Jurnal Teknologi

Full paper

Energy Efficiency Criteria for Green Highways in Malaysia

Rozana Zakaria[a*], Foo Kian Seng[a], Muhd Zaimi Abd. Majid[a], Rosli Mohamad Zin[a], Mohd Rosli Hainin[a], Othman Che Puan[a], Haryati Yaacob[a], Noriha Derin[b], Farinie Ainee[a], Norlizah Hamzah[a], Saied Omar Balubaid[a], Ain Naadia Mazlan[a], Mohd Affendi Ismail[a], Yazlin Shalfiza Yazid[a], Raja Rafidah Raja Mohd Rooshdi[a], Farzaneh Moayedi[a]

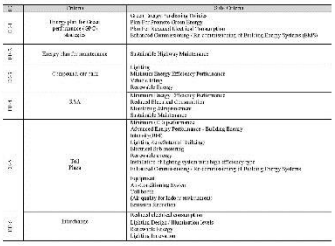
[a]*Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*
[b]*East Regional Manager, Malaysian Highway Authority (LLM), Malaysia*

*Corresponding author: rozana@utm.my

Article history

Received :10 May 2013
Received in revised form :
25 September 2013
Accepted :15 October 2013

Graphical abstract



Abstract

Green highway is a roadway planned and designed with desires to integrate transportation functionality and ecological. A green highway takes high consideration on the approach of environment to the transportation system development, the ecosystem, urban growth, public health and also to surrounding communities. Reference to standard system such Green Roads Rating System becomes more popular being used to measure the classification of a green highway. This journal paper aimed to discuss on how important is the energy efficiency criteria to be measured in the green highway development. Energy is considered highly related to highway development due to it is the most infrastructures involves in massive construction activities from its construction up to the operation and maintenance process. Relevant energy criteria in green highway development had been figured out and a checklist of the comparison among the current relevant reference in the green highway is highlighted in this paper. These identified criteria for energy efficiency are importance to be considered in Malaysian Highway Index. The criteria include the consideration on Energy Plan for Green performance strategies, energy plan for maintenance, grey and green compound and car park, rest and service area (RSA), toll plaza and interchange.

Keywords: Green highway; energy efficiency; index; rating system

1.0 INTRODUCTION

Highway in every country plays significant roles where it provides linkages of transportation for nation economic activities. Highway is the infrastructures that commuting peoples and goods from one place to another. Highways development involve massive earthwork and conversion of land used in it construction. This requirement applies the knowledge of environmental science whereby control have to be made in conserving of natural resources, at the same time sustain the need of the present and future generation. To achieve a green highway planning, design, construction and assessment of highway need to integrate with local ecological protection consideration, therefore it help to avoid subsequent environmental destruction and excessive resource consumption. Whilst mentioned about resources energy efficiency is the upmost agenda in incorporating sustainable development concepts into highway projects [1]. In Malaysia, there is still no local index that relevant to the green highway development. There are essential needs to establish a code or guideline in Malaysia that can be referred by local highway designers in the planning, design and construction stage of Green Highway infrastructure. In year 2000, the total length of roads in Malaysia was approximately 65,445km. The total length of roads is increased by 33 percent from 2000 to 2005. From 2005 to 2007, the length of roads increased by 35 percent. According to Malaysia Highway Authority (MHA), there are altogether 29 highways in Malaysia with total length of 1 732.44 km [2].

In comparison to the green building initiatives, green highway is considered a new concern for the implementation in Malaysia. Taking the lesson learned from the success of green building and Green Building Index, a guideline or rating standard needed to be introduced to new and existing highway development. In establishing the rating index in particular Green Highway Index, one of the most important criteria is to reduce carbon emission. Energy Efficient index (EEi) in the Malaysian green highway will help to measure the classification of highway development whereby energy- efficiency requirement needed to be fulfilled to better meet the energy saving and low carbon emission. Therefore, EEi is critical to be established specifically for the Malaysian highways. This EEi should be applicable for tropical weather, environment, cultural and social needs. In order to establish EEi, the energy efficient criteria is upmost needed to be identified for the classification, limits or benchmark can be set up for rating system of green highway.

■2.0 THE CURRENT RELEVANT RATING SYSTEM & ENERGY EFFICIENCY INDEX IN GREEN HIGHWAY

A green highway generally can be defined by five main criteria's which are watershed driven storm water management; life cycle energy and emission reduction; recycle, reuse and renewable; conservation and ecosystem management; overall societal benefits [3].

