2013 International Conference on Advances in Engineering and Technology (AET 2013)

March 22-23, 2013 Hangzhou, China

QUANTITATIVE EVALUATION OF LOW CARBON ROAD MAINTENANCE AND ITS LEGISLATION

Ke Zhou，Yim Wong，Huicong Zhang
Renmin University of China, Law School
Beijing, China.
e-mail: rdzhouke@x263.net；
kwongccel@yahoo.com.cn；
chifengjirui@163.com

Michael Lee
University of Alberta, Edmonton
Alberta, Canada
e-mail: drmlee@hotmail.com

Charence Chiang
Renmin University of China, Law School
Beijing, China.
e-mail: charence@hotmail.com；

***Abstract*——*Low carbon highway maintenance is an integral part of a low carbon transportation network. Carbon emission evaluation is an important assessment besides the construction cost evaluation in the overall appraisal of highway maintenance. This evaluation requires a comprehensive set of measurement standards. In order for China to fulfil its obligation to the international climate change treaties and to realize the goals of carbon emission reduction in China, there is a need to accurately determine and record the level of carbon emission in road maintenance. This process must be based on accurate scientific data and derived from actual comparative studies of various low carbon highway maintenance technologies and case studies. Low carbon highway maintenance technology should be recognized by legislative measures.*

Keywords-Low carbon economy; Highway maintenance; Quantitative evaluation; Legislation

I. *MEASUREMENT OF CARBON EMISSION DURING THE PROCESS HIGHWAY MAINTENANCE*

The research into the testing and quantification carbon emission in highway construction and usage is a huge and systematic undertaking. The process involves testing, calculation and assaying of the carbon emission in many aspects of the construction process such as the use of raw material, emission of the deployed machinery and other quantities released during the construction process. These have to be tabulated to allow for a total carbon emission figure for the entire highway construction process. Simultaneously with this research, comparison can be made on new material, technology and application with respect to their carbon footprints, allowing the establishment of standards for carbon emission for the construction of environmentally responsible highway. These standards could also be used to evaluate whether a highway is meeting the carbon emission limits.

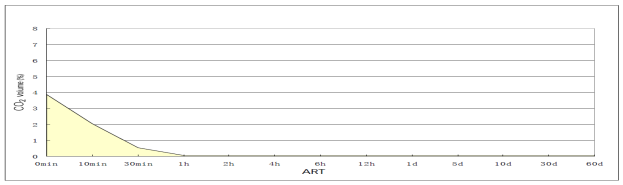
Preventative pavement maintenance (PPM) for asphalt road surface refers to a systematic approach to pavement maintenance before the appearance of structural damage or reduction of functionality occurs, thereby retaining or even enhancing the performance of the road surface. It also aims at extending the longevity of the road and decreasing the cost of cyclical maintenance during the life of the highway.

Field experience has verified that timely PPM treatment is effective in delaying road damage and prolonging the useable life of the road surface, hence postponing the costly major rehabilitation or rebuilding of the road. It could be a cost effective road maintenance technology, depending on how it is applied.

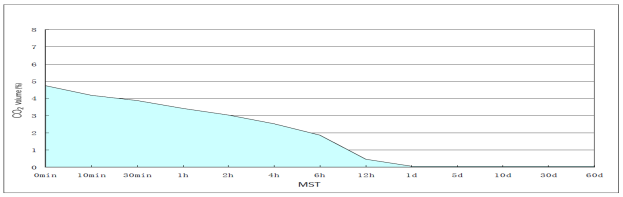
In general, there are four major PPM technologies: asphalt rejuvenation technology (ART), micro-surfacing technology (MST), hot ultrafine technology (HUT) and fog seal technology (FST). (1) ART is very effective in preventing the appearance of early defects in the asphalt surface and reviving all the functional qualities of the asphalt. Traffic can resume after 2-4 hours after ART treatment. (2) MST is also used at an early stage of the asphalt life cycle and is usually applied to high grade highways. Traffic can resume in 1-2 hours following resurfacing. (3) HUT produces a flat and even pavement. It has high anti-skid properties that are long lasting and it reduces road noise. Traffic can resume in 1 to 2 hours after application. (4) FST is a very common PPM technique used on high speed highways because of its low cost, high effectiveness and ease of application. It allows resumption of traffic very shortly after application. However, as this paper focuses on legislation in relationships with carbon emission, it is not the authors will to discuss, compare and evaluate all the foregoing methods in terms of costs, reliability and life span in this paper.

