan rutin dilakukan dengan bantuan aplikasi telefon pintar iaitu Motion X-GPS. Laluan rutin ini merangkumi kawasan sekitar bandar Melaka Dapatan kajian menunjukkan bahawa jumlah tenaga yang digunakan oleh bas RB secara puratanya adalah sebanyak 5.01 MJ. Data-data yang diperolehi melalui kajian ini akan digunakan dalam memperbaiki sistem RB yang lebih effisien dan berdaya saing.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter aims to present a brief overview of this research on the energy performance of rapid bus route in the context of Malaysian case study. This chapter will provide a background to the research, research overview, research problem and identify the research objectives that will be empirically examined through a Malaysian case study. This chapter will also present the significance of the research. Then it will present overview of the content of each chapter in this thesis.

1.2 Research Background

Mobility in urban areas rose quickly, and more importantly, becoming more and more automobile-oriented. In many urban areas, passenger mobility is increasingly dependent on private cars that cause air and noise pollution, emit the greenhouse gases that cause climate change, increasing dependence of fossil fuels, result in high cost time and accident costs, increase local government expenditure for investment, and decreased street and community life results in inequalities of access to different users (Litman, 2015).

This trend is clearly unsustainable and therefore the urban transportation in most cities in the world have should be planned with a view to creating a more sustainable transport system, economic, environmental and social (Williams, 2017). This will require an increase in alternatives to automobile and restrictions on the use of vehicles in cities,

especially in the downtown area that is experiencing congestion. One of the most effective alternatives to the automobile is public transport. Many cities in the world have invested in public transportation to attract people and encourage them to use public transportation (Vuchic, 2017). While the urban railway system, such as the weight of the train, tram, train and receive a lot of investment, three decades also saw Rapid bus (RB) was introduced as an innovative public transport mode, offering significant profit quality service over conventional bus operations, and significant cost savings and ease of implementation as compared to alternative train. RB became more popular in the city both in developing countries and advanced, with features that are cost effective, fast and simple implementation and potential high background (Nikitas and Karlsson, 2015, Queen, 2016, Verma and Ramanayya, 2014).

Rapid bus (RB) is a relatively new concept that is still suffering from a vague definition. Before their turn in the 20th century, only isolated cases like Curitiba (Brazil), Ottawa (Canada) and then Adelaide (Australia), including some early form of presentation, its own bus-based system that shows the level of reliability and versatility compared to the city's express bus Corridor (Goldman, 2011). However, it was in the late 1990, a new wave of system in Quito (Ecuador) and Bogotá (Colombia), based on the design of the Curitiba system, came to form what is known as a model Latin American BRT, has a set of common technical, financial and institutional characteristics (Campo, 2010, Wirasinghe et al., 2013). This model has been emulated recently in developing countries such as China and India, as well as in Malaysia. Given the context of cultural, economic and political environment is different from these countries, new experiences have been acquired potential and flexibility of BRT, and also with lack. Even with the doubts Orchidales, RB is now recognized worldwide as a mode of transport with a separate unique features (Aubert, 2005).

RB have often been a misunderstanding because it has been misapplied. Although only elements of a fully featured RB has been implemented, the name ' upper class ' almost always used not only due to confusion Orchidales, but for higher market compared with “inferior cousins” (“busways” or “bus improvements”) (Currie and Wallis, 2008). Misconceptions concerning the problem of academic and practitioners alike, and can give the wrong impression to the public. Most people are not aware of the characteristics of the RB and generally underestimate the ability of the passenger transport system with demand high service that is reliable and convenient. The first step in this study is to provide an adequate definition for buses, and existing systems that relate to this definition (es Salaam–Tanzania, Moebs, 2011).

Development of a new system of relative majority of academic Literature and RB planning guide has been written in the last decade. Research need to clear the initial case studies and focus on the maturity of the older system in Malaysia (Marcotullio and Marshall, 2007). RB is still fairly new modes, raises many questions policy. Most importantly, is RB evolved into a more important mode in underdeveloped and developing similar, or, especially limited to niche markets. In many ways, it may be too early to answer this question, because some RB systems have been maturity, when the life-cycle-cost true can be determined. However, there are early performance and financial data that indicates the current state of mode and give some insight into the future.