The green highway concepts have been practiced in Europe countries such as Sweden, the United Kingdom, Germany and etc. Green Roads Rating System is used to measure the responsive rate of Green Highway. This measurement system was developed by researcher from United States on 2007 whereby the determination of point value is based on the recommendation from United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) [4].

In example, Green Roads Rating System has 6 key categories to be considered during assessment in order to obtain the credits. The 6 key categories are Sustainable Design; Materials & Resource; Storm water Management; Energy & Environmental; Construction Activities and Innovation [5].

The New York State Department of Transportation's (NYSDOT's) has established GreenLITES (Green Leadership in Transportation and Environmental Sustainability) program. GreenLITES is a tool to advance the Department's efforts to better align sustainability in planning, design, construction, and maintenance operations with long term needs. GreenLITES is modeled after the building industry's Leadership in Energy and Environmental Design (LEED) certification program for green building practices as well as University of Washington's Greenroads program. GreenLITES Design identifies more than 175 sustainable items in five categories which are Sustainable Sites, Water Quality, Materials & Resources, Energy & Atmosphere, and Innovation [6].

Besides Green Roads Rating System, the other rating system is Illinois - Livable and Sustainable Transportation (I- LAST) which has 8 categories included planning; design; environmental; water quality; transportation; lighting; materials; and innovation [7].

Previous study conducted by Balarabe, 25 green highway elements was identified and three elements relatively have influenced to energy efficiency. These elements include use of energy efficient facilities, low effect of road type on vehicle energy consumption and use of renewable energy for energy supply [8, 9]. Table 1 shown the elements and sub-elements of green highway.

Table 1 Elements and sub-elements of green highway [8, 9]

Group	Sub-Elements	Codes
ecology	preliminary inspection of propose route to reduce destruction of environment	eco0001
	preservation of animal habitat	eco0002
	topsoil preservation and reuse	eco0003
	ecological functions of drainage corridor	eco0004
	environmental monitoring measures after project completion	eco0005
landscaping	diversified and multilevel landscaping	lan0001
	vegetation coverage	lan0002
	carbon sequestration	lan0003
	plant endemic and bird and butterfly attracting plants	lan0004
	restoration of possible vegetation	lan0005
waste reduction	use of road structure to minimize disturbance of original ground scenery	was0001
	selection of automated /IBS working methods	was0002
	minimization of waste during the construction process	was0003
	minimization of excavation and earthmoving	was0004
materials	use of recycled highway materials	mat0001
	use of environmentally friendly materials	mat0002
	use of equipment that are easy to maintain and manage	mat0003
	application of durable material	mat0004
water conservation	use of highly water-permeable side slopes shapes	wat0001
	water-permeable pavement design	wat0002
	direct infiltration design	wat0003
	water storage infiltration design	wat0004
energy efficiency	low effect of road type on vehicle energy consumption	ene0001
	use of energy efficient facilities	ene0002
	use of renewable energy for energy supply	ene0003

The study found the use of energy efficient facilities is very important and the two other elements fall in important level of agreement to be considered in the framework of green highway assessment.

Besides, energy efficiency should be seriously concerned in green highway development. Energy consumption in highway includes embodied energy from its materials manufacturing, construction, operation and maintenance process. The 'standard' two-lane road, emits 12 tons of carbon dioxide (CO_2) equivalents per lane kilometer while the operation and maintenance of a two-lane road entails on average annual emissions of 33 tons of CO_2 equivalents per lane kilometer [10]. It is advantages to enhance energy efficiency in highway because energy consumption in highway development will contribute to carbon foot print. In consideration of the carbon emission of 12 tons/km/lane, rough estimation carbon contributes by 4 lanes of highway construction is 83,175 ton CO_2.

Malaysia naturally has abundant sunshine and thus solar radiation. On the average, Malaysia receives about 6 hours of sunshine per day with mean daily solar radiation range from 14.90 Mjm^{-2} to 22 Mjm^{-2} [11]. This is because Malaysia is located near the equator. The climate is categorized as humid tropical climate or equatorial with temperatures averaging 30°C where it receives much sunlight during day time. The condition would possible to use solar as a source of renewable energy and it is advantages to enhance energy efficiency in highway infrastructure. In Malaysia highways, the example of Green Technology applied is installation of Light-Emitting Diodes (LED) for street lighting and solar energy devices such as chevron sign and speed limit sign [12]. These

initiatives are applied at Karak-Kuala Lumpur highway. The other example is street lighting using solar energy is at Pedas Lay at North South Expressway [12].