Currently there is no established testing method for carbon emission in the road construction or road maintenance processes. To compare the carbon emission of the different PPM technologies, the level of CO_2 is chosen as the carbon emission indicator. The CO_2 emission during the application process of these technologies and the subsequent emission during the operational stages could be scientifically determined and an environmental evaluation of the techniques could be assessed to achieve the goal of finding a "low carbon" and "environmentally friendly" way of preventative pavement maintenance.

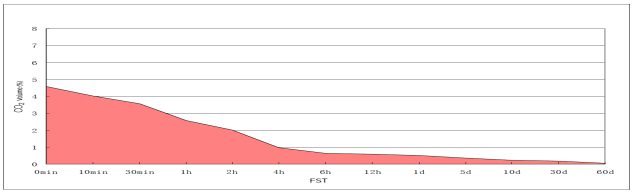
A comparative study has been performed on the four PPM technologies: ART, MST, HUT and FST, plus the general asphalt road standard paving technology (AST). The study involved laboratory tests as well as field tests on actual job sites to determine the CO_2 concentration of air samples associated with these technologies. The utilization of different PPM technologies results in significant differences in CO_2 emission concentration and absolute CO_2 quantity released. The highest emission concentration and quantity are associated with the technology employing heated mixture compounds, such as HUT. The next highest is the technologies using reactive materials such as in MST and FST. ART has the lowest level of concentration as well as absolute CO_2 quantity released [1]. Figures 1-5 illustrate the CO_2 quantity released for each technology:



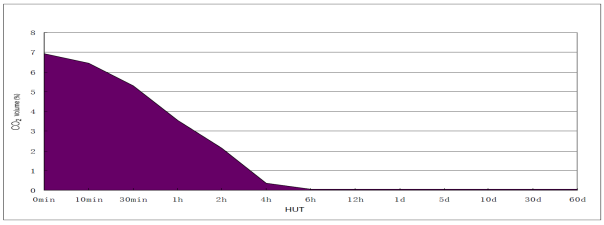
Figures 1



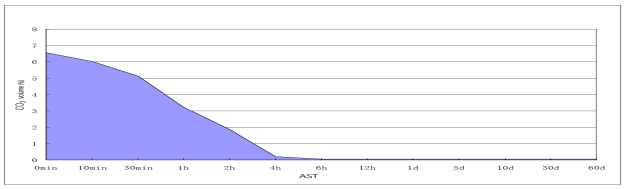
Figures 2



Figures 3



Figures 4



Figures 5

II. LOW CARBON ROAD MAINTENANCE TECHNOLOGY REQUIRES LEGISLATIVE PROTECTION

When considering legislative control over low carbon road maintenance technology, the merit of the technology must be determined. The adoption of low carbon road technology is an integral part of achieving a low carbon transportation network and hence a low carbon economy. Secondly, recognizing the standard of low carbon PPM in law reinforced with penalties and fines structure, will push for a broad adaptation of true low carbon technology and encourage the beneficial development of the whole industry. Based on this, it follows that relying on legislation to promote the healthy development in the PPM industry is essential.

The progress of a low carbon transportation network requires the support of low carbon PPM technology. Presently, there is no uniform standard for PPM technologies. In order to quantify the PPM technologies and to standardize and ultimately consolidate the standards in law, a robust set of scientific data must form the basis of this process. A comparative study on the PPM technology, especially in actual field test situations, must be conducted to provide the foundation for legislation.

The ultimate goals for PPM technology legislation are to achieve environmental righteousness, to promote low carbon economic development and to realize the balance between mankind and nature. The immediate aim is to accomplish the harmony between practical economic development and the natural environment and to further the growth of the PPM industry. Low carbon PPM technology can illustrate that practical economic development and natural resources are compatible. Law making will promote the healthy development of the PPM industry and a low carbon transportation network and contribute to the foundation of an overall low carbon economy. The principle behind low carbon PPM legislation is intimately linked to the ethical foundation and aim of such legislation.

The utility value of the low carbon PPM legislation resides in its actual effect on the habitat efficiency and the relationship between the economic output of society against the environmental cost incurred. Habitat efficiency (resource productivity quotient) = economic output (productivity, or GDP)/environmental resource consumption. This principle also applies to the highway maintenance industry, requiring the use of the least amount of resources and minimal emission to achieve the greatest effect in the maintenance process. The current national sentiment in China and the existing environment conditions both demand us to increase the habitat efficiency ratio. The realization of low carbon PPM habitat efficiency will be a pillar in the overall low carbon economic development movement.

