

ASSESSMENT OF CARBON FOOTPRINT IN ROUTINE MAINTENANCE  
WORK OF STATE ROAD IN PERAK

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A project report submitted in partial fulfilment of the  
requirements for the award of the degree of  
Master of Engineering (Construction Management)

School of Civil Engineering  
Faculty of Engineering  
Universiti Teknologi Malaysia

JANUARY 2020

## **DEDICATION**

I dedicate this journey to my mother, father, wife and children for their unfaltering motivation and support throughout this study..

## ACKNOWLEDGEMENT

In preparing this report, I have involved with numerous personnel from various offices. My sincere recognition goes to personnel in Public Works Department and Empayar Indera Sdn. Bhd. These people have contributed a lot to my project especially during the data gathering and sharing the experience and thoughts throughout the project. In particular, I wish to express my sincere appreciation to my supervisor, Professor Ir. Dr. Rosli Mohamad Zin for encouragement, critics and guidance. Without continued support and understanding, this project would not have been the same as presented here.

I am also indebted to all Universiti Teknologi Malaysia (UTM) lecturers for their help, support and knowledge throughout my studies. I want to express my gratitude here to Ir. Jeffryl Azniel Adzar for assistance in supplying the relevant works of literature.

My dedication and sincere appreciation also extends to all my fellow classmates for their support and assistance during various occasions. Their views and tips are useful in keeping the motivation. Unfortunately, it is not possible to list all of them in this limited space.

Last but not least, I am also deeply grateful to my entire family member who had given endless and strenuous support for me to complete my study. Their compassionate help had helped me a lot in keeping the paces throughout this course.

## **ABSTRACT**

Although sustainability focus was set majorly on construction, operation and maintenance sector must also take into account the same consideration in every activity involved. Operation and maintenance phases involve significant resources for it to remain serviceable throughout its life cycle. These resources use energy that release emission and later contribute to the rise of earth temperature that sparks concern on climate change and global warming. Thus, showed that assessment of carbon dioxide activities that contributed to global warming on these vast road networks are significant. Even though rating tools like pHJKR developed for sustainability rating, this rating tool is not until the operational and maintenance phase. Therefore, sustainability assessment not being executed during this phase and also for carbon emission specifically. Main objectives of this study are to assess or evaluate the activities involved in one of the road maintenance activity, which is routine maintenance. The study conducted focused on the stretch of state road in Perak consisted of 2,102.78km in length according to assessment boundaries set-up to identified sources of carbon emission in seven routine maintenance activities and administration part. The study conducted focused on the data gathered during assessment in various activities involved in the source of emissions. Types of data involved are the quantity of resources used in the activity then later calculated with appropriate emission factors for determination of carbon footprint produced in the routine works. Results showed the amount of carbon emission produced in the routine maintenance activities for every district involved during the operational (on-site activities) and also at the administration side (water, electrical and commuting).

## ABSTRAK

Walaupun tumpuan utama kelestarian adalah ditumpukankan secara khusus ke atas sektor pembinaan, pertimbangan yang sama terhadap operasi dan penyelenggaraan juga perlu diambil kira dalam setiap aktiviti yang terlibat. Fasa operasi dan penyelenggaraan melibatkan sumber yang ketara agar aset boleh digunakan sepanjang kitaran hayatnya. Kesemua sumber ini menggunakan tenaga yang melibatkan pelepasan dan menyumbang kepada kenaikan suhu bumi yang mencetuskan kebimbangan mengenai perubahan iklim dan pemanasan global. Oleh itu, perkara ini menunjukkan bahawa penilaian aktiviti karbon dioksida yang menyumbang kepada pemanasan global pada rangkaian jalan raya yang luas ini adalah penting untuk dilaksanakan. Walaupun penarafan seperti pHJKR dibangunkan untuk menilai taraf mampan, penarafan ini tidak melibatkan fasa operasi dan penyelenggaraan. Oleh itu, penilaian kelestarian tidak dilaksanakan dalam fasa ini dan juga untuk pelepasan karbon secara khusus. Objektif utama kajian ini adalah untuk menilai aktiviti yang terlibat dalam salah satu aktiviti penyelenggaraan jalan raya iaitu penyelenggaraan rutin. Kajian difokuskan kepada jalan raya negeri di Perak yang melibatkan 2,102.78km panjang jalan berdasarkan kepada sempadan had penilaian yang ditetapkan untuk sumber karbon yang dikenal pasti di dalam tujuh aktiviti penyelenggaraan rutin dan termasuk untuk pengurusan. Kajian yang dijalankan memberi tumpuan kepada data yang dikumpulkan semasa penilaian dalam pelbagai aktiviti yang terlibat dalam sumber pelepasan. Jenis data yang terlibat adalah kuantiti sumber yang digunakan dalam aktiviti. Pengiraan akan dibuat dengan dengan merujuk kepada faktor pelepasan yang sesuai untuk menentukan kesan karbon yang dihasilkan dalam kerja rutin. Keputusan menunjukkan jumlah pelepasan karbon yang dihasilkan dalam aktiviti penyelenggaraan rutin bagi setiap daerah yang terlibat semasa operasi (aktiviti di tapak) termasuk juga untuk pengurusan (air, elektrik dan perjalanan).