3.0 METHODOLOGY USED IN IDENTIFYING ENERGY EFFICIENCY CRITERIA

The consideration of selection is based on comparison of current relevant references in green highway. All the reference or guideline had been reviewed and the criteria that relevant to energy efficiency had been listed out. Table 2, shows the energy efficiency criteria and sub-criteria of several green highway index in cross-international comparison.

In comparison, GreenRoads rating system is focusing on improving energy efficiency of operational systems. The purpose is to reduce lifetime energy consumption of lighting systems for roadways. GreenRoads rating system for energy efficiency set a standard to install lighting systems with luminaires that meet or exceed the 2009 Energy Star standard for roadway lighting [5].

Table 2 Energy criteria in current green highway rating system [1]

Reference	Criteria	Sub-criteria
Greenroads[5]	Energy Efficiency	Improve energy efficiency of operational systems
I-LAST[7]	Lighting	Reduced Electrical Consumption
		Stray Light Reduction
GreenLITES[6]	Energy and Atmosphere	Minimum EE Performance
		Stray Light Reduction
ENVISION[13]	Energy	Reduce Energy Consumption
		Use Renewable Energy
		Commission and Monitor Energy Systems

Another example is I- LAST. It concentrates on lighting in order to response to energy efficient of green highway which reducing electrical consumption and stray light reduction. In order to reducing electrical consumption, there are seven elements which are use for the alternative energy source to power street lighting, warning signs, and remote Intelligent Transportation Systems (ITS) components; retrofit existing street lighting with high efficiency types; replace signs with retro-reflective signs to eliminate sign lighting; Retrofit existing sign lighting with high efficiency types; use of high efficiency street lighting on new installations; use of alternative energy source for bus stops; and use of high efficiency (such as LED) traffic signals. While in stray light reduction, the objective is to consider incorporating cut off or full cut off roadway light fixtures to reduce adverse effects of artificial light including excessive sky glow, glare, light trespass, and light clutter [7].

Additionally for GreenLITES, it also has the criteria of reduce electrical consumption and stray light reduction. Points will be awarded for project designs that reduce electrical consumption above and beyond typical measures. Specifically for solar/battery powered street lighting or warning signs; replace overhead sign lighting with higher type retro-reflective sign panels; use of LED street lighting and solar bus stops. While in stray light reduction, the objective is to reduce stray light. Points also will be awarded for project designs that reduce stray light above and beyond typical measures. Specifically retrofit existing light heads with full cut-offs and item deleted, keep as place holder [6].

Envision has the criteria of energy which has the sub-criteria of reduce energy consumption, use renewable energy, and commission and monitor energy systems that relevant to the study [1]. The purpose of energy reduction is meet by controlling energy conservation through reducing overall operation and maintenance energy throughout the project life cycle. While in the use renewable energy, the purpose is achieve through renewable energy sources. Finally is the commission and monitor energy systems, it is to ensure efficient functioning and extend useful life by specifying the commissioning and monitoring of the performance of energy systems [13].

By referring to "Preliminary Guide to Nurture Green Highway in Malaysia", there are several sub- criteria listed including solar energy, Light Emitting Diodes (LED) street light, Rest and Service Area (RSA), interchange and electrical toll collection system (ETC) that relevant in this study [12]. Solar energy is the alternative to generate electricity which is from sunlight. The energy from sunlight that absorbs by solar panel will transfer to electricity and very particular for street lighting and other facilities at RSAs, toll and interchange. LED street light can also be install at RSAs and interchange because it is economically viable, energy efficiency and reliable. The advantages of LED lighting are long life reliability, maintenance free operation, energy efficiency, environmental benefits and new lighting possibilities. While for ETC, it is recommended to install at all toll plaza because this will solve long queuing vehicles approaching the toll plaza which consume fuel energy and causes pollution to environment [12].

In the journal of "development of an assessment framework for green highway construction", there is a criterion of energy conservation which has the sub-criteria of use of energy conservation facilities and use of natural energy or reuse of waste heat.[13] Use of energy conservation facilities is the facilities that should be employed to avoid unnecessary energy waste. While for the use of natural energy or reuse of waste heat is energy that should be obtained from natural sources such as wind power and waste heat from incinerators [14].

While in the thesis with title "Green guide of roads rating system", there is criterion of energy and atmosphere which has the sub-criterion of infrastructure energy efficiency, fossil fuel reduction and equipment emission reduction [15]. In infrastructure energy efficiency, the objective is to reduce pollution from energy consumption. It is done by design and installation of any lighting, pump systems and treatment systems that are includes as part of the project. The target is to achieve a 15% reduction in energy used from the baseline of normal energy use. While for fossil fuel reduction, the objective is to reduce the reliance and use of fossil fuels in construction equipment and work vehicles on road construction projects by using hybrid and alternative fuels like bio-diesel and

electric hybrids. Besides, in equipment emission reduction, it is dedicated to reduce the emission from construction equipment and work vehicles on road construction projects by using hybrid engines, bio-fuels, as well as the retrofitting of construction equipment and vehicles on-site [15].