III. LEGISLATION AS AN IMPETUS TO STANDARDIZE LOW CARBON HIGHWAY TECHNOLOGY

Active promotion of low carbon PPM technology is needed for the realization of a low carbon transportation network. The push for low carbon PPM is not only the responsibility of the industry itself, but also the joint effort of government and many organizational units. The success of

this drive will require the strong support of legislation which should be clear in its purpose whilst the development of the low carbon PPM industry requires that the technology become standardized. Many technologies about reducing CO_2 emission load are inseparable from our existing conditions of material life. The real challenge is from political environment: the technology and its practice is to ensure sustainability. [2] Legislation can also act as a shield to discourage the unscrupulous claim of low carbon by some operators in the industry.

The promotion of low carbon PPM technology needs the cooperation of all stake holders including government, industry and trade organizations. If a regional government wishes to reduce the carbon emission in road maintenance by a certain percentage each year, it could assign this task to a research institute or unit that has proven strength in this area. The unit will design a plan to reduce or eliminate the carbon emission, import the technology required, organize and implement, and ultimately supervise and verify the effectiveness. It is through this quantitative approach with data support that will allow the use of low carbon technology to other industries and sectors. Population growth, urbanization and electrification are also determining factors in the level of energy consumption. If a comprehensive energy management system is to be implemented, industries and government departments should jointly form an energy conservation coalition through which effective and reliable technologies could be disseminated. The promotion and expansion of low carbon PPM technology likewise will need recognition in law.

IV. THE STRUCTURE OF THE LEGISLATION FOR LOW CARBON PPM TECHNOLOGY

First, confirm that you have the correct template for your paper size. This template has been tailored for output on the US-letter paper size. If you are using A4-sized paper, please close this template and download the file for A4 paper format called "CPS_A4_forMany of the low CO_2 emission technologies already exist in our current material world. The real challenge for the continual adoption of the right technology lies in the legislative environment. The legislative consideration should take into account the current condition of the natural resource environment and the real capability of the available low carbon PPM technology as they exist currently in China. The legal framework should ensure these factors are compatible in the low carbon PPM legislation.

A. Encourage, restrict or prohibit: naming system policy

It is necessary to establish a low carbon PPM technology registry and demonstration system. The Interior Ministry and its related departments should establish a low carbon road policy according to the current socio-economic conditions in the country. Legislation should also build in a mechanism that will enforce key industries to revitalize themselves. In order to ensure environmental security, list of hazard materials and their environmental capacity should be conformed in low-carbon Road Maintenance legislation. [3]As a relatively new technology, low carbon PPM will undoubtedly challenge the traditional operational and production model that is in existence now. Legislation will set out standards, and guidelines for encouragement and penalties.

B. Maintaining the Integrity of the Specifications Road maintenance technology market entry policy

Athough some scholar points that there are some shortcomings when we consider solving environment issues by financial incentive[4], The advances of low carbon PPM technology will have to follow market forces, but still need to adhere to the rules of the market and environmental conservation which dictate the conditions whether the technology would be allowed to compete. The main

requirements are: whether the technology and equipment are meeting standards set by the central government; whether the environmental impact is satisfactory; and whether the product can be reused or recycled. Through the establishment of an environmental impact index and a natural resource utilization index, the corporation will be measured against the allowable standards. Restrictions will be placed on the ones that do not meet the requirements whilst those with superior compliance will receive contract prevalence, subsidies or preferential investment considerations. This policy will increase the market entry threshold for those corporations or industries that are energy inefficient and high polluting and open the door for low energy consuming and low polluting ones to enter the market and attract investment through operating models such as franchising and licensing. This policy will strengthen the general criteria for market entry in PPM technology.

C. Low Carbon Road Maintenance Technology Planning Policy

Legislative value of low-carbon road maintenance technology is in the same strain with its ethical basis and its intent. Ecological harmony is the objective value pursued by the low carbon road maintenance technical legislation; Eco-efficiency is the instrumental value of low-carbon road maintenance legislation[5] .In order to define the objectives of the development of low carbon road system and to guide the future of low carbon road maintenance technology, legislation should be established to define the low carbon road maintenance planning policy. It is through planning that low carbon road maintenance could be assured of the right development direction, timeline objectives, standardization and contingency procedures.

D. Harmful and Poisonous Material Policy

The leakage of harmful or poisonous substances into the environment is difficult to eliminate and its effect on the human population could be long lasting. In the process of road maintenance, it is therefore more desirable to prevent the harmful or poisonous substances from invading the environment in the first place. In seeking to establish legislation to govern low carbon road maintenance, the harmful or poisonous materials should be listed and their allowable concentration in the environment has to be determined. This policy not only reduces or eliminates undesirable substances in road maintenance but also encourages the development and adoption of new technology and materials that are more environmentally friendly. In the short term, the ban or restriction of the harmful substances may increase the cost of the projects, however in the long term will generate huge benefits by greatly reducing the cost of disposal of the pollutants, which will undoubtedly contribute to future economic growth.