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## LIST OF ABBREVIATIONS

CF	-	Carbon Footprint
GHG	-	Greenhouse gas
kW	-	kilowatt
MW	-	Megawatt
CO <sub>2</sub>	-	Carbon dioxide
tCO <sub>2</sub>	-	Tonne carbon dioxide
LCA	-	Life Cycle Assessment
t	-	tonne
km	-	kilometre
kgCO <sub>2</sub> e/m <sup>3</sup>	-	kilogram Carbon Dioxide equivalent per metre cube
m <sup>3</sup>	-	meter cube
m <sup>2</sup>	-	meter square
JKR	-	Jabatan Kerja Raya
UK	-	United Kingdom
US	-	United States
pHJKR	-	Penarafan Hijau JKR
PPM	-	Plan Preventive Maintenance
PAS2050	-	Publicly Available Specification
BSI	-	British Standard Institution
LCI	-	Life Cycle Inventories
RSA	-	Rest Stop Area
gal	-	gallons
Nos	-	Numbers
O&M	-	Operation & maintenance

## LIST OF SYMBOLS

°C - Degree Celsius

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# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

As infrastructure development are initiated vastly towards nation growth, the awareness of the industry player must move simultaneously together towards environmentally conscious in their involved activities. In today's worlds that is environmentally conscious, industry can't afford to ignore the impacts on the ecological and the contribution towards climate change (Zammataro, S., 2010). One of the most infrastructures that had made a significant contribution to the growth of a nation is the road network. Located at urban and rural areas, any part of the world, roads are recognised as a means of making access or open up to socio-economic, thus making it the most crucial of all public assets. In Malaysia, the total length of road in the year 2000 by referring to Road Statistic Report was 67,590.46 km but this figure had hugely climbed up to 300% making the entire length of roads to 237,022.353 km (Statistik Jalan, Edisi 2018). Therefore, by looking at these figures, it is not only vital for executing plan strategies in maintaining the roads built performing like the way it was when newly built but at the same times also being environmentally friendly. Many of the issues regarding environment had majorly focused on the vast sector of the construction industries besides the highway maintenance side where it's very little examined, but the effort to study the impact have slowly realised as society is moving towards more to be environmentally conscious.

Maintaining a road infrastructure on this scale is an enormous and challenging task. Roads are one of the most prevalent types of public infrastructure widely used around the world that demand continuous investments and improvements for it to stand serviceable (Mao, R. et al., 2017). As the roads that linked people from town to town, big and small, the non-toll road considered to be closest to the people. For major roads, these roads had generally categorised into

federal and state roads. According to data obtained from Public Work Department (JKR), proportions for both of these roads as reported in 2017 are Federal Road consists of 14,886.841km in Peninsular Malaysia and 3,062.890km for Sabah and Sarawak. Length of state road in Peninsular Malaysia is 165,326.634km and 51,745.108km in Sabah and Sarawak, which make the total length to 237,022.353km of roads in Malaysia (Statistik Jalan, Edisi 2018). Previously maintained by JKR, beginning from 2001 implementation of maintenance for these federal roads is done by the concessionaire. These road maintenance concessionaires divided into zones throughout Peninsular Malaysia. Following the steps of the federal roads, the state government had also appointed concessionaire for state road maintenance which had started in 2013. The objective is to make road maintenances being done routinely and periodically to keep the road in good condition as the road will deteriorate during its life cycle. These scopes of work generally had been categorised into every component available on road infrastructure, for example, patching of pothole and grass cutting including a routine inspection to make the road performing in good condition in every aspect.

Maintaining these vast networks of road involves machinery and equipment as similar to any nature and effort of doing work on a larger scale. Also, for this purpose, there is no exception as a means or method to simplify the works, making the works done faster and efficiently. These types of machinery are ranging but not limited to such as from heavy or medium (Lorries, compactor, grader and backhoe) machinery to small equipment (grass cutting machine and air blower). These lists of machinery will release carbon particles to the air when operating during maintenances activities, thus providing a substantial amount of carbon emissions. Besides these work activities at the site, other things that also contribute, such as electricity, water, and staff commuting.