Any highway projects that introducing and implements green energy purchasing policies which meet the International Electro-technical Commission standard (IEC). The IEC cover a vast array of technologies in its standardization and conformity assessment activities [16]. For emissions from purchased electricity use, it is recommended to employ efficient electrical equipment, such as "SON high pressure sodium" for lighting and signals. It is also a growing trend that renewable energy facilities prefer solar panels to be built on highway right-of-ways to generate energy for highway electricity use.

Through the literature review and comparison from current green highway rating lead to the customization of the interest and priority of energy efficiency criteria for green highway development. A focus group discussion consists of 30 members including researchers, academicians and highway professionals have been conducted to justify the green highway main criteria. They were divided to five main groups. One of the group in charged on the energy efficient criteria. This group had gone to intensive literature review and summarized the critical sub-criteria of energy efficiency that related to highways. Based on the group critical discussion, they had come out with six sub-criteria of energy efficiency criteria which shown in Table 3.

4.0 RESULTS AND DISCUSSION

From the comparison on the above current relevant rating system through extensive study of existing literature review and the research methodology applied, this paper illustrates the initial proposal of energy efficiency criteria for Malaysia new green highway index. Table 3 describes the identified criteria.

There are categories of infrastructure to assess energy efficiency for the green highway. These include policy applied in green highway, infrastructure in highway like gray and green compound and car park, RSA, Toll plaza, and interchange. By categorizing it ease the process of analysis of results for the future assessment for Malaysia Green Highway Index application.

The first criterion is Energy Plan for Green Performance (GPC) strategies. This procedure need to be followed in design, construction and operation stage. The strategies should include to meet the International Electro technical Commission standard (IEC); percentage of utilization of renewable energy resources used in completed works; percentage of operational energy reductions throughout the project life cycle; and updating building operating plan as necessary to reflect any changes in occupancy schedule, equipment runtime schedule, design set points and lighting levels.

While the second criterion is Energy Plan for Maintenance, it is the meant foe sustainable highway maintenance. The developer must apply Energy Maintenance Plan (EMP) as state in the contract. This may include re-evaluating EMP by referring to ISO14000 which is Environment management systems and standards. Besides, Highway Maintenance Manual is also one of the standards for their reference. These steps will ensure that all parties involve alert and execute the maintenance plan effectively.

For criteria of Compound and Car Park, it is suggested to provide reasonable luminosity of the street light; provide control technology for the lighting for car park and landscape; and provide signboard to inform vehicle drivers to switch off the engine at parking area. These steps will reduce the energy use and consider as sustainable element in green highway.

In Rest and Service Area, developers are required to calculate the project performance by expressing the energy produced by the renewable energy systems as a percentage of the building annual energy use; provide building Automation System for buildings having area greater than 4,000 m^2 of air- conditioned space; all the procedure must meet the requirement of ISO 16484; use of Energy Management System (EMS) to monitor and trend log building system performance; and providing a designated building maintenance office that is fully equipped with facilities (including tools and instrumentation) and inventory storage. The RSA which follow these step will awarded more rating point in the assessment. For Toll plaza, provision of auto-sensor controlled lighting or motion sensors is important. Besides, lighting fixture is install using the high efficiency type; providing training for management staff to build awareness and skills in a broad range of sustainable building operation topics; and energy efficiency, renewable energy and other building emission reduction actions is also critical to be consider in the project. Last criteria is the Interchange of highway which is percentage reduction of energy consumption if use high energy efficiency lighting or smart lighting; reasonable lighting design or illumination levels; percentage operational energy reductions if use green highway criteria like installation of energy efficiency equipment's such as solar panel; and installation of sensor device at interchanges. At the interchange of highway, there are many lighting system like high mast, spotlight and street light. These lighting system will gain more energy saving if establish above requirement suggested by expertise.

5.0 CONCLUSION

This research proposed criteria of energy efficiency that significant to Malaysian Green Highway Index. A thorough reviewed on sustainable related requirements of Greenroad, I- LAST, GreenLITES, ENVISION and relevant studies has established a checklist of the comparison among the current relevant references in that lead to initial criteria of energy efficiency proposed to be the part of energy index in Malaysian green highway. The research results show that the proposed criteria in energy efficiency index are Energy plan for Green performance (GPC) strategies; Energy plan for maintenance; compound & car park; Rest and service area (RSA); Toll plaza and interchange.