Figure 1.1: Public transport in developing cities(Edwards, 2011, Hall, 1988)

1.3 Research Overview

Develop strategy of sustainable transportation has become the main focus of many cities around the world. These strategies can range from bicycle and pedestrian infrastructure better to invest in the metropolitan railway system (Kenworthy, 2006). In major cities, where a further, high capacity Service is necessary, city officials arguing the merits and costs of rail compared to bus (Deng and Nelson, 2011). Each has their respective advantages given the particular context, with rail usually provides higher speed higher, capability, but often at a higher cost. For the past two decades, rapid bus (RB) has emerged as a major alternative to the rail bus Debate opponents. Although RB system found in cities around the world, their greatest success occurred in developing countries, where people demand high-quality transit system without having to pay the high prices the lifetime dream of rail weight to develop and the country can't afford large-scale infrastructure development (Potter and Lloyd-Evans, 2014). For these city centres, RB has become, in about 10 years, the alternative of choice for mass, but at an affordable price and

fast to implement, transit. It reflects the different roles that pictures can be played by buses in public transport, they are for on what is a regular bus service offers, enter a realm traditionally reserved for rail transit (Campo, 2010).

Today there are more than 120 cities in the world that applied RB in their public transportation network either as primary mode or as a feeder service to the rail transport system (DAVENPORT[1] and SWITALSKI, 2006). RB system is not a recently rising public transportation trend: especially in Malaysia it has been implemented for decades. It has started to become more popular in other parts of the world in the past decades too (Potter and Lloyd-Evans, 2014).

The reason for this research is to create a template and proposal for hybrid bus powertrain in the future. This research is only a piece of possibly deeper research. Since this technology is still quite rare on roads.

1.4 Research Problem

Exhaust gases have recently climbed to the top of many municipal government's agenda. It is no wonder, because the number of megacities and cities around the globe is rapidly rising and so is the necessity to transport all its inhabitants. At the same time, statistics clearly show the influence of exhaust gases on our health. However, there are indirect effects of air pollution on people´s lives.

The most worrying and discussed part of gases created by internal combustion engines is the CO_2, carbon dioxide in other words. Although not toxic and thus harmless to living creatures, it is the cause of greenhouse effect and increase of holes in ozone layer. The latter is dangerous for its negative effect on our skin, increasing the number of skin cancer treated people.

Global warming is well known phenomenon of today. It seems as overpublicized issue recently, but it should not be underestimated. Not only does it affect our health, but world economy, biological diversity and geography of the Earth as well.

The most alarming predictions of scientists point at 4 degrees higher average temperatures on the surface of the planet at the end of 21st century. That could have terminal effects on humankind.

Although there are various and more important causes for exhaust gases emissions, they often aren´t immediate and direct threat for our health, because they´re not in the proximity of people. Even though it´s necessary to solve that problem as well, to focus firstly on the most dangerous parts of air pollution.

1.5 Research Objectives

Cities will be the engine of the world in the current century. Trends such as urbanization, the growth of cities' GDP, the political role and also the recognition of cities as a hub of innovation and culture will provide them with a unique potential to increase the quality of life of people around the world.

- To characterise the energy needed for an urban bus (rapid bus) with different route characteristics.
- To evaluate and analyse the energy consumption for the rapid bus over selected different routes.

1.6 Research Significant

The transport sector contributes significantly to the global energy use and greenhouse gas (GHG) emissions, and is strongly dependent on liquid fossil fuels produced from crude oil. Climate change, security of energy supply, and environmental concerns has called attention from governments to shift towards more sustainable mobility. Projections

show that the number of vehicles is likely to more than double globally by 2050 due to rising demand for mobility (Madlener, 2011). The greenhouse gas emissions of the transport sector are projected to increase by 50% between 2010 and 2050 (Madlener, 2011) if no new policies come into effect. Meanwhile, a reduction of global GHG emissions of 50% to 85% by 2050 compared to 1990 levels is required to meet the 2°C target suggested by the Intergovernmental Panel on Climate Change (IPCC) (Solomon, 2007). A further expansion of the transport sector must happen in a sustainable way which means also reducing fossil fuel use and emissions. In addition, an energy and emissions efficient road transport implies more reliance on the use of public road transport vehicles such as buses rather than on large fleets of cars (Kenworthy, 2008).

1.7 Research Approach

An effective public transport is important to development of. For the majority to form the urban population, public transportation is the only practical ways to access employment, education and public services, especially when those services beyond a viable walking or cycling. Unfortunately, the current situation of public transport services in developing cities often does little to meet the real needs of the population mobility. Bus service is also too often unreliable, troublesome and dangerous. In response, transportation planners and public officials have sometimes turned to mass transit alternatives are very expensive like Metro train-based. Due to the railway infrastructure costs are high, only cities can build the system over several kilometres in some limited corridors. The result is a system that does not meet the broader transport needs. However, the municipality ended up with long-term debt which could affect investment in more areas such as urgent health, education, water and sanitation.