E. Highway Maintenance Technology "Green Index" Policy

"Green Index" is a measure through which an industry's performance in social and environmental responsibility would be gauged. Low carbon road construction and maintenance should abide by a set of green indices, set by government in conjunction with industry that replaces the current assessment criteria. Carbon emission levels would be included in the economic calculations and resource usage need to be balanced by equivalent compensation. This green index policy will have two approaches: (a) Change the traditional method of GDP calculation to include environmental impact calculations to reflect the true value of the GDP. (b) Write the green index policy into law and through legislation promote the concept of "green audit" that translates the elements of environmental impact into measureable parameters. Once these elements can be sorted in a quantifiable manner, then accounting principles could be applied to access the true environmental cost of each project

or used to compare the merits of various low carbon road maintenance technologies.

F. Low Carbon Road Maintenance Technology "Economic Stimulus" Policy

The development of low-carbon road maintenance is not only the responsibility of corporate, but also the government, industry organizations and so on[6].At the same time that government is guiding the development of low carbon road maintenance technology, government should also encourage the industry by providing economic incentives to leverage the investment from private sector to actively participate in this industry. Policy making needs to strike a balance between environment protection and basic market forces. In this policy, we suggest the inclusion of the following four elements: (a) Government adjust the cost of low carbon road maintenance contracts by leveraging subsidies financed through taxation or fees levied on environmental deficient materials and techniques. (b) By using a naming system policy in conjunction with an assurance bond system, corporations that are environmentally responsible will have an advantage over their less environmentally friendly competitors. This will eventually lift the entire industry to a higher level of environmental consciousness. (c) Government to issue bonds, loans or investment funds to lead the way for more low carbon road maintenance investment and its development. (d) Government increase its investment directly in low carbon road construction and maintenance and thereby increases the demand in this industry. The resulting competition from suppliers would allow the best players in the field to emerge with superior environmental technology that could then be widely adopted.

V. CONCLUSION

Low carbon road maintenance technology that can be quantified is the trend in road maintenance technology. The evaluation of the merits of the different technologies could only be determined by scientific quantitative analysis of the procedure and results of these technologies. Based on data from these studies, procedural and performance standards should be set for the industry which can then be regulated through government policy. In terms of legislation, the value of low carbon road maintenance technology should be recognized, and then technical standards adopted in law. Legislation should encourage superior technology to prosper and inferior ones to fade away so that the low carbon road maintenance technology could have a sustained bright future.

ACKNOWLEDGMENT

The authors are greatly in debt to the Board of Directors of Crown Capital Enterprise Ltd. of Hong Kong for their years of support in the research and study in the environmental and law making issues by the Law School of Renmin University of China. The authors are also grateful to Mr. Andrew Pound, FRICS and Ms. Jean Kan; our colleagues Yuan Gao, LLM and Meishu Wang, LLM of Renmin University of China for extending so much of their valuable time and effort in editing this paper.

REFERENCES

[1] The Carbon Emission Quantification of the Low Carbon Road Maintenance Technology in China" presented at the APEED 2012 by Dr. Ke Zhou ; Yim Wong, LLM ; Dr. Xijuan Xu, Huicong Zhang, LLM and Charence Chiang, P.Eng. LLM, unpublished.

[2] Anthony J. McMichael, Kirk R. Smith, Carlos F. Corvalan. "The Sustainability Transition: A New Challenge," Bulletin of the World Health Organization, vol. 78, Jan. 2000, pp. 1067.

[3] Liu X.M.: Circular Economy and Low-carbon Economy, Beijing: Modern Education Press, 2011, pp. 187.

[4] MacMillan Douglas Craig; Phillip Sharon, "Can Economic Incentives Resolve Conservation Conflict: The Case of Wild Deer Management and Habitat Conservation in the Scottish Highlands." Human Ecology, vol. 38, 2010, pp. 485-493.

[5] Yang Zewei, "Developed Countries, A New Energy Policy Law And Policy Research", Wuhan: Wuhan University Press, 2011, pp. 163.

[6] John C. Dernbach, "Development Goals and Indicatiors: Targets, Timetables, and Effective Implementing Mechanisms: Necessary Building Blocks for Sustainable Development," William&Mary Environmental Law and Policy Review, vol. 27, fall 2002, pp. 79-109.