Acknowledgement

This work was financially supported by Malaysia Highway Authority Contract Grant (Vot no: 4B056), research team members from Construction Research Alliance, Universiti Teknologi Malaysia and Malaysian Highway Authority

Table 3 Initial energy efficiency criteria and sub-criteria proposed for Malaysian green highway index

ID	Criteria	Sub- Criteria
EE-1	Energy plan for Green performance (GPC) strategies	Green Energy Purchasing Policies Plan For Promote Green Energy Plan For Reduced Electrical Consumption Enhanced Commissioning / Re-commissioning of Building Energy Systems (EMS)
EE-2	Energy plan for maintenance	Sustainable Highway Maintenance
EE-3	Compound, car park	Lighting Minimum Energy Efficiency Performance Vehicle Idling Renewable Energy
EE-4	RSA	Minimum Energy Efficiency Performance Reduced Electrical Consumption Monitoring &Improvement Sustainable Maintenance
EE-5	Toll Plaza	Minimum (EE) performance Advanced Energy Performance - Building Energy Intensity(BEI) Lighting Zone(Internal Building) Electrical Sub-metering Renewable energy Installation of lighting system with high efficiency type Enhanced Commissioning / Re-commissioning of Building Energy Systems Equipment Air-Conditioning System Toll booth (Air quality for Indoor environment) Emission Reduction
EE-6	Interchange	Reduced electrical consumption Lighting Design / Illumination levels Renewable Energy Lighting Innovation

References

[1] R. Zakaria, *et al*. 2012. Identification of Energy Efficiency Criteria for Malaysia Green Highway: *Proceeding of 8th Asia Pacific Structural and Construction Engineering Conference and 1st International Conference on Civil Engineering Research (APSEC-ICCER 2012)*. 2: 375–378.

[2] R. Zakaria, *et al*. 2012. The Risk Perspective of Green Highway Investment: *Proceeding of 8th Asia Pacific Structural and Construction Engineering Conference and 1st International Conference on Civil Engineering Research (APSEC-ICCER 2012)*. 2: 375–378.

[3] James M. Bryce. 2008. Developing Sustainable Transportation Infrastructure: Exploring the Development and Implementation of a Green Highway Rating System. *ASTM WISE Intern Project*. University of Missouri.

[4] Martina Soderlund. 2007. Green Roads: A Sustainability Rating System for Roadways, *Master Thesis*. University of Washington Seattle.

[5] University of Washington. 2011. Greenroads Abridged Manual. Washington. *Greenroads Manual*. Version 1.5.

[6] New York State Department of Transportation. 2010. Green Leadership in Transportation and Environmental Sustainability. *GreenLITES Project Design Certification Program*. New York. Version 2.1.0.

[7] Illinois Department of Transportation. 2010. Illinois-Livable and Sustainable Transportation. *I-LAST Rating System and Guide*. Version 1.0.

[8] Sani Balarabe Abu bakar. 2011. The Elements Identification of Green Highways in Malaysia. *Master Thesis*. Universiti Teknologi Malaysia.

[9] Mohd Affendi Ismail, *et al*. 2013 .Fundamental of Malaysia Green Highway. *Applied Mechanics and Materials*. 284–287: 1194–1197.

[10] Arvid Strand, P. N. 2009. Better roads increase emissions. Retrieved 1 5, 2012, from *Transport Bussiness International*: http://www.transportbusiness.net

[11] Malaysia Meteorological Department. 2011. Monthly Weather Bulletin. Retrieved 11 9, from *official Portal Malaysian Meteorological Department*: http://www.met.gov.my.

[12] Ismail Md Salleh. 2010. Preliminary Guide to Nurture Green Highway In Malaysia. *LLM/P/T8-10*. First Edition. 1–42.

[13] Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure. 2012. A Rating System for Sustainable Infrastructure. *Envision™ Guidance Manual*. USA .Version 2.

[14] Rong-Yau Huang and Cheng-Hung Yeh. 2008. Development of an Assessment Framework for Green Highway Construction. *Journal of the Chinese Institute of Engineers*. 31(4): 573–58.

[15] Matthew Clark. 2009. Green Guide for Roads Rating System. *Degree Thesis*. Worcester Polytechnical Institute. 68.

[16] International Electrotechnical Commission. 2011. High-pressure sodium vapour lamps-Performance specifications. *IEC 60662*. Switzerland. Edition 2.0.