## **1.2 Background of Problem Statement**

In the report produced by Ministry of International Trade and Industry (MITI) during the United Nations Framework Convention on Climate Change (UNFCCC),

the construction sector categorised as one of the main greenhouse gas (GHG) emission contributor in Malaysia with the percentage of level assessment is 7.99%. Although the construction sector is highlight regularly, the maintenance sector is not less important and needless to say always being overlooked. For maintenance of the road, considering the staggering amount or length of road network involved, effort to assess the carbon emissions during maintenance activities had been treat as a sub-industry on effort in reducing the carbon footprint. A review of current life-cycle carbon analysis and research on operation of highway maintenance bring out little or no evidence that such a throughout methodology occur within the civil infrastructure maintenance sector (Itoya, E. et al., 2013). As in line with the Green Technology Master Plan Malaysia 2017-2030, operation of all organisations that released GHG emissions into the atmosphere need to be in constantly monitored and controlled to safeguard the progress of sustainable development is on track.

Climate change or global warming had raised the issue of the increases in GHG that give effect on temperature changes in and around the earth surface. Outcomes from this condition whether being notice or not include rise in sea level and temperature at the sea surface, drop down in sea ice, and change in rainfall. The Intergovernmental Panel on Climate Change (IPCC) in 2014 had published the 5<sup>th</sup> Assessment report on climate change based on scientific evidence stating increasing of carbon dioxide (CO<sub>2</sub>), which is one of the GHG that is contributing to global warming and more alarming, is that the cause to this effect is mostly contributed human action. Malaysia is not excluded from this impact through a warming inclination that cause an increase of mean surface temperature from 0.6°C to 1.2°C and facing an escalation of rainfall intensity and rise of the sea-level (Begum, R.A., 2017).

Around the world, consensus such as the 21st Conference of the Parties (COP21), referring to the countries that had agreed and signed up to the 1992 UNFCCC that are aiming to monitor and reducing the rise in temperature from this global warming. Therefore, following effort like all the other nations, Malaysia is on the need and is making way for the effort with the global community in reducing the GHG. This effort included which in 1989 by the ratified of the Montreal Protocol.

Also, under the UNFCCC through the Paris Agreement, in 2017 under the Trade and Industry Related Emerging Issues Division, MITI had reported that Malaysia had committed to reduce GHG emissions by 45% by 2030 in relation to our 2005 GDP which is total carbon emissions per unit of Gross Domestic Product, followed by on the 23rd Conference of Parties in Bonn, Germany on November 2017. During this, several initiatives/programme is being highlighted to show that Malaysia is striving to achieve a reduction of GHG, which targeted in 2030. These include Green Technology Master Plan 2017-2030, Energy Efficiency Action Plan, Transportation Sector and Low Carbon Cities Framework. All this initiative is a long term process in the effort to tackling the climate change issue and emission reduction target.

Achieving these globally higher-level targets will be much harder if the organisations are lacking the awareness and effort in their included field. Therefore, every person involved should emphasise in doing their part to assess the activities that contribute to the GHG. Malaysia needs to strive more to be in line with countries such as the UK that already make it compulsory by having a legal requirement stipulated in the UK's Climate Change Act 2008 where infrastructure clients are making their supply chain to furnish carbon footprint information and also considering it as a requirement in the contract and a main part criteria of tender selection especially involving public sector client (Itoya, E. et al., 2013).

### **1.3 Problem Statement**

The much-emphasised effort in the global and upper scale level highlight above may only be a success by having more significant effort towards sustainability in every subsector that contributing to the emission of carbon dioxide that contribute to the carbon footprint. With continuous effort on controlling and monitoring the reduction of emission every year, then only the potential emissions reduction is achievable. Therefore by assessing these, sustainability and green are considered as vital in achieving the objective. In other words, this assessment will act as a start-up that leads to continuous improvement in marking where the situation that we are now and the ways forward to a better sustainable environment.

There is no doubt that road routine maintenance scope of work which consists of maintenance of pavement, road shoulder, grass cutting, road furniture, bridges and culverts, drainage, landscaping, and including routine inspection are contributing to the amount of carbon dioxide emission. In the UK, according to Itoya, E. et al., (2013), civil infrastructure, together with the highway maintenance sector, is under growing pressure to deliver services which is low in 'low-carbon'. Therefore, considering there is a substantial amount of carbon dioxide released on these activities by looking at the length of the road. It is an important effort for these activities and other related things that contribute to sources of carbon emission in road maintenance in this road category be looked at as part of the effort to sustainability by having an assessment and reported as an estimated quantity of GHG emitted per unit of activity.