However, there is an alternative between poor public transit service and high municipal debt. Rapid Bus (RB) can provide high-quality, metro-like transit service at a fraction of the cost of other options. To get the necessary data, study will use mobile and its in-built GPS sensor. Then, to measure the altitude and distance on the route, will use the MotionX-GPS application. This software shows all the necessary data, such as speed, altitude, distance and also offers possibility to safe a point on a map for later revision.

1.8 Scopes of study

The scopes of this study are as flow:

1- The routes selected are limited to Bukit Beruang (Melaka) area.

2- The equipment utilized are MotionX-GPS ,google map and a smart phone.

3- The date obtained from the application will be analysed using Microsoft Excel.

1.9 Dissertation Structure

This study has organized in five chapters as follow:

Chapter 1 gives the overview, thesis objective and key research problems as well as the thesis outline.

Chapter 2 provides background information on rapid bus and existing conditions of the public bus transport system.

Chapter 3 presents the methodology and scope of this study. In addition, an overview is given of the estimated quantities, methods and functional units.

Chapter 4 dedicates to the data gathering and usage this data to discuss the results of the study.

Chapter 5 concludes this study and recommends further actions and propose future study areas.

1.10 Summary

This chapter provides detail, information about the research background and highlighted current research problems. In this research, work wants to focus on analyzing the available methodology for the study with different parameters discussed in this study. The analysis of this study will be useful for the various researchers to increase its efficiency and performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter intends to present a review of the literature on the subject, and to discuss the scope of this research area by adopting critical analysis. The chapter will begin by presenting an historical background of establishing new phenomena by attempting to clarify the diverse findings revealed in the literature. Then the chapter will categorise by using different approaches to present an in-depth insight, by evaluating those parties that have an involvement in the system and those who are responsible for the developing progression of the project.

2.2 Public Transportation

The obvious help in reducing air pollution in cities and easing the jammed roads is higher use of the public transport. The best option would be to employ only electric driven vehicles, such as trams, trolleybuses or subway (Richards, 2012). That way, could cut local exhaust gases in city centers altogether. But it is often not possible or it would be too expensive to build subway or to lay down railways in every city in the world. Even stretching electric lines above every street to provide power for trolleybuses would be expensive. And besides, all named vehicles don't offer such flexibility in their routes as conventional buses. These use mostly big capacity diesel engines that emit exhaust gases (Combs, 2013). What's more, diesel engines produce the toxic NOx, dangerous to humans.

Even though most modern buses employ modern measures to cut emissions, such as particle filters, SCR or AdBlue, they produce considerably more local emissions than above-mentioned electrical means of transport (Ehsani et al., 2018). What's more, when compared to tram, conventional bus makes considerably more noise than tram. So does it produces more vibrations and is therefore less comfortable for passengers. Diesel engines are typically well known for their low fuel consumption. That may be the truth when speaking about long journey services, where the engines keep running at constant, low revs (Council, 2013). In urban areas though, buses have to come to a full stop and then accelerate in short distances. This creates the most pollutants and repeated stops mean that all the gathered momentum is wasted and dissipated as heat through braking.

2.3 History of Public Vehicles

On the seventeenth century, more specifically in 1661, Blaise Pascal invented what can be considered the first public transport in the world: a system of horse-driven cheap public transport for Paris (lately known as omnibus) (Daniels and Warnes, 2006). Pascal had the authorization of King Louis XIV to open five routes to the Palais du Luxembourg, with fixed schedules. The use of the five lines began on March 18th, 1662 and the basic route used to cost the same as a pound of meat (Blackburn, 2005). However, it could not be sustainable. Parliamentarians were involved since the beginning and due to their noble privileges they could not bear the possibility of sharing the transport with less wealthy people. Thus the company collapsed after 15 years. Omnibuses only appeared again in 1826, in Nantes. A young man called Stephen Bureau envisioned transporting the employees of his grandfather, who used to be a ship-owner, from their offices in the rue Jean-Jacques Rousseau to the Customs services in the district of Salorges. At the same time, in the same city, Stanislas Baudry, a colonel of Napoleon's army, owns a flour mill in