There are several tools developed for the green and sustainable rating assessment internationally and locally. These rating tools, for example, are Greenroads, GreenLITES, INVEST, and STARS which developed in the US. As in Malaysia, a great effort had been established by the development of two rating tools for the rating of sustainable roads, which is MyGHI for highways and also pHJKR (Roads) for non-toll roads. Under the Kementerian Kerja Raya (KKR), JKR as one of the implementing agencies under KKR are involved with planning and implementing new projects, including upgrading road works and also maintaining it. Therefore, as an effort and in line with one of the JKR Strategic Framework 2016-2020 where one of the frameworks is leading sustainability, pHJKR (Roads) was developed where the first version or version 1.0 established in 2012. In 2013, the introduction of a new version or version 2.0 with the inclusion of the Roads Upgrading work category. The rating under this tool involves the lifecycle in the planning, design, and construction phase.

According to pHJKR (roads) tools, sustainability ratings rated during phases of planning, design, and construction stage for new and upgrading roads with a set of specific project cost and type of roads. Therefore, assessment is not carried out during road operation where maintenance work is carried out since there are no criteria or guide during this life cycle phase after completion or during operational.

Considering that no assessment during this life cycle is done even for the previously rated as a green road or for other roads during operational, it is certain that there is no assessment being done at this current time also on the carbon emissions during this operation and maintenance phase. Furthermore, considering that much effort is still currently under development on the carbon assessment on road maintenance at the category of this road.

By considering Malaysia's commitment in the Green Technology Master Plan Malaysia 2017-2030, effort in controlling and monitoring of GHG emissions intensity released into the atmosphere through the operation of each organisation must be undertaken to ensure the progress of sustainable development being set by reducing of emissions intensity. Therefore it is beyond doubt that effort should also be put on the scope of road maintenance too. Emphasising on this effort is important considering at the length of roads mentioned earlier in the roads statistic. Wherein the opinion that this activity will contribute to a substantial amount of carbon footprint and thus it is genuinely crucial for the assessment of road maintenance carbon emission to be comprised as part of the sustainable assessment and later reported as an estimated quantity of GHG emitted per unit of activity. The world is striving towards the effort on making greener and sustainable environment; therefore, the activity done in the maintenance of roads should also being asserted to be much greener. As an effort of carbon reduction, the early steps to be taken are the need to start assessing the produced amount of carbon.

By the development of MYCarbon GHG Guidelines, Malaysia had shown a great commitment to the intention of reducing the emissions and providing an advanced GHG reporting and management throughout the organisations in Malaysia.

#### **1.4 Aim and Objective**

This study aims to assess the activities contributing to carbon dioxide emission as a means to identify the amount of carbon footprint produce at state roads

during routine maintenance. The following objectives are determined to achieve this aim:

- (a) To assess identified activities that contribute to the source of carbon dioxide in routine maintenance works.
- (b) To gather the amount from the identified activities in routine maintenance works that contributes to the carbon dioxide emissions quantity.
- (c) To determine the carbon dioxide emissions quantity for carbon footprinting in routine maintenance of state roads.

## **1.5 Scope and Limitations of the Study**

This study will be set on to routine maintenance activity at state roads in Malaysia, focusing on the state of Perak. The maintenance of these roads previously was done by Public Work Department (PWD) and starting from 2013; the routine maintenance awarded to Concession Company. For maintenance of roads in Perak, three offices had been set up as regional office which situated in the district of Manjung, Larut, Matang & Selama and Kinta for the management of the whole 12 districts in Perak. Coordination during studies at the site is with the representatives in Concession Company, which are the regional manager, supervisor, and their contractors and also include personnel from PWD.

Assess activities are routine maintenance work done by the concessionaire company that had been appointed in maintaining the state road in Perak. Base activities include in the assessment referring to scope of work as in the contract agreement between the state government which are pothole patching, maintenance of road shoulder, grass cutting, maintenance of road furniture, maintenance of bridges and culvert, drainage and routine inspection. Assessment also includes management

activities from commuting, utility consume and other consumed items example used of paper.

## **1.6 Significance of Study**

Carbon emissions from routine maintenance work have a significant impact on the environment due to the length of the road. These vast length of the road had trigger the necessities to know the amount of carbon produced by the activities done. Although they are opinion suggesting that emission is probably low due to amount of resources used, but the situation is becoming much critical every day and effort need to start as early as possible in regards much is to be study and determined

Considering the increased awareness on the amount of carbon released by human activities, evaluation of the carbon produced during routine maintenance becomes much significant. During the assessment, exposure to the personnel involved contributed to new knowledge and perspective on the carbon produced by these activities through sources that lead to emissions. Thus, highlighted the current situation in the scenario for future improvement, mostly for the steps taken after that towards the carbon reduction.

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